Invitation to make a submission

The Commonwealth Department of the Environment (DotE) and the Western Australian Environmental Protection Authority (EPA) invites people to make a submission on this Fourth Train Proposal. The environmental impact assessment process is designed to be transparent and accountable, and includes specific points for public involvement, including opportunities for public review of environmental review documents. In releasing this document for public comment, the EPA advises that no decisions have been made to allow this proposal to be implemented.

Chevron Australia Pty Ltd (Chevron Australia) as proponent and operator on behalf of the Gorgon Joint Venturers (GJVs), proposes to expand production from the Gorgon Gas Development Foundation Project (Foundation Project) located on Barrow Island, Western Australia (WA), from the approved 15 million tonnes per annum (MTPA) of Liquefied Natural Gas (LNG) to 20 MTPA through the development of the Gorgon Gas Development Fourth Train Expansion Proposal (Fourth Train Proposal). The Fourth Train Proposal involves drilling additional subsea wells and installing subsea gas gathering systems in gas fields in the Greater Gorgon Area; constructing a Feed Gas Pipeline System to connect these gas gathering systems to the Gas Treatment Plant on Barrow Island; and adding a fourth LNG train at the Gas Treatment Plant. In accordance with the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the Western Australian *Environmental Protection Act 1986*, a combined Public Environmental Review / Draft Environmental Impact Statement (PER/Draft EIS) has been prepared that describes this proposal and its likely effects on the environment. The PER/Draft EIS is available for a public review period of eight weeks from 7 July 2014 to 1 September 2014.

Comments from government agencies and from the public will assist the EPA to prepare an assessment report in which it will make recommendations to government. DotE will also be informed by comments on the PER/Draft EIS and will prepare a separate assessment report for the Commonwealth Minister for the Environment.

Where to get copies of this document

Copies of this document may be obtained from reception at Dynon's Plaza, 905 Hay Street, Perth, WA 6000, Telephone: (08) 9413 6000 at a cost of $10 for a printed version, or free of charge for a CD version.

The PER/Draft EIS may also be accessed through the proponent's website at:

http://www.chevronaustralia.com/our-businesses/gorgon/environmental-responsibility/environmental-approvals

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action – including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Electronic submissions will be acknowledged electronically. The proponent will be required to provide adequate responses to points raised in submissions. In preparing its assessment report for the Minister for the Environment, the EPA will consider the information in submissions, the proponent's responses and other relevant information. Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992* (WA) , and may be quoted in full or in part in the EPA's report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining a group interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to ten people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the PER/Draft EIS or the specific proposal. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements of the PER/Draft EIS:

- clearly state your point of view
- indicate the source of your information or argument, if this is applicable
- suggest recommendations, safeguards, or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful
- refer each point to the appropriate section or recommendation in the PER/Draft EIS
- if you discuss different sections of the PER/Draft EIS, keep them distinct and separate, so that there is no confusion as to which section you are considering
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name
- address
- date
- whether you want your submission to be confidential.

The closing date for submissions is 1 September 2014.

The EPA prefers submissions on the PER/Draft EIS to be made at:
https://consultation.epa.wa.gov.au

Alternatively, submissions can be:

- posted to: Chairman, Environmental Protection Authority, Locked Bag 10, East Perth, WA 6892
- delivered to: Environmental Protection Authority, Level 8, The Atrium, 168 St Georges Terrace, Perth

If you have any questions on how to make a submission, please phone the OEPA on (08) 6145 0803.

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Executive Summary

Introduction

Chevron Australia Pty Ltd (Chevron Australia), on behalf of the Gorgon Joint Venturers (GJVs), proposes to expand production from the approved Gorgon Gas Development Foundation Project (Foundation Project) located on Barrow Island, Western Australia (WA). The GJVs propose to increase the nominal liquefied natural gas (LNG) production capacity from the approved 15 million tonnes per annum to 20 million tonnes per annum through the development of the Gorgon Gas Development Fourth Train Expansion Proposal (Fourth Train Proposal).

The approved Foundation Project is currently under construction and comprises three LNG trains on Barrow Island, processing gas gathered from the Gorgon and Jansz–Io fields (Figure ES-1). The Environmental Impact Statement/Environmental Review and Management Programme prepared for the approved Foundation Project included information relating to the intent to further develop gas in the Greater Gorgon Area through future capacity increases of the processing facilities on Barrow Island. The opportunity to accelerate the development of these gas resources was identified in 2010.

The Fourth Train Proposal will involve drilling new production wells and installing subsea infrastructure, constructing a new Feed Gas Pipeline System, and adding a fourth LNG train and associated infrastructure at the Gas Treatment Plant on Barrow Island. The fourth LNG train will be designed to integrate with the three LNG trains already approved under the Foundation Project. Existing LNG and condensate export facilities (constructed as part of the approved Foundation Project) will be used to export products generated by the Fourth Train Proposal.

This Public Environmental Review/Draft Environmental Impact Statement (PER/Draft EIS) has been prepared to address both the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Western Australian *Environmental Protection Act 1986* (EP Act) requirements. This PER/Draft EIS describes the elements of the Fourth Train Proposal, the potential impacts from the Fourth Train Proposal, the mitigation and management measures that the GJVs propose to implement, and concludes with an assessment of environmental acceptability of the Fourth Train Proposal.

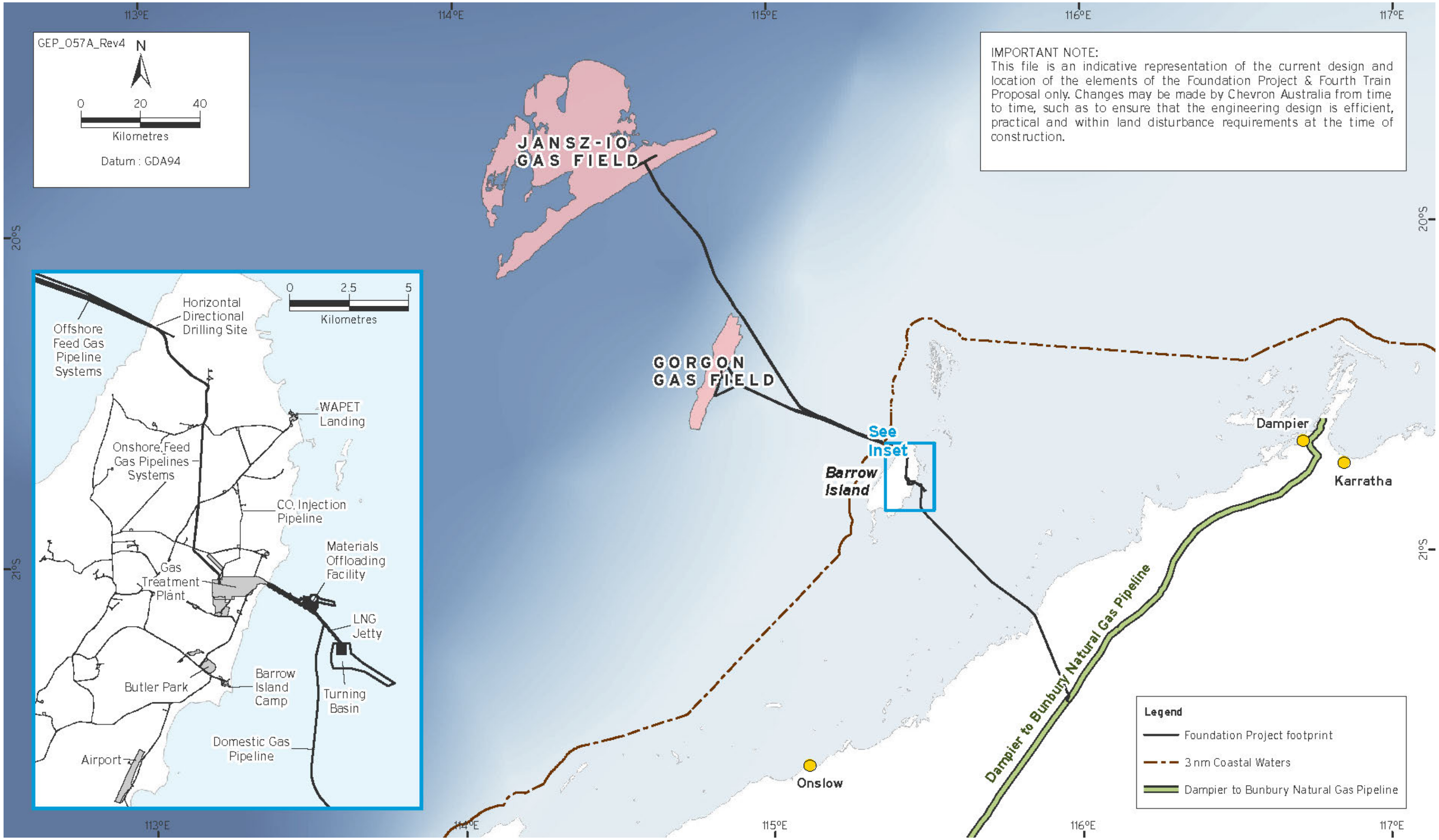

Figure ES-1: Location of the Foundation Project Infrastructure

Project Proponent

Chevron Australia is the proponent and operator of the Fourth Train Proposal on behalf of the following companies, collectively known as the GJVs:

- Chevron Australia Pty Ltd
- Chevron (Texaco Australia Pty Ltd) Pty Ltd
- Shell Development (Australia) Pty Ltd
- Mobil Australia Resources Company Pty Limited
- Osaka Gas Gorgon Pty Ltd
- Tokyo Gas Gorgon Pty Ltd
- Chubu Electric Power Gorgon Pty Ltd.

The GJVs are subsidiaries of leading companies in the global oil and gas industry, with proven technical and management skills for safe, efficient, and environmentally responsible development.

Fourth Train Proposal Objectives

The Fourth Train Proposal aims to commercialise the identified recoverable gas and condensate reserves from the Greater Gorgon Area, while continuing to protect the conservation values of Barrow Island and its surrounding waters. Chevron Australia seeks to manage the environmental, health, safety, and security issues associated with the Fourth Train Proposal in a responsible manner and in accordance with Chevron Corporation standards, recognised global industry standards, and legislative requirements, while providing an acceptable return on investment.

Environmental and Social Commitment and Responsibility

Chevron Corporation operates according to its core values outlined in *The Chevron Way*. Protection of people and the environment is included in this value system, which places the highest priority on health and safety and the protection of assets and the environment. This value system is put into practice through Chevron Corporation's Operational Excellence Management System (OEMS), which includes many elements that relate to environmental and social commitment and responsibility.

In 2009, Chevron Corporation received attestation from Lloyd's Register Quality Assurance Limited that the OEMS meets all the requirements of the ISO 14001 environmental management system standard and the Occupational Health and Safety Assessment Series management specification 18001, and that the OEMS is implemented throughout the Corporation. These standards are international benchmarks and demonstrate Chevron Corporation's commitment to world-class performance.

Chevron Australia, an Australian subsidiary of Chevron Corporation, has operated in an environmentally responsible manner on Barrow Island and Thevenard Island for approximately 45 years. The approved Foundation Project has been under construction since late 2009 and, to date, there have been no material non-compliances with Commonwealth or State Ministerial Conditions.

Legal Framework

The Fourth Train Proposal is subject to both Australian (Commonwealth) and Western Australian (State) legislation. The primary environmental protection legislation that relates to the approval of the Fourth Train Proposal is the EPBC Act and the EP Act.

In addition to these Acts, the Gorgon Gas Processing and Infrastructure Project Agreement (the State Agreement) and its ratifying Act, the *Barrow Island Act 2003* (WA), govern the use of Barrow Island by the GJVs. Chevron Australia also considered other Commonwealth and State legislation, policies, and guidelines and applied its own policies and guidelines in the development of this PER/Draft EIS.

The Commonwealth and State governments agreed to a parallel coordinated environmental assessment process. This PER/Draft EIS has been prepared to satisfy the requirements of both jurisdictions.

Foundation Project Overview

In February 2003, ChevronTexaco Australia Pty Ltd (now Chevron Australia) submitted an environmental, social, and economic review of the initial (now approved) Gorgon Gas Development to the WA Government. The WA Government requested the strategic level review to make an informed decision on whether to provide in-principle approval for the restricted use of Barrow Island for gas processing.

The Gorgon Gas Processing and Infrastructure Project Agreement (State Agreement) was signed in September 2009. The State Agreement and its ratifying Act, the *Barrow Island Act 2003* (WA), govern the undertakings between the GJVs and the WA Government resulting from the environmental, social, and economic review process, and grant in-principle access to Barrow Island to the GJVs for gas processing purposes bounded by a range of conditions and obligations.

Since then, the Foundation Project has been subject to a number of Commonwealth and State environmental assessments for the development of gas processing facilities and associated infrastructure on Barrow Island and its surrounding waters, as outlined in Table ES-1.

Table ES-1: Summary of Environmental Approvals for the Foundation Project

Proposal	Element	Level of Assessment	Approval Granted	Approval Reference
Initial Gorgon Gas Development	Gas field wells and subsea infrastructure Feed Gas Pipeline System (offshore and onshore) Gas Treatment Plant on Barrow Island, including two nominal five million tonnes per annum LNG trains, domestic gas and condensate facilities Port and marine facilities Butler Park (Construction Village) and associated facilities Proposal to inject carbon dioxide (CO_2) into the Dupuy Formation Domestic gas pipeline to the mainland	Environmental Impact Statement/ Environmental Review and Management Programme	Commonwealth Minister for the Environment and Water Resources: October 2007	EPBC Reference: 2003/1294) (as amended)
			WA State Minister for Environment: September 2007	Ministerial Implementation Statement No. 748 (superseded by Ministerial Implementation Statement No. 800)

Proposal	Element	Level of Assessment	Approval Granted	Approval Reference
Jansz–Io Development Project and Jansz Feed Gas Pipeline	Installation of Jansz Feed Gas Pipeline System (offshore and onshore) Development of Jansz–Io deepwater gas field	Environmental Impact Statement/ Assessment on Referral Information	Commonwealth Minister for the Environment and Water Resources: March 2006	EPBC Reference: 2005/2184
			WA State Minister for Environment: May 2008	Ministerial Implementation Statement No. 769
Revised and Expanded Gorgon Gas Development	Addition of a nominal five million tonnes per annum LNG train Expansion of the Carbon Dioxide Injection System Extension of the causeway and the Materials Offloading Facility	Public Environmental Review	Commonwealth Minister for the Environment, Heritage and the Arts: August 2009	EPBC Reference: 2008/4178
			WA State Minister for Environment: August 2009	Ministerial Implementation Statement No. 800
			WA State Minister for Environment: June 2011 (dredging and dredge spoil disposal)	Ministerial Implementation Statement No. 865
Gorgon Gas Development Additional Construction Laydown and Operations Support Area (Additional Support Area)	Additional 32 ha of uncleared land for the Foundation Project to provide construction and operations support	Assessment on Proponent Information	N/A	Regulated through variations to EPBC Reference: 2003/1294 and EPBC Reference: 2008/4178
			WA State Minister for Environment: April 2014	Ministerial Implementation Statement No. 965

The Foundation Project includes offshore and onshore components to develop the gas reserves of the Gorgon and Jansz–lo fields, as outlined in Table ES-2. The Foundation Project commenced construction in late 2009. To date, significant progress has been made in developing the offshore and onshore components. The Foundation Project will be constructed, commissioned, and operated in a phased manner, with the three LNG trains being completed sequentially.

Chevron Australia is committed to ensuring the Foundation Project is constructed and operated in a way that protects the conservation values of Barrow Island. Chevron Australia's Environmental Management Framework is a fundamental component for achieving this commitment. The Environmental Management Framework includes Chevron Australia's OEMS, Environmental Assessment and Monitoring Program (which incorporates this statutory impact assessment and subsequent Ministerial Conditions and statutory Environmental Management and Monitoring Plans, Programs, Systems, Procedures and Reports [hereafter collectively referred to as EMPs]), and Subsidiary Documents.

A number of EMPs are currently being developed or have been approved and are being implemented for the Foundation Project. All EMPs are submitted for approval as required under the relevant Ministerial Conditions and are amended or revised as required by the relevant Ministerial Condition or when additional/different scopes of work and/or experience results in changes to mitigation and/or management measures.

Environmental monitoring programs are being implemented to identify and track environmental impacts from the execution of the Foundation Project. As required under the relevant Ministerial Conditions, information gathered through specified environmental monitoring programs is presented in the Chevron Australia Annual Environmental Performance Reports.

The approved Foundation Project EMPs are designed with an integrated environmental approach, which includes adaptive management processes. Changes to approved Foundation Project EMPs are identified through ecological monitoring, incident response and audits, and the environmental performance reporting process. Auditing of performance against EMPs and the incident response process have both assisted in the identification of potential gaps in the EMPs. This information has then been incorporated into updates to the EMPs through the use of the adaptive management process.

Fourth Train Proposal Description

The Fourth Train Proposal will require the construction of additional subsea production wells and infrastructure, a new Feed Gas Pipeline System, a fourth LNG train, and supporting utilities and infrastructure on Barrow Island. Wherever practicable, the Fourth Train Proposal will share facilities with the approved Foundation Project, including the LNG and condensate export facilities. Table ES-2 compares the key characteristics of the Fourth Train Proposal to those of the Foundation Project. Additional detailed design and construction information, where relevant, will be provided by the GJVs in subsequent EMPs and works approval applications.

Table ES-2: Comparison of the Fourth Train Proposal and the Approved Foundation Project – Key Characteristics

Element	Approved Foundation Project	Fourth Train Proposal
Offshore components		
Number of gas fields	Two (Gorgon and Jansz–Io)	Additional four (Chandon, Geryon, Orthrus [including Orthrus Deep], and Maenad)
Number of production wells*	Approximately 35 subsea production wells from Gorgon and Jansz–Io gas fields	Additional 16 (approximately) subsea production wells
Subsea infrastructure*	Subsea trees, intrafield pipelines, and manifolds in the Gorgon and Jansz–Io gas fields	Additional subsea trees, intrafield pipelines, and manifolds in the Fourth Train Proposal gas fields
Offshore Feed Gas Pipeline System#	Two separate Feed Gas Pipeline Systems linking the Gorgon and Jansz–Io gas fields and Barrow Island	An additional Feed Gas Pipeline System to provide additional capacity for accessing gas fields within the Greater Gorgon Area
Marine component of the shore crossing (west coast of Barrow Island)^	Offshore from North Whites Beach	Additional shore crossing offshore from North Whites Beach adjacent to the Foundation Project crossing

Element	Approved Foundation Project	Fourth Train Proposal
Onshore Feed Gas Pipeline System		
Length onshore (Barrow Island)	Approximately 14 km	One additional Feed Gas Pipeline System (approximately 14 km)
Terrestrial component of the shore crossing	North Whites Beach Area of disturbance (horizontal directional drilling onshore construction area) approximately 7 ha	North Whites Beach Area of disturbance (horizontal directional drilling onshore construction area) up to approximately 10 ha
Gas Treatment Plant		
Number of LNG trains	Three	Additional one
Size of LNG trains	5 million tonnes per annum (nominal) each	5 million tonnes per annum (nominal)
LNG tank size	2 × 180 000 m^3 (nominal)	One additional 180 000 m^3 (nominal) tank may be required
Gas processing drivers	6 × 80 MW (nominal) gas turbines fitted with dry low nitrogen oxide burners	Two additional 80 MW (nominal) gas turbines fitted with dry low nitrogen oxide burners
Power generation	5 × 116 MW (nominal) conventional gas turbines fitted with dry low nitrogen oxide burners	One additional 116 MW (nominal) conventional gas turbine fitted with dry low nitrogen oxide burners
Condensate production rate	3600 m^3/day (nominal) hydrocarbon condensate	Additional condensate production of 2900 m^3/day (nominal)

** infrastructure in Commonwealth jurisdiction*

 # infrastructure in both Commonwealth and State jurisdiction

^ infrastructure in State jurisdiction

Figure ES-2 shows an overview of the Fourth Train Proposal key infrastructure on and near Barrow Island, in relation to the Foundation Project.

The offshore and horizontal directional drilling construction activities for the Foundation Project are expected to be finished before the start of offshore construction activities for the Fourth Train Proposal. Therefore, the Fourth Train Proposal will result in additional construction activities at both the horizontal directional drilling site and offshore.

The Fourth Train Proposal will also result in additional construction activities at the Combined Gorgon Gas Development on Barrow Island. To support these construction activities on Barrow Island, construction facilities and services (e.g. water supply, wastewater treatment) that were approved and installed for the Foundation Project may be retained and shared during the construction period of the Fourth Train Proposal (or replaced with similar facilities). This will provide synergies (i.e. re-use of existing utility infrastructure) between the Foundation Project and the Fourth Train Proposal, and assist in reducing potential environmental impacts.

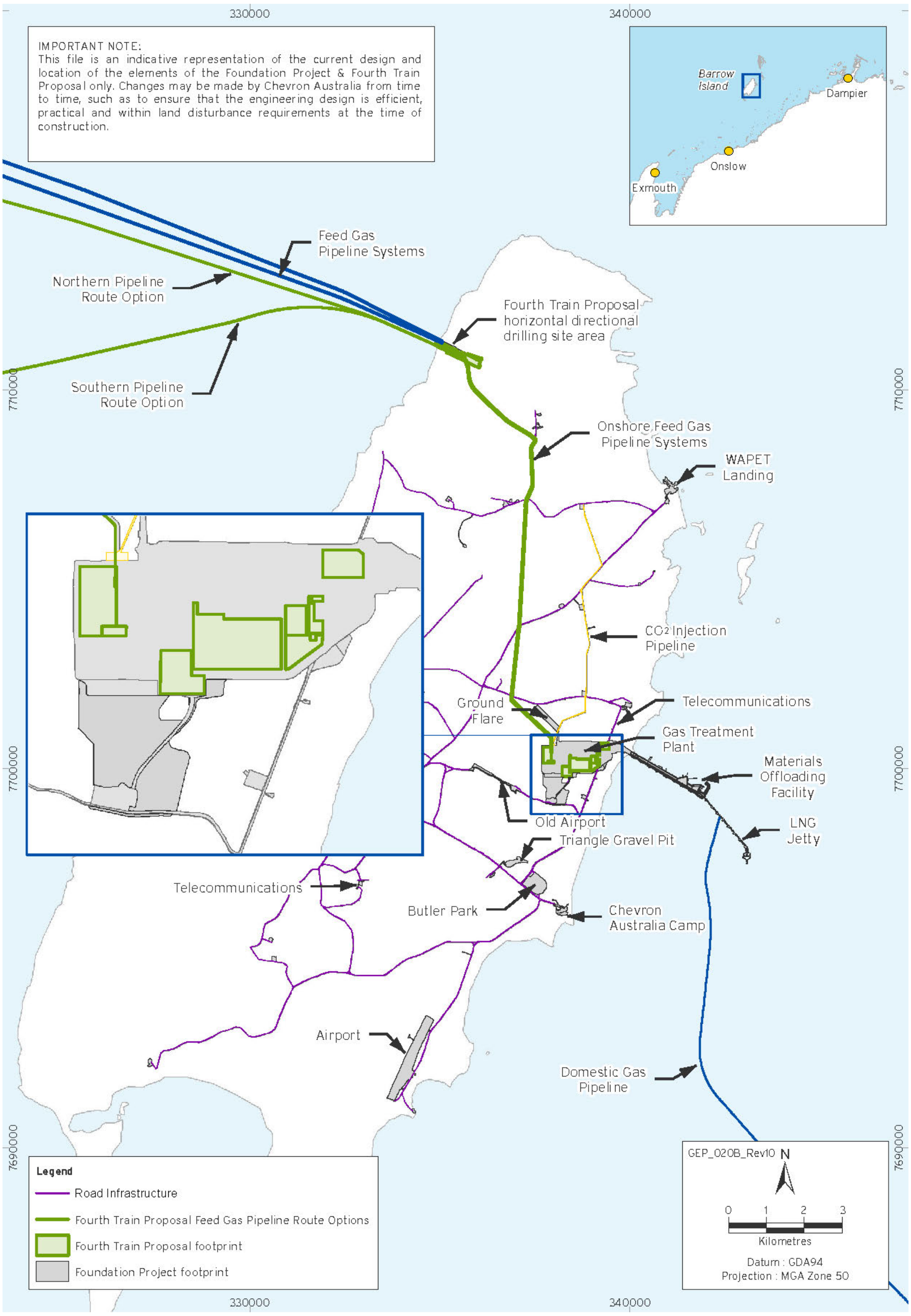

Figure ES-2: Overview of the Key Fourth Train Proposal Infrastructure on or near Barrow Island in Relation to the Approved Foundation Project

Key offshore construction activities for the Fourth Train Proposal include drilling and well completion, installation of subsea infrastructure, the Offshore Feed Gas Pipeline System, and construction of the shore crossing for the Feed Gas Pipeline System. Key onshore construction activities include installation of the Feed Gas Pipeline System, earthworks, and construction of additional infrastructure at the Gas Treatment Plant. Where practicable, utilities and infrastructure (e.g. reverse osmosis facilities, sanitary wastewater systems, and power generation) established for the Foundation Project will be used, with no anticipated increase to their output as approved under the Foundation Project. All proposed activities for the Fourth Train Proposal are consistent with those assessed for the Foundation Project.

Key offshore operational activities for the Fourth Train Proposal will include the extraction and transport of gas and condensate to Barrow Island, pipeline and well maintenance activities, and the injection of monoethylene glycol (a hydrate inhibitor) into the Feed Gas Pipeline System. Key onshore activities include gas processing activities at the Gas Treatment Plant. When the Fourth Train Proposal becomes operational, both the Fourth Train Proposal and the Foundation Project will be operated together as a single entity.

The gas fields to be developed as part of Fourth Train Proposal are located between 100 and 200 km from Barrow Island and comprise Geryon, Chandon, Orthrus (including Orthrus Deep), and Maenad. The feed gas may be mixed onshore with the Gorgon and/or Jansz–Io feed gas (after the gas mixes through the Inlet Facilities). The GJVs, through this PER/Draft EIS, are also seeking approval for Fourth Train Proposal feed gas to be processed by the Foundation Project LNG trains (prior to the construction of the fourth train, and also when the fourth train is operational). Foundation Project feed gas is also expected to be processed by the Fourth Train Proposal LNG train.

Due to the early stage of project definition and engineering details, the exact locations for some of the Fourth Train Proposal infrastructure have not yet been determined by the GJVs. Design or construction options that are being investigated by the GJVs are described in this PER/Draft EIS, where relevant, to outline the scope of works required for environmental impact assessment in later sections of this document. Additional detailed design and construction information, where relevant, will be provided by the GJVs in subsequent Environmental Management Plans and Subsidiary Documents.

Development Alternatives

During the preparation of this PER/Draft EIS, a number of alternatives to the Fourth Train Proposal were considered, taking into account the advantages and disadvantages of each alternative; these are summarised in Table ES-3.

Table ES-3: Comparison of Alternatives to the Fourth Train Proposal

	Alternative considered	Advantages	Disadvantages
Developing the gas resource	Using existing gas processing facilities in the Pilbara Region	• Reduces the requirement for new infrastructure and overall footprint • Synergies can reduce emissions, discharges, and wastes • Economies of scale and synergies	• Existing pipelines do not have the capacity to transfer the gas • Incompatible commercial arrangements
	New location in the Pilbara Region	• Avoids additional potential environmental impacts on Barrow Island and the surrounding marine environment • May result in higher levels of emissions, discharges, and wastes when compared to the Fourth Train Proposal	• New infrastructure required, potentially creating a greater net environmental impact • Additional social impacts • Inability to use the Carbon Dioxide Injection System on Barrow Island

	Alternative considered	Advantages	Disadvantages
Defer or not develop	Defer until Foundation Project has capacity	• Reduces requirement for new infrastructure and overall footprint • Economies of scale and synergies	• Economic benefits to the region, State, and Commonwealth will be delayed • Inability to capitalise on the availability of experienced workers created by the Foundation Project
	No development of the gas resource	• Eliminates additional potential environmental impacts to Barrow Island and the surrounding marine environment	• Loss of economic benefits to the nation, State, and the Pilbara Region that would increase general economic growth and sustain regional development • Loss of job opportunities and business/service income to support the construction activities and the loss of government revenue

An evaluation of the environmental, social, and economic advantages and disadvantages of the above alternatives concluded that the Fourth Train Proposal, which includes the construction of a new Offshore Feed Gas Pipeline System and an additional LNG processing train within the Foundation Project Gas Treatment Plant, was the preferred alternative.

The Fourth Train Proposal has the potential to create considerable economic benefits for Australia. As a brownfield development, the Fourth Train Proposal has the ability to create synergies with the Foundation Project that could potentially result in a lower net environmental impact than the other development options presented above. The Fourth Train Proposal is also the most cost-competitive option of the development options discussed and the commercial agreements already in place are the most compatible for developing the gas fields in the Greater Gorgon Area.

Development Timeline

The major construction activities for the Fourth Train Proposal are expected to take approximately five years to complete. Additional Fourth Train Proposal gas fields will be developed to maintain the supply of gas into the Gas Treatment Plant. It is expected that drilling additional wells and construction tie-backs to the Feed Gas Pipeline via intrafield flowlines will take approximately two to three years per gas field.

Construction of the Fourth Train Proposal may be conducted in stages; in particular, gas fields included in the Fourth Train Proposal and associated infrastructure may be developed to support the three-train Foundation Project before construction of the fourth LNG train begins.

If the Fourth Train Proposal is implemented as a staged development to provide additional gas for the three-train Foundation Project, the required infrastructure (including the wells and control umbilical) is expected to take an extra three years (approximately) to construct. If the additional LNG Tank is required and if it is constructed independently of other works within the Gas Treatment Plant, this construction is expected to take approximately four years.

The production life of the Fourth Train Proposal will fall within the first long-term lease period of 60 years allowed under the State Agreement. When the Combined Gorgon Gas Development is no longer operationally viable, it will be decommissioned. Individual equipment may be decommissioned before this time, although re-use and recycling alternatives will be considered before decommissioning. The GJVs will adopt the best management practices in environmental management in place at the time of decommissioning.

Stakeholder Engagement

Stakeholder engagement for the Fourth Train Proposal has built upon the stakeholder engagement program that already exists for the Foundation Project. Stakeholder engagement for the Fourth Train Proposal has been undertaken with a range of participants from government, industry, and community groups.

The purpose of this ongoing consultative process is to:

- inform stakeholders about the Fourth Train Proposal by providing accurate and accessible information
- provide adequate opportunities and time frames for stakeholders to consider the Fourth Train Proposal and to engage in meaningful dialogue
- identify and attempt to resolve potential issues
- consider and address issues raised by stakeholders and provide feedback
- ensure alignment between the Fourth Train Proposal and Foundation Project stakeholder engagement activities
- consider stakeholder views in planning future engagement.

Stakeholder views and comments received to date have been reflected in the preparation of this PER/Draft EIS. This PER/Draft EIS will be available for public review for a period of eight weeks, during which time public submissions will be sought. The Commonwealth Department of the Environment (DotE) and the Western Australian Environmental Protection Authority (EPA) will assess the PER/Draft EIS following receipt of public submissions and Chevron Australia's response to those submissions, before reporting to the relevant Ministers for a final decision on whether the Fourth Train Proposal should be approved and, if so, under what conditions. Comments from government agencies and from the public will assist the EPA to prepare an assessment report in which it will make recommendations to government. DotE will also be informed by comments on the PER/Draft EIS and will prepare a separate assessment report for the Commonwealth Minister for Environment.

Existing Environment

Location

The Fourth Train Proposal Area is the area within which primary activities for the Fourth Train Proposal will be undertaken. The Fourth Train Proposal Area is located off the Pilbara coast in WA, approximately 1200 km north of Perth and 120 km west-south-west of Dampier. Barrow Island is located on the eastern side of the Fourth Train Proposal Area, approximately 70 km off the Australian mainland. The terrestrial component of the Fourth Train Proposal will be located on Barrow Island and largely contained within the Foundation Project footprint.

Climate

Barrow Island experiences an arid subtropical climate. Summer (September to April) is characterised by high temperatures (20 to 34 °C), high humidity, and winds predominantly from the west and south-west. Winter (May to August) is characterised by moderate temperatures (17 to 26 °C), fine weather, and predominantly strong east to south-east winds. The mean annual rainfall on Barrow Island is 306 mm, which is greatly influenced by rain-bearing low-pressure systems, thunderstorms, and tropical cyclone activity. The Pilbara

Region experiences an average of five tropical cyclones per year, with an average of two per year passing through the Barrow Island area.

Terrestrial Environment

Barrow Island is approximately 25 km long and 10 km wide, and covers an area of approximately 23 500 ha. Barrow Island is a geological extension of the Cape Range Peninsula; it separated from mainland Australia as a result of rising sea levels between 8000 and 10 000 years ago.

Five landscape units have been identified on Barrow Island. The western side of Barrow Island is characterised by steep valleys, escarpments, and exposed limestone ridges. The eastern coastline is characterised by vegetated sand dunes and expansive tidal flats.

There are no permanent creeks on Barrow Island. Seeps along the west coast provide the only permanent source of surface water. There are a number of aquifers beneath Barrow Island—a shallow unconfined aquifer and several saline aquifers.

Barrow Island is a Class A Nature Reserve for the protection of flora and fauna gazetted under the *Land Administration Act 1997* (WA) and regulated through the *Conservation and Land Management Act 1984* (WA). The flora of Barrow Island is relatively diverse and representative of flora found in the arid Pilbara Region and Cape Range area. A total of 825 vegetation associations have been identified on Barrow Island, none of which are ecological communities listed under the EPBC Act or Threatened Ecological Communities (TECs), as listed in the Western Australian Department of Parks and Wildlife (DPaW) TEC Database. Two vegetative Priority 1 Ecological Communities have been identified on Barrow Island.

A total of 376 plant taxa have been recorded on Barrow Island, none of which are listed as threatened flora under the EPBC Act, and/or listed as Declared Rare Flora under the *Wildlife Conservation Act 1950* (WA). Three Priority Flora Species have been recorded on Barrow Island.

Thirty-three Non-Indigenous Terrestrial plant taxa have been recorded on Barrow Island, six of which are native introductions. None of these introduced plant species are listed as Weeds of National Significance or Declared Plants under the *Agricultural and Related Resources Protection Act 1976* (WA). There is no evidence of Non-indigenous Terrestrial Species establishing on Barrow Island as a result of the approved Foundation Project.

Barrow Island is an important refuge for native fauna, hosting 110 vertebrate species (51 bird species, 15 mammal species, two bat species, 43 reptile species, and one frog species). Eight of these vertebrate species are protected under the EPBC Act and/or *Wildlife Conservation Act 1950* (WA).

Barrow Island is recognised as being of high conservation significance for subterranean fauna communities. The subterranean fauna that occurs on Barrow Island is listed by the DEC as a Priority 1 Ecological Community. A total of 19 troglofauna and 63 stygofauna taxa have been recorded on Barrow Island. Eleven of these species are protected, or treated as protected for assessment purposes, under the EPBC Act and/or *Wildlife Conservation Act 1950* (WA).

Coastal and Marine Environment

Barrow Island is situated in the North-west Marine Region, which is divided into six bioregions by the Commonwealth Government. The North-west Marine Region is made up of numerous habitats, biological communities and ecosystems, and is characterised by high species-richness due to the diversity of marine habitats available, although productivity of the area is generally considered low and associated with boom and bust cycles driven by cyclones.

Barrow Island and its surrounding waters are part of the Montebello, Lowendal, and Barrow Islands group, which has been gazetted as the Montebello–Barrow Island Marine Conservation Reserves, except for the Barrow Island Port and Varanus Port. Ecological and social values have been defined for the Conservation Reserves to facilitate the conservation of marine biodiversity and to provide a framework to sustainably manage human activities in the area.

The marine fauna surrounding Barrow Island is highly diverse, and includes both tropical and subtropical species that are found in other parts of the Indian Ocean and the western Pacific Ocean. Species listed as Threatened and/or Migratory under the EPBC Act and/or protected under the *Wildlife Conservation Act 1950* (WA) are known to be present in the waters around Barrow Island and include Whale Sharks, sawfish, Dugongs, Humpback Whales, marine turtles, sea snakes, and a number of marine and migratory birds. Barrow Island is also noted for its regional importance for nesting Green Turtles and Flatback Turtles, with the Green Turtle population being considered an important proportion of the North West Shelf genetic stock. The Commonwealth Government has identified a number of Biologically Important Areas in the North-west Marine Region. Biologically Important Areas host protected species that may display biologically important behaviours such as breeding, foraging, resting, or migration.

The nearshore environment of Barrow Island is characterised by limestone pavement covered in places with a thin veneer of unconsolidated sediment and varying densities of macroalgal assemblages. A dense macroalgal assemblage dominates the subtidal pavement off the west coast of Barrow Island in the vicinity of North Whites Beach, with seagrass and coral colonies rarely present. On the east coast, the broad limestone pavement has been partially disturbed by construction activities associated with the Foundation Project and is sparsely colonised by macroalgal assemblages and scattered hard and soft corals, which increase in size and density along the edge of the pavement. Deepwater habitats in the Fourth Train Proposal Area are generally characterised by soft sediments displaying low species-richness and abundance, which is typical of other deepwater habitats observed on the North West Shelf.

Social, Cultural, and Economic Environment

Barrow Island has been actively used for petroleum exploration and production purposes since 1967. Access is restricted to a fly-in, fly-out workforce that is associated with the Foundation Project, DEC activities, and Chevron Australia WA Oil Asset (WA Oil).

Barrow Island is located within the Shire of Ashburton in the Pilbara Region of WA. Three nautical miles west of Barrow Island, the sea comes under Commonwealth jurisdiction for a further 200 nautical miles. The State Waters and the Commonwealth Marine Area surrounding Barrow Island support a number of uses, including commercial and recreational fishing, tourism, shipping, and oil and gas projects.

On Barrow Island there are 17 Aboriginal heritage places listed on the WA Department of Aboriginal Affairs' Register of Aboriginal Sites, all of which are artefact scatter except for one rock shelter. No ethnographic sites are listed. To date, surveys conducted within the Foundation Project footprint and Fourth Train Proposal Footprint with local Aboriginal representatives, have not identified any ethnographic or historical sites.

The waters surrounding the Onslow/Barrow Island region are known to contain a number of lugger shipwreck sites, including the earliest known shipwreck of European origin (*The Trial*, located approximately 45 km north of Barrow Island) within Australian waters. The Materials Offloading Facility and the shore area adjacent to the Foundation Project Gas Treatment Plant site has been examined by a marine heritage expert, and surveys have been conducted along the Foundation Project pipeline route for the Offshore Feed Gas Pipeline Installation Management Plan. Neither assessment has revealed any shipwreck material.

Australia's abundant natural resources (such as coal, iron ore, copper, gold, natural gas, uranium, and renewable energy sources) attract a high level of foreign investment. The resources sector is one of the major contributors to the national and State economies. The dominance of the resources sector directly and indirectly impacts the services sector, which is the largest employer in WA.

Emissions, Discharges, and Wastes

The Fourth Train Proposal is not predicted to produce any different sources of emissions, discharges, and wastes when compared to the Foundation Project. However, the Fourth Train Proposal will result in an incremental increase in emissions and volumes of discharges and wastes.

Atmospheric Emissions

Baseline artificial sources of atmospheric emissions on Barrow Island include the WA Oil operations and the Foundation Project. Atmospheric emissions may occur over the life of the Fourth Train Proposal, and emissions sources are expected to include flaring during drilling and completion of offshore wells, flaring and acid gas venting from the Gas Treatment Plant, and emissions from power generation equipment and transport.

Atmospheric modelling was undertaken for both routine and non-routine operations to determine the dispersion of significant emissions and the impacts to ambient air quality from the Fourth Train Proposal.

Modelling of atmospheric pollutants on a local and regional scale indicated that atmospheric pollutants would not exceed ambient air criteria, as defined by the National Environment Protection (Ambient Air Quality) Measure. Modelling was also undertaken to assess ground-level concentrations of air toxics (including hydrogen sulfide, benzene, toluene, ethylbenzene, and xylene) from acid gas venting at the Gas Treatment Plant during operation of the Fourth Train Proposal and Foundation Project. Results indicated that ground-level concentrations of air toxics would not exceed either occupational or residential criteria at relevant receptors. Deposition rates of atmospheric pollutants (sulfur and nitrogen) at Barrow Island and on the mainland were shown to be an order of magnitude lower than the World Health Organization Guidelines for Air Quality. The modelling studies indicate that the predicted change to the ambient air quality on Barrow Island and in the Pilbara Region from the implementation of the Fourth Train Proposal will be negligible.

Light Emissions

The Fourth Train Proposal is not expected to result in different types of light emission sources compared to the Foundation Project, but is expected to emit additional light including from increased flaring events, an increased number of luminaires, and an increase in marine vessel export frequency.

During construction, offshore sources of light from the Fourth Train Proposal will include marine vessels involved in construction activities, such as drilling rigs, pipe-lay barges, tugs, module carriers, and logistics vessels. Onshore sources of light during construction include mobile light towers, construction vehicles and construction facilities at the horizontal directional drilling site and Gas Treatment Plant, and Butler Park (Construction Village). The light emissions from Fourth Train Proposal construction activities will be short term.

During the commissioning and operations of the Fourth Train Proposal, light will be generated from lighting at the Gas Treatment Plant, flaring and infrastructure, shipping and associated marine support vessels, and additional lighting at Butler Park (Construction Village). Flaring will occur from the Foundation Project Ground Flare and Boil-off Gas Flare, and from the additional Boil-off Gas Flare that may be required for the Fourth Train Proposal. If installed, this additional Boil-off Gas Flare will be constructed as an enclosed flare to manage light spill. The Fourth Train Proposal is expected to increase the frequency of LNG and condensate shipments and logistics shipments to and from Barrow Island, resulting in an incremental increase in the frequency and/or duration of light emissions from the LNG Jetty and at the Materials Offloading Facility.

Light spill modelling was undertaken to determine the effects of light spill on sensitive environmental receptors. The modelling included the operational Foundation Project together with an operational Fourth Train Proposal on Barrow Island. The light spill modelling of the Fourth Train Proposal, in addition to the approved Foundation Project, predicted very low levels of illuminance at sensitive environmental receptors, including Bivalve Beach.

Noise and Vibration

Sources of marine noise during offshore construction activities include marine vessel activity, drilling, and pipe-laying. The frequency and intensity of the noise generated will depend on the marine vessels used and the activity being conducted, but it is expected that the Fourth Train Proposal offshore construction noise emissions profile and intensity will be similar to the baseline noise emissions from the existing and approved oil and gas construction activities in the area. Offshore construction activities associated with the Fourth Train Proposal are expected to be intermittent and short term.

Onshore artificial noise and vibration emissions may arise from construction activities such as blasting, trenching, power generation, and the transportation of personnel and materials. Onshore noise and vibration emissions due to the construction of the Fourth Train Proposal are expected to be less than those generated during the construction of the Foundation Project; many of the construction activities proposed are similar to those of the Foundation Project, although on a smaller scale. The Fourth Train Proposal will extend the duration of most construction activities on Barrow Island and therefore extend the duration of noise emissions from those construction activities.

During operations, marine noise is expected from operational shipping activities and maintenance of offshore infrastructure. Operational offshore noise emissions will either be low level during routine operations, or intermittent in the case of non-routine operations. Onshore, the dominant source of operational noise from the Fourth Train Proposal on Barrow Island is expected to be the Gas Treatment Plant. Noise modelling predicted that the combined levels of noise generated at Butler Park (Construction Village) when the Foundation Project and Fourth Train Proposal were both in operation was below the noise level criteria set under the WA Environmental Protection (Noise) Regulations 1997.

Discharges to Land and Water

The Fourth Train Proposal will have similar discharge types to land and water as the Foundation Project, with only a small increase in volume. A number of potential discharge sources from the construction and operation of the Fourth Train Proposal were identified, including marine vessels, horizontal directional drilling activities, reverse osmosis facilities, and sanitary wastewater systems (Table ES-4).

Table ES-4: Potential Discharges to Land and Water from the Construction and Operation of the Fourth Train Proposal

Activity Type	Activity or Discharge Source	Indicative Discharge Type
Construction	Marine vessels	Ballast water, deck drainage, macerated food waste, greywater, reverse osmosis reject brine, and cooling water
	Production well drilling and completion	Drilling fluids and drilling cuttings, completion brine
	Horizontal directional drilling activities	Drilling cuttings and fluids
	Reverse osmosis facilities	Reverse osmosis reject brine
	Sanitary wastewater systems	Treated effluent from sanitary wastewater systems
	Hydrotesting of pipelines and Gas Treatment Plant elements	Hydrotest water

Activity Type	Activity or Discharge Source	Indicative Discharge Type
Operations	Marine vessels	Ballast water, deck drainage, macerated food waste, greywater, reverse osmosis reject brine, and cooling water
	Reverse osmosis facilities	Reverse osmosis reject brine
	Gas Treatment Plant	Produced formation water, glycol solution, and stormwater drainage
	Sanitary wastewater systems	Treated effluent from sanitary wastewater systems

Discharges from offshore drilling activities will include low-toxicity water-based drilling fluids and drilling cuttings. Should non-aqueous drilling fluids be used for the production wells, the drilling fluids will be recovered and drilling cuttings will be treated to reduce the volume of synthetic fluid entrained on the cuttings prior to their discharge. Other discharges from offshore drilling activities may include products used for wellbore clean-up, completion, and well testing (such as excess cement and completion brine).

Hydrotest water will be produced from the pre-commissioning of the Feed Gas Pipeline System, intrafield flowlines, and facilities within the Gas Treatment Plant, such as the third LNG Tank (if required). It is expected that any chemical additives required during hydrotesting will be biodegradable and a hierarchy of disposal options will be applied to the management and disposal of hydrotest water.

The Fourth Train Proposal plans to dispose of produced formation water, contaminated drainage, and treated effluent from sanitary wastewater systems generated on Barrow Island via deep well injection into the Flacourt and Malouet Formations, at a depth of approximately 1500 m. Disposal will be via the approved Foundation Project deep injection wells. Investigations have predicted that the subsurface formations are able to safely accommodate the increased volumes of the Fourth Train Proposal deep well injection discharges.

Solid and Liquid Wastes

The Fourth Train Proposal is expected to generate similar waste streams as the Foundation Project, although a number of waste streams that occurred in the construction of the Foundation Project (e.g. waste associated with the dredging program and construction of the Materials Offloading Facility and the LNG Jetty) will not occur in the Fourth Train Proposal, due to the difference in work scopes.

The construction waste generated by the Fourth Train Proposal is expected to be approximately less than one-third of the waste anticipated for the Foundation Project. Operation of the Fourth Train Proposal is expected produce a higher proportion of hazardous solid and liquid waste streams than during construction. However, the Fourth Train Proposal is not expected to produce different hazardous or controlled wastes compared to those approved for the Foundation Project.

Solid and liquid waste streams generated during the construction and operation of the Fourth Train Proposal will include:

- general waste (e.g. scrap metals, waste concrete, excess spoil)
- solid hazardous or controlled waste (e.g. medical/sanitary wastes, contaminated soil, contaminated sludge from the Gas Treatment Plant)
- liquid hazardous or controlled waste (e.g. contaminated drilling waste from horizontal directional drilling, waste from wastewater treatment facilities, bilge water)
- quarantine risk material (e.g. marine vessel ballast water, soil and plant material found on personnel, kitchen wastes).

Waste generated during Fourth Train Proposal activities will be managed through the hierarchical process of:

1. source reduction
2. re-use
3. recycle/recovery
4. treatment
5. responsible disposal.

Where it is necessary to treat or dispose of Fourth Train Proposal wastes on the mainland, it is expected that appropriate wastes will be sent to a Chevron Australia-approved and appropriately licensed landfill facility on the mainland for recycling, treatment, or disposal.

Accidental Releases (Spills and Leaks) to the Marine Environment

Accidental releases (spills and leaks) to the marine environment may result from offshore components of the Fourth Train Proposal, including well blowouts, rupture of the Feed Gas Pipeline System, spills or leaks from subsea infrastructure (including intrafield flowlines and cluster manifolds), marine vessel incidents (including grounded vessels), and incidents at the Materials Offloading Facility. However, the probability of a large-scale spill or leak occurring is predicted to be very low.

Materials that have the potential to be unintentionally released include production fluids (gas, condensate, and produced water), diesel, monoethylene glycol, and hydraulic fluids.

Hydrocarbon spill modelling was undertaken for the Fourth Train Proposal to determine the fate and transport of hydrocarbons spilled to the marine environment. The modelling was conducted over different seasons to account for the seasonality of meteorological conditions including ocean currents and weather patterns, as these factors affect the extent and potential impact of a hydrocarbon spill.

Note: Hydrocarbon spill modelling assumed that no intervention to contain the spill had occurred. Therefore, the modelling outputs are considered by Chevron Australia to reflect the worst-case probabilities for each spill scenario. Chevron Australia has comprehensive management measures in place for the prevention of hydrocarbon pollution including EMPs and Subsidiary Documents; however, the effects of the hydrocarbon spill response was not taken into account in the hydrocarbon spill modelling study.

The hydrocarbon spill modelling study related to the implementation of the Fourth Train Proposal indicates that there is a very low probability of spills and leaks reaching environmentally sensitive areas above threshold concentration levels.

Assessment Method

The Fourth Train Proposal is an expansion of the approved Foundation Project; as such, key components of the Fourth Train Proposal, including its design and proposed approaches to construction and operation, are largely the same as elements of the Foundation Project. The identification of potential impacts from the Fourth Train Proposal was informed by the various environmental impact assessment studies completed for the Foundation Project and technical studies completed for the Fourth Train Proposal.

The approach to assessing the potential impacts of the Fourth Train Proposal commenced with the scoping phase, which involved identifying relevant activities, environmental stressors and factors, the preliminary identification of potential incremental and additional impacts, and establishing the assessment framework. Incremental impacts refer to the *change* in emissions, discharges, wastes, impacts, likelihood, and risk due to the implementation of the Fourth Train Proposal from that of the Foundation Project. Additional impacts refer to the *total* emissions, discharges, wastes, impacts, likelihood, and risk due to the Fourth Train

Proposal when added to that of the approved Foundation Project. The term 'potential impact' has been used to capture relevant, likely, direct, indirect, and facilitated impacts, as required by the Tailored Guidelines issued by the Department of Sustainability, Environment, Water, Population and Communities Environment, Water, Population (SEWPaC) in 2011 .

The scoping phase culminated with the finalisation of the Environmental Scoping Document for the Fourth Train Proposal, which was approved by the EPA in May 2012. In addition, SEWPaC issued a set of Tailored Guidelines for the preparation of a Draft EIS for the Fourth Train Proposal; these Guidelines establish the required scope of the assessment to address EPBC Act requirements.

Following approval of the Environmental Scoping Document, the assessment phase of the Fourth Train Proposal involved a more detailed prediction and assessment of potential impacts. This assessment phase included the results of predictive modelling and technical studies, monitoring results from the Foundation Project, and research results. Potential impacts were based on worst-case scenarios and any potential overlap between the construction of the Fourth Train Proposal and Foundation Project.

Potential Impacts

The key potential impacts resulting from the Fourth Train Proposal are summarised for the terrestrial environment in Table ES-5, the coastal and nearshore environment in Table ES-6, and the social, cultural, and economic environment in Table ES-7.

When compared to the Foundation Project, it is expected that the Fourth Train Proposal will not result in any different impacts to the environmental or social values of Barrow Island or its surrounding waters.

Mitigation and Management Measures

To ensure that the potential impacts of the Fourth Train Proposal are effectively managed, the GJVs intend to adopt the same impact mitigation and management measures as committed to and implemented by the Foundation Project where their activities and designs are alike. The illustrative mitigation and management measures proposed to be applied to the Fourth Train Proposal are outlined in:

- Table ES-5 for the terrestrial environment
- Table ES-6 for the coastal and nearshore environment
- Table ES-7 for the social, cultural, and economic environment.

The development of mitigation and management measures for the Foundation Project, which are intended to be used for Fourth Train Proposal, follows a hierarchical approach to managing potential impacts:

1. avoidance at source (i.e. removing the source of impact)
2. abatement at source (i.e. reducing the source of potential impact)
3. attenuation (i.e. reducing the potential impact between the source and the receptor)
4. abatement at receptor (i.e. reducing the potential impact at the receptor)
5. remediation (i.e. repairing the damage after it has occurred).

The selection of illustrative mitigation and management measures for the Fourth Train Proposal also reflects the objects of the EPBC Act, the principles for ecologically sustainable development (Section 3A of the EPBC Act), and the EPA's Environmental Principles, where relevant.

Table ES-5: Summary of Potential Impacts, Mitigation and Management Measures, and Predicted Environmental Outcomes for the Terrestrial Environment

Factor	Objectives	Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures[1]	Predicted Outcomes
Soils and landforms	To maintain the integrity, ecological functions, and environmental values of soils and landforms	***Vegetation clearing and earthworks*** • Removal of approximately 0.45% of Barrow Island's sand dunes (3.5 ha) during construction of the horizontal directional drilling site • Exposure of soils at the Fourth Train Proposal horizontal directional drilling site, delay to Foundation Project reinstatement activities (e.g. at the Additional Support Area), re-clearing of Foundation Project land that has been reinstated (e.g. along the Foundation Project Feed Gas Pipeline Systems footprint and the Foundation Project horizontal directional drilling site), may result in short-term, localised erosion • The Fourth Train Proposal may require approximately 100 ha of earthworks on previously cleared sites within the Gas Treatment Plant site, Foundation Project Additional Support Area, horizontal directional drilling site, and Feed Gas Pipeline Systems footprint, and up to approximately 10 ha of vegetation clearing and earthworks at the Fourth Train Proposal horizontal directional drilling site. Earthworks may result in compaction, and/or changes to the soil profile, although impacts at the Gas Treatment Plant site and Foundation Project horizontal directional drilling site and Additional Support Area will be reduced as the ground has been disturbed previously.	• Terrestrial and Subterranean Environment Protection Plan and associated Procedures • Horizontal Directional Drilling Management and Monitoring Plan • Solid and Liquid Waste Management Plan • Post-Construction Rehabilitation Plan and associated sub-Plan	• Construction impacts from clearing and earthworks are predicted to be largely short term and localised • Operations phase impacts from spills and leaks are expected to be localised and mostly contained through design and management controls • Potential impacts are not predicted to affect the integrity, ecological functions, or environmental values of soils and landforms

[1] Extension of the relevant mitigation and management measures as applied to the approved Foundation Project in the listed EMPs. These EMPs may require minor amendments to ensure they also apply to the relevant activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal horizontal directional drilling activities, locations, and potential impacts will also need to be prepared and approved.

Factor	Objectives	Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures[1]	Predicted Outcomes
		Spills and leaks • Additional volumes of hazardous materials will be stored, transported, and used, which may result in localised short-term soil contamination in the event of a spill or leak		
Surface water and groundwater	To maintain the quantity and quality of water so that existing and potential environmental values, including ecosystem function, are protected To reduce the potential for erosion due to stormwater flow	***Spills and leaks*** • Additional volumes of hazardous materials will be stored, transported, and used, which has the potential to result in short-term localised contamination of surface and groundwater in the event of a spill or leak. ***Physical presence of infrastructure*** • The presence of additional hardstand areas at the Gas Treatment Plant site and Fourth Train Proposal horizontal directional drilling site has the potential to result in localised alterations to infiltration and natural drainage patterns	• Terrestrial and Subterranean Environment Protection Plan and associated Procedures • Terrestrial and Subterranean Environmental Monitoring Program • Horizontal Directional Drilling Management and Monitoring Plan • Solid and Liquid Waste Management Plan • Post-Construction Rehabilitation Plan and associated sub-Plan	• Potential impacts to surface water and groundwater during construction and operations are predicted to remain localised • Potential impacts are not predicted to affect environmental values, including ecosystem function
Terrestrial flora and vegetation communities, including restricted flora	To maintain the abundance, diversity, geographic distribution, and productivity of flora at species and ecosystems levels through the avoidance or management of adverse impacts and improvement in knowledge To protect Declared Rare and Priority Flora, consistent with the provisions of the *Wildlife Conservation Act 1950* (WA)	***Vegetation clearing and earthworks*** • Additional clearing of up to (approximately) 10 ha of previously uncleared land at the Fourth Train Proposal horizontal directional drilling site, which will result in short-term localised loss of vegetation and flora species. This includes partial clearing of five conservation-significant vegetation associations, including one association containing more than 2% cover of the flora species *Erythrina vespertilio*, which has a restricted distribution on Barrow Island • Delay to Foundation Project reinstatement activities (e.g. at the Additional Support Area), re-clearing of Foundation Project land that has been reinstated (e.g. along the Foundation Project Feed Gas Pipeline Systems footprint and the Foundation Project horizontal directional drilling site)	• Terrestrial and Subterranean Environment Protection Plan and associated Procedures • Terrestrial and Subterranean Environment Monitoring Program • Fire Management Plan • Horizontal Directional Drilling Management and Monitoring Plan • Air Quality Management Plan • Solid and Liquid Waste Management Plan • Post-Construction Rehabilitation Plan and associated sub-Plan	• The potential impacts to vegetation and flora during construction and operations are not expected to result in a widespread or long-term decrease in abundance of flora or impact the vegetation community structure • Potential impacts are not predicted to affect the abundance, diversity, geographic distribution, and/or productivity of flora at species and/or ecosystems levels

Factor	Objectives	Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures[1]	Predicted Outcomes
		Fire • Additional construction activities, increasing the time within which higher fire-risk activities will take place more frequently		
Terrestrial fauna, including protected species	To maintain the abundance, diversity, geographic distribution, and productivity of fauna at species and ecosystem levels through avoidance or management of adverse impacts and improvement of knowledge To protect Specially Protected (Threatened) Fauna, consistent with the provisions of the *Wildlife Conservation Act 1950* (WA) To protect EPBC Act-listed Threatened and Migratory species	***Vegetation clearing and earthworks*** • Additional clearing of up to (approximately) 10 ha of previously uncleared land at the Fourth Train Proposal horizontal directional drilling site, which will result in the direct disturbance of additional habitat as compared to the Foundation Project. This clearing may lead to short-term localised displacement of fauna and/or increased competition • The Fourth Train Proposal will also result in a delay to Foundation Project reinstatement activities (e.g. at the Additional Support Area), and may require re-clearing of Foundation Project land that has been reinstated (e.g. along the Foundation Project Feed Gas Pipeline Systems footprint or the Foundation Project horizontal directional drilling site) ***Fire*** • Additional construction activities, increasing the time within which higher fire-risk activities will take place more frequently, potentially affecting fauna habitat ***Physical interaction*** • Additional construction activities and associated vehicle movements, machinery use, and site excavations could result in injury or mortality to fauna individuals ***Noise and vibration*** • Operations noise may create changes in behaviour or mask terrestrial fauna communication in the vicinity of the Gas	• Terrestrial and Subterranean Environment Protection Plan and associated Procedures • Terrestrial and Subterranean Environment Monitoring Program • Fire Management Plan • Horizontal Directional Drilling Management and Monitoring Plan • Air Quality Management Plan • Long-term Marine Turtle Monitoring Plan • Solid and Liquid Waste Management Plan • Post-Construction Rehabilitation Plan and associated sub-Plan	• Potential construction and operations impacts are predicted to be localised, which may result in the potential loss of individuals; however, impacts to population viability are not predicted • Potential impacts are not predicted to affect the abundance, diversity, geographic distribution, and/or productivity of terrestrial fauna at species and/or ecosystems levels. Conservation-significant fauna are considered protected in line with the EPBC Act and the *Wildlife Conservation Act 1950* (WA)

Factor	Objectives	Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures[1]	Predicted Outcomes
		Treatment Plant		
Subterranean fauna, including protected species	To maintain the abundance, diversity, geographic distribution, and productivity of fauna at species and ecosystem levels through avoidance or management of adverse impacts and improvement of knowledge To protect Specially Protected (Threatened) Fauna, consistent with the provisions of the *Wildlife Conservation Act 1950* (WA)	***Spills and leaks*** Additional volumes of hazardous materials will be stored, transported, and used, which has the potential to result in contamination of subterranean fauna habitat, including groundwater, in the event of a spill or leak ***Unplanned carbon dioxide migration*** The Fourth Train Proposal is not expected to introduce any different uncertainties associated with CO_2 injection, compared to those assessed for the Foundation Project. Given the current measures to mitigate risks associated with unplanned CO_2 migration, it is considered highly unlikely that such a situation would eventuate over the life of the project	• Terrestrial and Subterranean Environment Protection Plan and associated Procedures • Terrestrial and Subterranean Environment Monitoring Program • Short Range Endemics and Subterranean Fauna Monitoring Plan • Solid and Liquid Waste Management Plan • Post-Construction Rehabilitation Plan and associated sub-Plan • Carbon Dioxide Injection System Monitoring Program	• Potential construction and operations impacts are predicted to be localised, resulting in the potential loss of individuals; however, impacts to population viability are not predicted • There is no evidence of large caves or other large-scale geomorphological features that might create barriers to gene flow between the Fourth Train Proposal Footprint and adjacent habitats on Barrow Island • Potential impacts are not predicted to affect the abundance, diversity, geographic distribution, and productivity of subterranean fauna at species and/or ecosystem levels, including conservation-significant species

Table ES-6: Summary of Potential Impacts, Mitigation and Management Measures, and Predicted Environmental Outcomes for the Coastal and Nearshore Environment

Factor	Objectives	Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures[2]	Predicted Outcomes
Foreshore	To maintain the integrity, ecological functions, and environmental values of the soil and landform of the coast	***Spills and leaks*** Potential for a spill and/or leak to occur resulting from additional infrastructure and marine vessels, which has the potential to impact sediment quality of the foreshore area. The level of potential impact is highly dependent on the hydrocarbon type, spill location, and prevailing weather conditions	• Horizontal Directional Drilling Management and Monitoring Plan • Offshore Feed Gas Pipeline Installation Management Plans • Marine Environmental Quality Management Plan • Coastal Stability Management Plan • Post-Construction Rehabilitation Plan and associated sub-Plan • Subsidiary Documents developed for the implementation of the Fourth Train Proposal, including: ▪ Commonwealth Environment Plans (and Oil Spill Contingency Plans) ▪ State Environment Plans (and Oil Spill Contingency Plans)	• The potential exists to impact the integrity of the foreshore through contamination of sediments via a spill or leak. The probability that a spill or leak will occur and that extensive areas above Mean High Water Springs will be impacted is considered unlikely • Potential impacts are not predicted to affect foreshore integrity, ecological functions, and environmental values of the soil and landforms of the coast
Seabed (intertidal and subtidal)	To maintain the integrity, ecological functions, and environmental values of the seabed To protect the environmental values of areas identified as having significant environmental attributes	***Discharges to sea*** Additional discharge sources and an increase in overall volume of discharges when compared to the Foundation Project, which may introduce chemical contaminants, particulates, and nutrients onto the seabed ***Seabed disturbance*** Seabed disturbance may result from horizontal directional drilling activities (on the west coast) and seabed preparation activities (on the east coast) ***Physical presence of infrastructure*** Physical presence of infrastructure off the west coast of Barrow Island may result in a change to	• Horizontal Directional Drilling Management and Monitoring Plan • Marine Facilities Construction Environmental Management Plan • Offshore Feed Gas Pipeline Installation Management Plan • Marine Environmental Quality Management Plan • Reverse Osmosis Brine Disposal Management and Monitoring Plan • Solid and Liquid Waste Management Plan • Subsidiary Documents developed	• Potential impacts to the seabed are predicted to be localised and recovery will occur, except for a small area of substrate lost off the west coast of Barrow Island, which will be replaced with the installation of the Feed Gas Pipeline System. This area is beyond the limestone pavement bedform feature • Potential impacts are not expected to affect the integrity, ecological functions and environmental values of the

[2] Extension of the relevant mitigation and management measures as applied to the approved Foundation Project in the listed EMPs. These EMPs may require minor amendments to ensure they also apply to the relevant activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal horizontal directional drilling activities, locations, and potential impacts will also need to be prepared and approved.

Factor	Objectives	Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures[2]	Predicted Outcomes
		seabed quality through the presence of the Feed Gas Pipeline System and/or through the placement of stabilisation material ***Spills and leaks*** Potential for spills and leaks to occur due to additional marine vessels activity and the presence of additional infrastructure during the construction and operation phases. Spills and leaks may result in the physical or chemical contamination of the intertidal area and/or subtidal areas	for the implementation of the Fourth Train Proposal, including: • Commonwealth Environment Plans (and Oil Spill Contingency Plans) • State Environment Plans (and Oil Spill Contingency Plans)	seabed
Marine water quality	To maintain the quality of marine water so that existing and potential environmental values, including ecosystem functions and integrity of the seabed and the coast, are maintained	***Discharges to sea*** Increase in the number of marine vessel discharge events and overall volume of discharges when compared to the Foundation Project, which may lead to localised changes in water quality Extended duration of operation of the reverse osmosis facility to support the Fourth Train Proposal construction ***Spills and leaks*** In the unlikely event of a substantial spill or leak due to the Fourth Train Proposal, the potential impacts to water quality may include the formation of surface sheens (slicks), and entrained and dissolved hydrocarbons within the water column. Chemicals used for the treatment of spills (e.g. surfactants) also have the potential to impact water quality through changes to chemical and physical characteristics of the receiving water body	• Long-term Marine Turtle Management Plan • Marine Facilities Construction Environmental Management Plan • Horizontal Directional Drilling Management and Monitoring Plan • Offshore Feed Gas Pipeline Installation Management Plan • Marine Environmental Quality Management Plan • Reverse Osmosis Brine Disposal Management and Monitoring Plan • Solid and Liquid Waste Management Plan • Subsidiary Documents developed for the implementation of the Fourth Train Proposal, including: ▪ Commonwealth Environment Plans (and Oil Spill Contingency Plans) ▪ State Environment Plans (and Oil Spill Contingency Plans)	• Given the high-energy environment and dispersive capacities of the receiving environment, water quality changes on the west coast of Barrow Island will be highly localised and short term, and will only occur during construction • Potential impacts are not predicted to affect marine water quality and its relationship to the maintenance of environmental values, ecosystem values, ecosystem functions, and integrity of the seabed

Factor	Objectives	Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures[2]	Predicted Outcomes
Marine fauna	To maintain the abundance, diversity, geographic distribution, and productivity of marine fauna at species and ecosystems levels through the avoidance or management of adverse impacts and improvement in knowledge To avoid, reduce, and/or mitigate against impacts on the ecological functions and environmental values of marine benthic habitats (except benthic primary producer habitats) To protect Specially Protected (Threatened) Fauna consistent with the provisions of the *Wildlife Conservation Act 1950* (WA) To protect EPBC Act-listed Threatened or Migratory species	***Artificial light*** Additional short-term artificial light sources and emissions on the west coast of Barrow Island and additional long-term artificial light emissions on the east coast (from the Gas Treatment Plant site, coastal infrastructure, and vessels) have the potential to affect sensitive marine fauna that rely on visual cues (particularly marine turtles) resulting in behavioural responses ***Discharges to sea*** Additional discharges to sea from marine vessels, drilling (shore crossing), hydrotesting, and the reverse osmosis facility (reject brine) may result in metabolic impacts on individuals in the immediate vicinity, or behavioural responses such as area avoidance ***Physical interaction*** Additional marine vessel movements during the construction and operations phases may increase physical interaction with large, slow-moving marine fauna (turtles in particular) resulting in injury and/or mortality ***Spills and leaks*** Potential for spills and leaks to occur due to additional construction activities and additional marine vessels and infrastructure. Contact (inhalation, ingestion, or adsorption) may result in sublethal (physiological/reduced health) or acute responses (mortality); reductions in reproductive capacity may also occur (particularly in avifauna)	• Long-term Marine Turtle Management Plan • Marine Facilities Construction Environmental Management Plan • Horizontal Directional Drilling Management and Monitoring Plan • Offshore Feed Gas Pipeline Installation Management Plan • Marine Environmental Quality Management Plan • Solid and Liquid Waste Management Plan • Reverse Osmosis Brine Disposal Management and Monitoring Plan • Marine Environmental Quality Management Plan • Solid and Liquid Waste Management Plan • Reverse Osmosis Brine Disposal Management and Monitoring Plan • Subsidiary Documents developed for the implementation of the Fourth Train Proposal, including: ▪ Commonwealth Environment Plans (and Oil Spill Contingency Plans) ▪ State Environment Plans (and Oil Spill Contingency Plans)	• Construction impacts on marine fauna are predicted to be localised • Although potential impacts on individuals may be observed, impacts to the population viability of marine fauna are not anticipated. No impact to the abundance, diversity, or geographic distribution of marine fauna, nor their health status is anticipated. Potential impacts to the population viability of marine species specifically protected by Commonwealth or State legislation are also not expected

Factor	Objectives	Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures[2]	Predicted Outcomes
Benthic Primary Producer Habitats (BPPH)	To maintain the abundance, diversity, geographic distribution, ecological function, and productivity of mangroves, marine macrophytes (seagrass, macroalgae), and corals through the avoidance or management of adverse impacts and improvement in knowledge	***Discharges to sea*** Localised short-term smothering and reduced light attenuation to BPPH (predominantly macroalgal assemblages) off the west coast of Barrow Island, due to construction activities, including horizontal directional drilling ***Spills and leaks*** Potential for spills and leaks to occur due to additional infrastructure and marine vessels, which may impact BPPH through physical (smothering) or chemical (sublethal or lethal toxicity) effects	• Horizontal Directional Drilling Management and Monitoring Plan • Marine Facilities Construction Environmental Management Plan • Offshore Feed Gas Pipeline Installation Management Plan • Marine Environmental Quality Management Plan • Solid and Liquid Waste Management Plan • Reverse Osmosis Brine Disposal Management and Monitoring Plan • Subsidiary Documents developed for the implementation of the Fourth Train Proposal, including: ▪ Commonwealth Environment Plans (and Oil Spill Contingency Plans) ▪ State Environment Plans (and Oil Spill Contingency Plans)	• Construction impacts to BPPH are likely to be short term and localised, and unlikely to result in habitat distribution change, although some small localised degradation or loss may occur • Potential impacts are not predicted to affect the abundance, diversity, geographic distribution, ecological function, and productivity of BPPH

Table ES-7: Summary of Potential Impacts, Mitigation and Management Measures, and Predicted Outcomes for the Social, Cultural, and Economic Environment

Factor	Objectives	Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures[3]	Predicted Outcomes
Workforce and public health and safety	To avoid adverse impacts on the health and/or wellbeing of the workforce and/or public or their access to health care services	***Atmospheric emissions*** Atmospheric emissions from the Fourth Train Proposal have the potential to impact workforce and public health and safety by altering ambient air quality and creating a hazard to human health and wellbeing ***Fire and extreme weather events*** Fire and extreme weather events, including tropical cyclones and thunderstorms, have the potential to impact the workforce ***Physical interaction*** Heightened marine vessel activity during construction has the potential to result in an incident between a Fourth Train Proposal marine vessel and a third-party marine vessel, which could result in injuries to the public or workforce	• Horizontal Directional Drilling Management and Monitoring Plan • Offshore Feed Gas Pipeline Installation Management Plan • Air Quality Management Plan • Best Practice Pollution Control Design Report • Fire Management Plan • Subsidiary Documents developed for the implementation of the Fourth Train Proposal, including: ▪ Commonwealth Environment Plans (and Oil Spill Contingency Plans) ▪ State Environment Plans (and Oil Spill Contingency Plans)	• Potential impacts are not predicted to affect the health and/or wellbeing of the workforce and/or public or their access to health care services
Cultural heritage	To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and that they comply with relevant heritage legislation	***Vegetation clearing and earthworks*** The Fourth Train Proposal will result in additional vegetation clearing, which may result in the inadvertent discovery of undetected buried cultural heritage material ***Spills and leaks*** Construction activities at the horizontal directional drilling site will result in an additional period during which spills and leaks could occur in the vicinity of a cultural heritage site ***Seabed disturbance*** Installation of the offshore Feed Gas Pipeline System will result in new geographic areas of seabed being disturbed, which may result in	• Horizontal Directional Drilling Management and Monitoring Plan • Offshore Feed Gas Pipeline Installation Management Plan • Aboriginal Cultural Heritage Management Plan • Subsidiary Documents developed for the implementation of the Fourth Train Proposal, including: ▪ Commonwealth Environment Plans (and Oil Spill Contingency Plans) ▪ State Environment Plans (and Oil Spill Contingency Plans)	• Prior to commencement of construction activities, Chevron Australia will ensure that the area has been surveyed for Aboriginal cultural heritage sites so that the sites can be identified and avoided • Potential impacts to cultural heritage are expected to be localised and are largely restricted to during construction • Potential impacts are not predicted to result in changes to the biophysical environment that would adversely affect historical and cultural associations

[3] Extension of the relevant mitigation and management measures as applied to the approved Foundation Project in the listed EMPs. These EMPs may require minor amendments to ensure they also apply to the relevant activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal horizontal directional drilling activities, locations, and potential impacts will also need to be prepared and approved.

Factor	Objectives	Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures[3]	Predicted Outcomes
		physical contact with an unknown shipwreck site		
Conservation areas	To protect the social values of areas identified as having significant environmental and/or heritage attributes	***Physical interaction*** Components of the Fourth Train Proposal may result in physical interaction with visitors who may be accessing the conservation areas for their social values ***Physical presence of infrastructure*** The presence of the Fourth Train Proposal may impact on the visual amenity and aesthetic values of Barrow Island and restrict movements of visitors who may be accessing the conservation areas for their social values ***Spills and leaks*** Spills and leaks from the Fourth Train Proposal have the potential to affect conservation areas and their associated social values, such as tourism, fisheries, and pearling.	• Terrestrial and Subterranean Environment Protection Plan and associated Procedures • Offshore Feed Gas Pipeline Installation Management Plan • Post-Construction Rehabilitation Plan and associated sub-Plan • Marine Environmental Quality Management Plan • Post-construction Rehabilitation Plan and associated sub-Plan • Project Site Rehabilitation Plan	• Potential impacts are not predicted to affect the social values of areas identified as having significant environmental and/or Heritage attributes
Land and sea use	To avoid adversely interfering with, or compromising, other economic uses of the land or marine environment	***Physical Interaction*** Physical interaction may impact upon the activities of other land users and sea users from increased traffic around mainland supply bases, and additional marine vessels, respectively ***Physical presence*** Additional petroleum safety zones around the subsea production wells and installation of the offshore Feed Gas Pipeline System may restrict movements of commercial shipping, fishing, and tourism operators ***Spills and leaks*** Spills and leaks may impact on the movements and activities of commercial shipping, fishing, and tourism operators	• Offshore Feed Gas Pipeline Installation Management Plan • Subsidiary Documents developed for the implementation of the Fourth Train Proposal, including: ▪ Commonwealth Environment Plans (and Oil Spill Contingency Plans) ▪ State Environment Plans (and Oil Spill Contingency Plans)	• The Fourth Train Proposal will require additional offshore construction activities and affect new geographic areas, as compared to the Foundation Project, although potential impacts to land and sea use are predicted to be localised • Potential impacts are not predicted to adversely interfere with, or compromise, other economic uses of the land or marine environment

Factor	Objectives	Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures[3]	Predicted Outcomes
Livelihoods	To deliver employment and skill development opportunities that benefit the local and regional population	***Physical interaction and physical presence*** Economic modelling predicts that the Fourth Train Proposal will generate additional direct and indirect employment, which is predicted to peak at 6300 during peak construction	The Fourth Train Proposal will actively support Australian Industry Participation as a core business policy; this will include the preparation of an Australian Industry Participation Plan	The Fourth Train Proposal is expected to deliver employment and skill development opportunities that benefit the regional and State population
Local communities	To avoid compromising the social infrastructure, cultural, and community structures of the local host community and, where relevant, to share benefits with the community	***Physical presence*** Potential impacts on local communities may result from increased traffic levels to and from supply bases	Extension of the same mechanisms applied to manage the potential social impacts of the Foundation Project	Potential impacts are not predicted to compromise the social infrastructure, cultural, and community structures of the local host community, but will result, where relevant, in benefits being shared with the community
National, State, and regional economy	To contribute to the achievement of national, State, and local development policies and plans with respect to socio-economy so that benefits are brought to the national, regional, and local economy and negative impacts on the economy are avoided or managed	***Physical presence*** Economic modelling predicts that the Fourth Train Proposal will result in an increase in: • total revenues, of approximately AU$97 billion (for an Net Present Value of approximately AU$46 billion), over the effective life of the Fourth Train Proposal • Australia's Gross Domestic Product by approximately 0.23% in its first full year of operation • Gross State Product, real private consumption, employment, and WA's net exports	The national, State, and regional economic impacts of the Fourth Train Proposal are expected to be positive, thus not requiring the implementation of mitigation and management measures	The Fourth Train Proposal will contribute to the achievement of national, State, and regional development policies and plans with respect to socio-economy so that benefits are brought to the national, State, and regional economies and that negative impacts on these economies are avoided or managed

Greenhouse Gas Emissions and Energy Management

The *Clean Energy Act 2011* (Cth; Clean Energy Act) , which was in force when this PER/Draft EIS was published, established a price on greenhouse gas emissions. Most greenhouse gas emissions from the Fourth Train Proposal would be directly covered by the Clean Energy Act. As such, there is an economic incentive for the implementation of cost-effective emissions reduction opportunities. However, Commonwealth Government policy in this area has undergone significant change over the last few years. This change is likely to continue during the period when the approval of the Fourth Train Proposal is being considered. The Commonwealth Government has proposed a Direct Action Plan as an alternative to pricing greenhouse gas emissions. The Direct Action Plan includes a proposal to establish an Emissions Reduction Fund to support carbon dioxide emissions reduction activity by business and industry. In its policy ‘Adapting to Climate Change’, the State Government has outlined that the regulation of greenhouse gas emissions are matters for the Commonwealth.

During construction of the Fourth Train Proposal, two greenhouse gas emissions sources are expected to dominate—emissions related to electricity generation and from the operation of various plant infrastructure and equipment. During the operations phase, combustion sources are expected to be the primary source of greenhouse gas emissions. The Gas Treatment Plant is expected to emit most of the greenhouse gases from the Fourth Train Proposal, with Gas Turbine Drivers and Gas Turbine Generators the key emissions sources. Greenhouse gas emissions predicted to occur from the operation of the Fourth Train Proposal Gas Treatment Plant are approximately 1.6 million tonnes per annum of carbon dioxide equivalent (CO_2-e). For the Fourth Train Proposal in addition to the Foundation Project Gas Treatment Plant, approximately 7.6 million tonnes per annum of CO_2-e is predicted to be generated.

Key greenhouse gas and energy efficiency management measures include use of the Foundation Project Carbon Dioxide Injection System for the injection of reservoir CO_2 from the Fourth Train Proposal gas fields. The Fourth Train Proposal will also use industrial gas turbines for the Gas Turbine Drivers, as they provide the most suitable technology option based on cost, health, safety, and environment requirements.

Quarantine Management

During construction, commissioning, operation, and future decommissioning, the Fourth Train Proposal will require the transfer of equipment, materials, supplies, personnel, marine vessels, and aircraft to Barrow Island. The quantities of such items are predicted to be no more than 30% of those required for the Foundation Project. No new introduction pathways have been identified for the Fourth Train Proposal beyond those already identified, assessed, and managed by the Foundation Project Terrestrial and Marine Quarantine Management System (QMS).

The QMS employs a number of quarantine barriers including detection, and physical, chemical, and biological interventions, and has been found to be effective at managing the quarantine risks associated with the Foundation Project. Therefore, the QMS, as amended from time to time, is suitable to effectively manage the quarantine risks from the Fourth Train Proposal.

The proposed measures to prevent, eradicate, and detect the introduction of Non-indigenous Terrestrial Species or Marine Pests from the implementation of the Fourth Train Proposal are such that the GJVs consider the risk of the introduction of Non-indigenous Terrestrial Species or Marine Pests to be environmentally acceptable.

Controlling Provisions

The following controlling provisions were determined as relevant to the Fourth Train Proposal by the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities:

- National Heritage Places (Sections 15B and 15C of the EPBC Act)
- Listed Threatened[4] species and communities (Sections 18 and 18A of the EPBC Act)
- Listed Migratory species (Sections 20 and 20A of the EPBC Act)
- Commonwealth Marine Environment (Sections 23 and 24A of the EPBC Act).

Potential Impacts

The key potential impacts resulting from the Fourth Train Proposal for the controlling provisions are summarised in Table ES-8. Implementation of the Fourth Train Proposal is not likely to result in any unacceptable direct, indirect, or facilitated incremental, additional, additive, or cumulative impacts on relevant controlling provisions, and is not expected to change the level of impact assessed for the Foundation Project.

While it is acknowledged that the inclusion of the Ningaloo Coast into the National Heritage List occurred after Foundation Project approval, the assessment of potential impacts of the Fourth Train Proposal on the Ningaloo Coast has determined that unacceptable impact on the values for which this area has been protected is unlikely.

No potential impacts on controlling provisions are determined to be irreversible. Although some potential impacts (e.g. alteration of seabed habitat in the Commonwealth Marine Area as a result of the presence of subsea infrastructure) may have long-term implications throughout the productive life—and perhaps beyond—of the Fourth Train Proposal, such impacts have the potential to be finite if infrastructure is removed during decommissioning. The specific approach to decommissioning will be determined in the future, and will reflect legislation, industry practice, and the assessment of options at that time.

No aspects of the Fourth Train Proposal are determined to conflict with, or be inconsistent with, the objects and principles of the EPBC Act, or the objectives, strategies, and plans for the Ningaloo Coast Natural Heritage Place, the protection and recovery of relevant EPBC Act-listed Threatened and/or Migratory marine species and their communities, or the Commonwealth Marine Environment.

Mitigation and Management Measures

The GJVs propose that the management framework, including Environmental Management Plans and Subsidiary Documents, established for the Foundation Project is adequate to effectively prevent and manage the potential impacts of the Fourth Train Proposal in relation to the controlling provisions. Minor modifications will be incorporated into the Environmental Management Plans and updates to, or new Subsidiary Documents will be developed as necessary to ensure that these management tools appropriately address the potential impacts of the Fourth Train Proposal on the controlling provisions.

The existing management framework for the Foundation Project is considered to be consistent with the objects and principles of the EPBC Act, including the adoption of a conservative approach to impact identification, assessment, mitigation, and management where potential impacts to the controlling provisions are not fully understood or are unknown.

[4] 'Threatened Species' referred to may encompass all current categories for species listings under the EPBC Act list of Threatened Flora and Fauna that are relevant to the Fourth Train Proposal Area. These include 'Critically Endangered', 'Endangered', 'Vulnerable' and 'Conservation Dependent' species.

Illustrative mitigation and management measures proposed to be applied to the Fourth Train Proposal are outlined in Table ES-8 for the controlling provisions.

Table ES-8: Key Potential Impacts, Mitigation and Management Measures, and Predicted Outcomes for Fourth Train Proposal Controlling Provisions

Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures	Predicted Outcomes
Controlling Provision: National Heritage Places **Objective:** To protect the environmental and social values of areas identified as having significant environmental and/or national heritage attributes		
In the unlikely event of a major hydrocarbon spill or leak, hydrocarbons have the potential to adversely impact the environmental and social values of the Ningaloo Coast through reductions in water and sediment quality; this also has the potential to have secondary impacts upon the amenity of the area, and upon marine biodiversity. The level of potential impact is highly dependent on the hydrocarbon type, spill location, and prevailing weather conditions.	• Best Practice Pollution Control Design • Air Quality Management Plan • EMPs required for the drilling and completion of Fourth Train Proposal production wells and for activities associated with the installation of the Fourth Train Proposal Feed Gas Pipeline System • Decommissioning and Closure Plan • Subsidiary Documents developed for the implementation of the Fourth Train Proposal, including: ▪ Commonwealth Environment Plans (and Oil Spill Contingency Plans) ▪ State Environment Plans (and Oil Spill Contingency Plans)	• In the event of a subsea well blowout in the Chandon Gas Field (worst-case scenario), widespread impacts to the Ningaloo Coast's environmental values are considered unlikely. The predicted travel time for the hydrocarbons to reach the Ningaloo Coast (worst-case of ten days) will also allow for the implementation of response measures to limit shoreline contact • The Fourth Train Proposal is not expected to result in any unacceptable adverse impacts to the National Heritage values of the Ningaloo Coast in the context of the relevant objects and principles of the EPBC Act, or relevant management or policy documents • The potential impacts identified for National Heritage Places will be adequately managed such that the impacts are environmentally acceptable and the environmental objectives for this controlling provision are met

<table>
<tr><th>Key Potential Impacts of the Fourth Train Proposal</th><th>Illustrative Mitigation and Management Measures</th><th>Predicted Outcomes</th></tr>
<tr><td colspan="3">Controlling Provision: Terrestrial Environment – EPBC Act-listed Threatened Species and Communities and EPBC Act-listed Migratory Species
Objective: To maintain the abundance, diversity, geographic distribution, and productivity of EPBC Act-listed Threatened and/or Migratory species at species and ecosystems levels through the avoidance or management of adverse impacts and improvement in knowledge</td></tr>
<tr><td>EPBC Act-listed terrestrial fauna are considered to be exposed to incremental, additional, and additive potential impacts from stressors including clearing and earthworks, fire, noise and vibration, physical interaction, and spills or leaks. Key potential impacts include:
• Additional clearing up to (approximately) 10 ha at the Fourth Train Proposal horizontal directional drilling site will result in localised habitat removal. This has the potential to impact fauna species in adjacent areas, due to increased predation and/or competition
• Unplanned fire events have the potential to impact upon terrestrial flora and fauna by displacing fauna to adjacent areas, which may then be subject to increased predation and/or competition
• Operational noise has the potential to mask White-winged Fairy-wren (Barrow Island) communication
• Physical interaction may impact upon terrestrial mammals, potentially resulting in entrapment, injury, or mortality; the additional construction activities due to the Fourth Train Proposal result in an additional period within which these impacts may occur
• Additional volumes of hazardous materials will be stored, transported, and used, which may result in contamination of subterranean fauna habitat, including groundwater, in the event of a spill or leak</td><td>• Terrestrial and Subterranean Environment Protection Plan and associated Procedures
• Terrestrial and Subterranean Environment Monitoring Program
• Short Range Endemics and Subterranean Fauna Monitoring Plan
• Fire Management Plan
• Horizontal Directional Drilling Management and Monitoring Plan
• Air Quality Management Plan
• Long-term Marine Turtle Monitoring Plan (for the management of light spill)
• Solid and Liquid Waste Management Plan
• Post-Construction Rehabilitation Plan and associated sub-Plan
• Carbon Dioxide System Monitoring Program
• Terrestrial and Marine Quarantine Management System
• Project Site Rehabilitation Plan
• Decommissioning and Closure Plan</td><td>• Potential construction and operations impacts are predicted to be localised, resulting in the potential loss of individuals; however, impacts to population viability are not predicted
• Implementation of the Fourth Train Proposal in conjunction with the Foundation Project is not predicted to conflict with, or be inconsistent with, the objects and principles of the EPBC Act, or the objectives, strategies, and plans listed for the protection and recovery of relevant EPBC Act-listed Threatened and/or Migratory terrestrial species and their communities
• The potential impacts identified for terrestrial fauna will be adequately managed such that the impacts are environmentally acceptable and the environmental objectives for EPBC Act-listed Threatened Species and Communities and/or Migratory Species within the terrestrial environment are met</td></tr>
</table>

Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures	Predicted Outcomes
Controlling Provision: Marine Species and Their Habitats – EPBC Act-listed Threatened Species and Communities and EPBC Act-listed Migratory Species **Objective:** To maintain the abundance, diversity, geographic distribution, and productivity of EPBC Act-listed Threatened and/or Migratory species at species and ecosystems levels through the avoidance or management of adverse impacts and improvement in knowledge		
EPBC Act-listed marine fauna are considered to be exposed to a range of incremental and additional potential impacts from stressors including artificial light, discharges to sea, noise and vibration, physical interaction, seabed disturbance, and spills or leaks. Key potential impacts include: • Artificial light has the potential to affect sensitive marine fauna that rely on visual cues (particularly marine turtles) resulting in behavioural responses • Discharges to sea have the potential to impact on marine fauna through behavioural avoidance or indirect impacts such as a reduction in habitat or water quality • Noise and vibration has the potential to impact on marine fauna, such as whales and dolphins that rely on acoustic cues for feeding, communication, orientation, and navigation. The extent of impact from noise and vibration depends on a number of variables including the frequency and intensity of the emitting noise, the receiving environment, metocean conditions, and the sensitivity of the marine fauna exposed. The annual migration of Humpback Whales between Antarctic feeding grounds and breeding grounds in the North-west Marine Region overlaps the Fourth Train Proposal Area, and may coincide with coastal and offshore marine activities for the Fourth Train Proposal. Noise generated by these activities may result in behavioural changes, such as avoidance of noise sources • Physical interaction of marine vessels with marine fauna has the potential to cause injury or mortality through direct strike, entrapment, or entrainment in vessel gear, or behavioural responses due to disturbance • Seabed disturbance may result in a change to, or permanent loss of, benthic primary producer habitat, and marine turtle foraging, nesting, and internesting areas. The extent and longevity of the potential impacts can be related to the nature, scale, and timing of the activities causing the disturbance, as well as the seabed substrate, habitat type, and benthic communities in the vicinity of the disturbance • A major hydrocarbon spill has the potential to impact Whale Sharks (e.g. due to acute toxicity), including at known aggregation areas at the Ningaloo Coast. However, modelling predicts that most hydrocarbons	• EMPs required for the drilling and completion of Fourth Train Proposal production wells and for activities associated with the installation of the Fourth Train Proposal Offshore Feed Gas Pipeline System • Coastal and Marine Baseline State and Environmental Impact Report • Long-term Marine Turtle Management Plan • Fauna Handling and Management Common User Procedure • Marine Facilities Construction Environmental Management Plan • Horizontal Directional Drilling Management and Monitoring Plan • Offshore Feed Gas Pipeline System Installation Management Plan • Offshore Feed Gas Pipeline System Pre-lay Activities Environment Plan • Marine Environmental Quality Management Plan • Post-Development Coastal and Marine State and Environmental Impact Survey Report • Solid and Liquid Waste Management Plan • Reverse Osmosis Brine Disposal Management and Monitoring Plan • Terrestrial and Marine Quarantine Management System • Decommissioning and Closure Plan • Subsidiary Documents developed for the implementation of the Fourth Train Proposal, including: ▪ Commonwealth Environment Plans (and Oil Spill Contingency Plans) ▪ State Environment Plans (and Oil Spill Contingency Plans)	• Potential impacts from the construction and operation of the Fourth Train Proposal are expected to be localised and/or short term: ▪ The Fourth Train Proposal is predicted to generate negligible additional light spill to known turtle nesting areas on the foreshore, when compared to the levels of light spill assessed and approved for the Foundation Project ▪ Discharges to sea and noise and vibration may result in avoidance behaviour; however, such behaviour is expected to be localised ▪ The potential impacts due to physical interaction and seabed disturbance will be close to the marine activities ▪ In the event of a spill or leak of condensate or diesel, high evaporation rates would reduce the potential for the spill to impact upon marine fauna. In addition, the wider availability of habitat for many Threatened and/or Migratory marine species across the North-west Marine Region reduces the potential for adverse effects at a species level in the unlikely event of a large-scale spill or leak • Implementation of the Fourth Train Proposal in conjunction with the

Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures	Predicted Outcomes
would evaporate, degrade, and disperse to low concentrations before reaching aggregation areas during aggregation periods reducing the potential for impact		Foundation Project is not predicted to conflict with, or be inconsistent with, the objects and principles of the EPBC Act, or the objectives, strategies, and plans listed for the protection and recovery of relevant EPBC Act-listed Threatened and/or Migratory species and their communities • The potential impacts identified for marine fauna will be adequately managed such that the impacts are environmentally acceptable and the environmental objectives for EPBC Act-listed Threatened Species and Communities and/or Migratory Species within the marine environment are met

<table>
<tr><th>Key Potential Impacts of the Fourth Train Proposal</th><th>Illustrative Mitigation and Management Measures</th><th>Predicted Outcomes</th></tr>
<tr><td colspan="3">Controlling Provision: Commonwealth Marine Environment
Objectives:
To avoid or mitigate any adverse effects of atmospheric emissions on environmental values or the health, welfare, and amenity of people and land uses
To avoid or mitigate potential impacts from light overspill
To avoid or mitigate any adverse effects of discharges on the environmental values of the marine environment or the health, welfare, and amenity of people and sea uses
To avoid adverse noise and vibration impacts to marine fauna
To handle and store hydrocarbons and other chemicals in a way that reduces the potential for leaks, spills, and emergency situations to impact on the environment to as low as reasonably practicable
To maintain the abundance, diversity, geographic distribution, and productivity of marine fauna (including EPBC Act-listed Threatened or Migratory species) at species' and ecosystems' levels through the avoidance or management of adverse impacts and improvement in knowledge
To avoid, reduce, and/or mitigate against impacts on the ecological functions and environmental values of marine benthic habitats
To maintain the quality of marine water so that existing and potential environmental values, including ecosystem functions and integrity, are maintained
To maintain the integrity, ecological functions, and environmental values of the seabed
To avoid adversely interfering with, or compromising, other economic uses of the Commonwealth Marine Area
To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and to comply with relevant heritage legislation
To avoid adversely interfering with, or compromising, the environmental values of areas identified as having significant environmental attributes</td></tr>
<tr><td>Potential impacts to environmental factors of the Commonwealth Marine Environment such as water quality, marine fauna, and benthic habitats may occur from stressors including discharges to sea, seabed disturbance, and spills and leaks. Potential impacts are expected to be limited to the vicinity of Fourth Train Proposal offshore activities. Key potential impacts include:
• Additional discharge sources and an increase in overall volume of discharges when compared to the Foundation Project, may lead to a reduction in water quality, changes to sediment quality, and direct and indirect effects to marine fauna
• Seabed disturbance from offshore construction activities may result in changes to the physical structure of the seabed, alteration of benthic habitats, and reduced ecological value of marine protected areas and key ecological features. The extent and longevity of the potential impacts can be related to the nature, scale, and timing of the activities causing the disturbance, as well as the seabed substrate, habitat type, and benthic communities in the vicinity of the disturbance
• In the unlikely event of a substantial spill or leak due to the Fourth Train Proposal, the potential impacts could extend over a large geographic</td><td>• EMPs required for the drilling and completion of Fourth Train Proposal production wells and for activities associated with the installation of the Fourth Train Proposal Offshore Feed Gas Pipeline System
• Best Practice Pollution Control Design
• Air Quality Management Plan
• Decommissioning and Closure Plan
• Subsidiary Documents developed for the implementation of the Fourth Train Proposal, including:
  ▪ Commonwealth Environment Plans (and Oil Spill Contingency Plans)
  ▪ State Environment Plans (and Oil Spill Contingency Plans)</td><td>• While new geographic areas have the potential to be affected by the Fourth Train Proposal when compared to the Foundation Project, these new areas and the habitats and communities that they support are considered to be well represented within the North-west Marine Region. The Fourth Train Proposal when considered in addition to the Foundation Project is not expected to result in adverse impacts to the ecological values, diversity, or productivity of the Commonwealth Marine Area
• The implementation of the Fourth Train Proposal in conjunction with the Foundation Project is not predicted to conflict with, or be inconsistent with, the objects and principles of the EPBC</td></tr>
</table>

Key Potential Impacts of the Fourth Train Proposal	Illustrative Mitigation and Management Measures	Predicted Outcomes
area. Key ecological features within the Commonwealth Marine Area that could be sensitive to spills or leaks of hydrocarbons include Mermaid Reef and waters surrounding Rowley Shoals. Potential impacts include a reduction in water quality, direct and indirect effects to marine fauna, and reduced ecological value of marine protected areas and key ecological features. The degree of impact within the Commonwealth Marine Area depends upon various factors, including the time of exposure (e.g. immediately preceding the spill or a number of days/weeks after the release), metocean conditions, the type of release (e.g. condensate versus heavy fuel oil), and proximity of the leak or spill to sensitive marine areas		Act, or the objectives, strategies, and plans relevant to the Commonwealth Marine Areas of the North-west Marine Region • The potential impacts identified for the Commonwealth Marine Environment will be adequately managed such that the impacts are environmentally acceptable and the environmental objectives for this controlling provision are met

Cumulative Impacts

A cumulative impact assessment was undertaken on the environmental and social factors outlined in this PER/Draft EIS. The cumulative impact assessment evaluated the potential incremental impacts of the Fourth Train Proposal when combined with the approved Foundation Project and other present and reasonably foreseeable future actions in the vicinity of the Fourth Train Proposal Area. Table ES-9 lists the actions that were considered in the cumulative impact assessment.

The cumulative impact assessment was based on a high-level analysis of potential impacts using professional judgement of subject matter experts, supported by baseline information and a range of quantitative assessments. The approach was largely qualitative, although cumulative atmospheric emissions impacts were quantified for the Pilbara Region.

The Fourth Train Proposal combined with the approved Foundation Project and WA Oil is not expected to result in any substantial cumulative impacts to the terrestrial environment on Barrow Island, due to both the nature of the stressors present (i.e. transient, geographically dispersed, temporally separated) and the application of appropriate mitigation and management measures by the Fourth Train Proposal. Similarly, the Fourth Train Proposal combined with the approved Foundation Project and other considered actions (Table ES-9) is not expected to result in substantial cumulative impacts to the marine environment.

The GJVs predict that, with appropriate controls in place on all relevant actions, the potential cumulative impacts to all factors can be acceptably managed to meet the objectives established for the Fourth Train Proposal.

Table ES-9: Actions Considered in the Cumulative Impact Assessment

Present Sources	Future Sources
• Approved Gorgon Foundation Project • Cape Lambert Power Station • CITIC Pacific Power Station, pellet plants, and mine vehicles • Dampier Power Station • Devils Creek Gas Project • Karratha Gas Plant • Other over water (including floating production, storage, and offloading vessels [FPSOs] and oil and gas rigs) and overland sources • Pilbara towns • Pluto LNG • Shipping – ports and channels • Varanus Production Area • WA Oil • West Pilbara Power Station – Karratha • Wheatstone Project • Yara Pilbara Fertilisers • Yurralyi Maya Power Station	• Anketell Point Power Station • Anketell Port vehicles • Balmoral South Power Station, pellet plants, and mine vehicles • Burrup Nitrates • Macedon Domestic Gas

Decommissioning

The future decommissioning of the Fourth Train Proposal has the potential to result in impacts to the terrestrial, coastal and nearshore, and social environments. There will be advances in decommissioning technology and information, potential changes to decommissioning procedures, and potential changes to regulatory requirements prior to the decommissioning of the Fourth Train Proposal. Therefore, the actual methodology used will be determined at the time of decommissioning to assess the best available option, taking into account relevant legislation, relevant safety and environmental issues, economic analysis, and practicability at the time.

Assuming current practices and technologies, decommissioning is predicted to result in potential impacts similar to those for the construction of the Fourth Train Proposal.

It is proposed that the following Foundation Project EMPs will also address potential impacts from decommissioning of the Fourth Train Proposal:

- Project Site Rehabilitation Plan
- Decommissioning and Closure Plan.

Potential impacts as a result of decommissioning activities are predicted to meet the objectives outlined in this PER/Draft EIS, resulting in the development areas being returned to Commonwealth or State agencies in an appropriate condition following decommissioning activities.

Environmental Management Framework

The GJVs have implemented a tiered Environmental Management Framework (Figure ES-3) for the approved Foundation Project, which has been effective in managing potential impacts associated with the Foundation Project. This Environmental Management Framework will also be adopted for the Fourth Train Proposal.

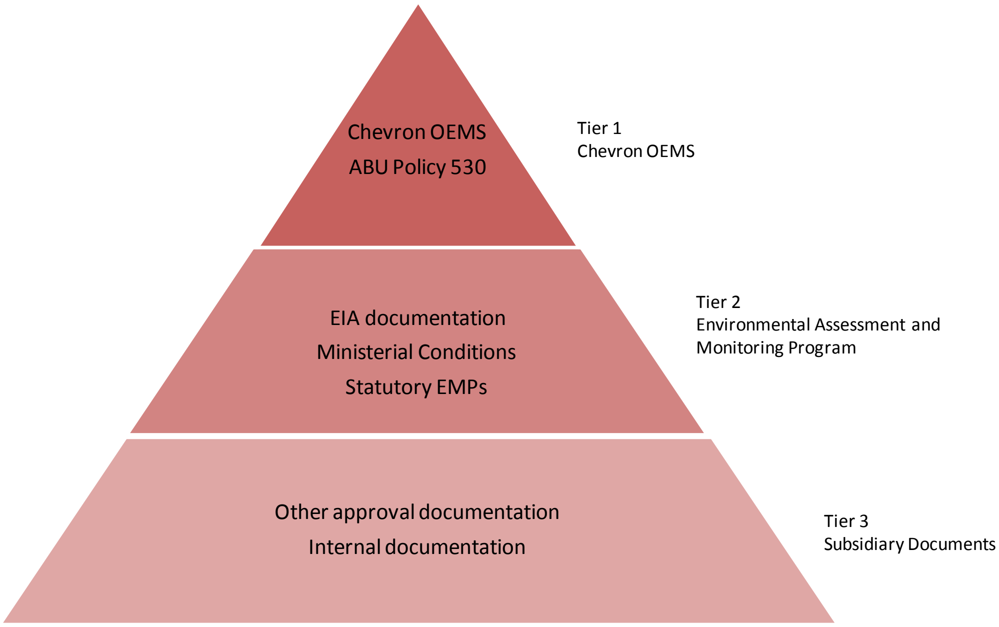

Figure ES-3: Environmental Management Framework

Tier 1 of the Environmental Management Framework includes Chevron Corporation's OEMS and Australasia Business Unit's Policy 530. The Chevron Australasia Business Unit (ABU) Policy 530 – Operational Excellence sets the overall goal of protecting the safety and health of people and the environment through the implementation of Operational Excellence. The policy applies to all Chevron Australia projects and requires, amongst other things, that processes are in place to conserve natural resources; comply with all applicable laws and standards; keep an inventory of all emissions, discharges, and wastes; and mitigate and manage significant potential risks and impacts to human health and the environment associated with these emissions, discharges, and wastes.

Tier 2 of the Environmental Management Framework incorporates the Environmental Assessment and Monitoring Program, which incorporates this statutory impact assessment, resultant Ministerial Conditions, and statutory EMPs. The relevant Ministerial Conditions equivalent to, or consistent with, those approved for the Foundation Project, are considered by the GJVs to be suitable in managing the environmental impacts of the Fourth Train Proposal (where they relate to the scope and impacts of the Fourth Train Proposal and when applied in conjunction with current regulations).

The EMPs required under the Ministerial Conditions for the approved Foundation Project detail the specific actions and responsibilities to address environmental impacts of the Foundation Project. A number of EMPs already exist for the Foundation Project. The GJVs propose to apply, where relevant, the same mitigation and management measures as contained in the most recently approved Foundation Project EMPs. Therefore, if the Fourth Train Proposal is approved, the GJVs propose that minor changes are incorporated into the relevant most recently approved Foundation Project EMPs to ensure that these documents also appropriately address the potential impacts of the Fourth Train Proposal (i.e. revisions to the plans will be made to ensure that incremental and additional impacts from the Fourth Train Proposal are adequately considered).

As part of the OEMS, Chevron Australia continually reviews and updates the EMPs to ensure compliance with the Ministerial Conditions. Adaptive management measures are incorporated into the EMPs as a result of various systems in place. These include changes to the Foundation Project EMPs, experience gained from ongoing Foundation Project construction and monitoring activities, regular ongoing reviews and updates to a number of EMPs as required by Ministerial Conditions, audit findings, and recommendations from the Expert Panels. The same mechanisms of adaptive management are planned to be used by the Fourth Train Proposal.

Tier 3 comprises a set of Subsidiary Documents, which includes approval documentation (required under legislation and/or that imposes relevant legal obligations on the GJVs or Chevron Australia, but which is not legally binding under the Ministerial Approval of the EPBC Act and EP Act) and internal documentation, which is required for Chevron Australia’s internal purposes but which is not legally binding under legislation. These Subsidiary Documents include Chevron Australia’s requirement for contractors and suppliers to implement a document management system that fully embraces the policy and objectives of the OEMS and to develop and implement their own activity and/or site-specific Environmental Management Plans, Procedures, and Work Method Statements. These internal documents are not legally binding under legislation, but build on and reflect the environmental protection measures contained within the EMPs for the Foundation Project.

The GJVs have a clear objective in the development of the Fourth Train Proposal to avoid, minimise, rectify, and reduce potential impacts associated with the Fourth Train Proposal. This approach is consistent with the Commonwealth and State Government’s Environmental Offsets Policies, which outline the need to consider all avoidance and mitigation measures, using environmental offsets as a last resort. The Fourth Train Proposal has been designed to avoid, prevent, or reduce the potential for unacceptable adverse impacts. The GJVs are confident that residual incremental, additional, and cumulative impacts can be acceptably managed within the context of the existing Foundation Project Environmental Management Framework such that they are acceptable and the objectives established for this assessment are met. Therefore, the Fourth Train Proposal has been assessed to have no unacceptable residual impacts and therefore no environmental offsets are considered to be required.

Net Conservation Benefits are defined in the *Barrow Island Act 2003* (WA) as 'demonstrable and sustainable additions to or improvements in biodiversity conservation values of Western Australia targeting, where possible, the biodiversity conservation values affected or occurring in similar bioregions to Barrow Island'. Under a variation to Clause 11 of Schedule 1 to the *Barrow Island Act 2003* (WA), the GJV participants have agreed to pay AU$60 million (indexed) in instalments to fund Net Conservation Benefits for a 15 million tonnes per annum LNG development. The Fourth Train Proposal will result in a proportionate increase in Net Conservation Benefits funding, which will be negotiated with the State Government.

Conclusion

The Fourth Train Proposal aims to efficiently and reliably recover and commercialise additional gas and condensate reserves in the Greater Gorgon Area. The addition of a fourth LNG train on Barrow Island will take advantage of the infrastructure and facilities already constructed or under construction for the Foundation Project.

This PER/Draft EIS is the primary source of information for the public and regulatory decision makers in their assessment of the potential environmental impacts of the Fourth Train Proposal. In preparing this PER/Draft EIS, the GJVs have considered and evaluated the environmental, social, and economic issues that may arise from the Fourth Train Proposal, consistent with the requirements of the EPBC Act and the EP Act.

The approach adopted by the GJVs to complete this PER/Draft EIS has been to comprehensively identify and assess the potential impacts associated with the Fourth Train Proposal. This has involved using information gained from various environmental and social impact assessment studies undertaken for the Foundation Project and a detailed prediction and assessment of potential impacts of the Fourth Train Proposal. Construction of the Foundation Project has provided the GJVs and decision-making authorities with valuable experience, which has been captured and used in the formulation of effective mitigation and management measures.

Potential Impacts

When compared with the approved Foundation Project, the Fourth Train Proposal is not expected to result in any different potential impacts to the environmental and social values of Barrow Island and its surrounding waters. The main outcomes of the environmental impact assessment for Fourth Train Proposal are highlighted in the subsections below.

Emissions, Discharges, and Wastes

No unacceptable emissions, discharges, and wastes are predicted to occur as a result of the incremental increase to emissions, discharges, and wastes produced by the Fourth Train Proposal. Construction activities will produce an increase in the volume of emissions, discharges, and wastes produced, although no different sources will be created. All emissions, discharges, and wastes produced by the Fourth Train Proposal are predicted to be within relevant statutory requirements.

Terrestrial Environment

No unacceptable impacts to the terrestrial environment are predicted to occur as a result of the Fourth Train Proposal. Vegetation clearing will be within the allocated area of uncleared land available for tenure on Barrow Island for gas processing activities under the *Barrow Island Act 2003* (WA). The construction and operations phases of the Fourth Train Proposal are expected to impact plant individuals, but not result in a widespread or long-term decrease in abundance of flora, or impact the vegetation community structure.

Potential impacts to surface water and groundwater are predicted to remain localised within the vicinity of the Combined Gorgon Gas Development Footprint. Potential impacts to terrestrial and subterranean fauna are predicted to result in loss at an individual level for some species on Barrow Island, including individuals of protected species, but without compromising population viability. Potential impacts are considered to be in line with relevant requirements of the EPBC Act, EP Act, *Wildlife Conservation Act 1950* (WA), and relevant plans and policies.

Coastal and Nearshore Environment

No unacceptable impacts to the coastal and nearshore environment are predicted to occur as a result of the Fourth Train Proposal. Potential impacts to the population viability of protected species or their habitats (either important or critical) are not anticipated, although impacts to individuals may occur. Potential impacts are also considered to be in line with the EPBC Act, EP Act, *Wildlife Conservation Act 1950* (WA), and relevant plans and policies.

The Fourth Train Proposal will result in additional artificial light emissions on the east coast of Barrow Island. Additional artificial light emissions off the west coast of Barrow Island will be limited to construction activities. Additional onshore light emissions for the Combined Gorgon Gas Development Gas Treatment Plant will be within the level of light emissions assessed and approved for the Foundation Project. Lighting management strategies aim to adequately manage artificial light emissions so as to avoid adverse lighting impacts on marine fauna.

The GJVs recognise that the Fourth Train Proposal will increase the potential for a spill or leak due to the presence of additional infrastructure and marine vessels. The consequence of a spill or leak from a worst-case spill scenario has the potential to result in significant environmental harm. However, the probability of such an event occurring was predicted to be unlikely. The spill modelling used assumed 'no intervention'. However, if such a spill were to occur, spill response measures would be executed that would reduce the potential impacts identified.

Potential impacts to the seabed will be localised. Mitigation and management measures to reduce potential impacts to important benthic primary producer habitat and marine fauna will be implemented. An increase in the volume of discharges to sea from marine vessels will occur; however, these will be localised, short term, low in toxicity, and likely to dissipate quickly into the receiving marine environment.

Controlling Provisions

The Fourth Train Proposal will increase the overall footprint currently approved for the Gorgon Gas Development in the marine environment, and to a lesser extent on Barrow Island. It will also extend the duration over which some controlling provisions (specifically listed Threatened and Migratory species and their habitats) may be exposed to potential impacts as a result of construction activities. However, the Fourth Train Proposal activities are similar to those of the approved Foundation Project; no different potential impacts were identified in relation to the Fourth Train Proposal when compared with those assessed and approved for the Foundation Project. No aspects of the Fourth Train Proposal are determined to be inconsistent with the EPBC Act objects or principles, or government policies and plans relevant to the Fourth Train Proposal controlling provisions. Despite the Fourth Train Proposal being subject to additional controlling provisions compared to the Foundation Project (i.e. National Heritage Places), the GJVs propose that the management framework already in place for the Foundation Project, could be extended (where relevant) to encompass the Fourth Train Proposal, and would serve to adequately manage potential environmental impacts for each of the Fourth Train Proposal controlling provisions. The GJVs are confident that controlling provisions can be acceptably managed such that no environmental offsets are considered to be required. No unacceptable incremental, additional, additive, or cumulative impacts are predicted to be likely for any of the Fourth Train Proposal controlling provisions and no potential impacts on the controlling provisions are determined to be irreversible.

Social, Cultural, and Economic Environment

No unacceptable impacts to the social, cultural, and economic environment are predicted to occur as a result of the Fourth Train Proposal. Additional marine vessel movements and additional petroleum safety zones are anticipated as a result of the Fourth Train Proposal, although this represents a small increase when compared to that assessed and approved for the Foundation Project. The Fourth Train Proposal will result in additional tax revenue, increased exports of natural gas, additional employment and training opportunities, greater business development opportunities through additional contracts, and increased spending in the national, State, and regional economies. Potential impacts are considered to be in line with the relevant legislation, plans, and policies.

Cumulative Impacts

No unacceptable cumulative impacts to the terrestrial, marine, and social, cultural, and economic environment are predicted to occur as a result of the Fourth Train Proposal. With appropriate controls in place on all relevant actions, the potential cumulative impacts are acceptably managed to meet the objectives established for the Fourth Train Proposal.

Proposed Management

The GJVs are committed to ensuring that the Fourth Train Proposal is developed and operated in an environmentally responsible manner that protects the conservation values of Barrow Island and its surrounding waters. The GJVs propose that the potential impacts associated with the Fourth Train Proposal can be effectively managed by the relevant Ministerial Conditions equivalent to, or consistent with, those approved for the Foundation Project.

Predicted Outcome

The GJV's approach to achieving this commitment and the assessment of the potential impacts of the Fourth Train Proposal is consistent with the principles of ecologically sustainable development, as listed in Section 3A of the EPBC Act and Section 4A of the EP Act. This includes the adoption of a conservative approach to managing uncertainties over environmental impacts and the adoption of all reasonable and practicable measures to minimise waste through the extension of Chevron Australia's Environmental Management Framework from the approved Foundation Project to the Fourth Train Proposal.

In addition, the Fourth Train Proposal is also consistent with the principle of intergenerational equity as the GJVs are committed to implementing a management framework, consistent with that of the Foundation Project, that aims to ensure the long-term conservation of the environmental and social values of the Fourth Train Proposal Area.

Experience to date has demonstrated that the approved Foundation Project has not resulted in any material non-compliances with Commonwealth or State environmental requirements. This may be attributed to the dedicated application of Chevron Australia's Environmental Management Framework, which aims to provide an effective method for managing the potential Foundation Project-attributable impacts. The objectives in this PER/Draft EIS that have been established to determine the predicted environmental outcomes reflect the ecologically sustainable development principle of conserving biodiversity and ecological integrity.

Overall, the Fourth Train Proposal will not result in a net environmental loss to the conservation values of Barrow Island, its surrounding waters, and the Commonwealth Marine Environment and there are benefits to be gained through the implementation of the Fourth Train Proposal.

The GJVs conclude that the Fourth Train Proposal will be environmentally acceptable, subject to the effective extension of the mitigation and management measures approved for the Foundation Project to the Fourth Train Proposal.

Section 1: Table of Contents

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1. Introduction

Chevron Australia Pty Ltd (Chevron Australia), on behalf of the Gorgon Joint Venturers (GJVs) (Section 1.3.7), seeks approval to enable production from the Gorgon Gas Development Foundation Project (Foundation Project) located on Barrow Island, Western Australia (WA) to be expanded from the approved 15 million tonnes per annum (MTPA) to 20 MTPA through the development of the **Gorgon Gas Development Fourth Train Expansion Proposal (Fourth Train Proposal)**.

The Fourth Train Proposal is related to these approved Gorgon Gas Developments, which are collectively termed the 'Foundation Project':

- the 10 MTPA initial Gorgon Gas Development
- the Revised and Expanded Gorgon Gas Development (which increased the production capacity of the Gorgon Gas Development to 15 MTPA)
- the Jansz–Io Development Project and Feed Gas Pipeline
- the Additional Construction Laydown and Operations Support Area (Additional Support Area).

At the time of writing, the Foundation Project is under construction. Section 3 provides further detail on the Foundation Project, its approvals history, and its environmental management and performance.

This document presents a combined Public Environmental Review (PER)/Draft Environmental Impact Statement (EIS) of the Fourth Train Proposal to satisfy the requirements for assessment under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Western Australian *Environmental Protection Act 1986* (EP Act), respectively.

1.1 Key Terms Used in this Document

Throughout this PER/Draft EIS, reference is made to the Foundation Project, the Fourth Train Proposal, and the Combined Gorgon Gas Development. For clarification purposes, the following definitions are provided:

- the **'Fourth Train Proposal'** refers to the Gorgon Gas Development Fourth Train Expansion Proposal, the development being proposed in this PER/Draft EIS, which is yet to gain approval
- the **'Foundation Project'** refers to Gorgon Gas Development Foundation Project, , as amended from time to time, which consists of:
  - the **'initial Gorgon Gas Development'**, the development proposed in the Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP) (Chevron Australia 2005) and subsequently approved under EPBC Reference: 2003/1294 and Ministerial Implementation Statement No. 748 (Statement No. 748)
  - the **'Revised and Expanded Gorgon Gas Development'**, the development proposed in the PER (Chevron Australia 2008) and subsequently approved under EPBC Reference: 2008/4178 and Ministerial Implementation Statements No. 800 and 865 (Statement No. 800 and Statement No. 865)
  - the **'Jansz–Io Development Project and Jansz Feed Gas Pipeline'**, the development assessed via EPBC Referral assessment processes and Environmental Impact Statement/Assessment on Referral Information (ARI) (Mobil Australia 2005; Mobil Exploration 2006) and subsequently approved under EPBC Reference: 2005/2184 and Ministerial Implementation Statement No. 769 (Statement No. 769)

- the **'Gorgon Gas Development Additional Construction, Laydown and Operations Support Area'**, changes to the Gorgon Gas Development as approved under Ministerial Implementation Statement No. 965 and regulated through variations to EPBC References: 2003/1294 and 2008/4178 (Chevron Australia 2013).

- the **'Combined Gorgon Gas Development'** refers to the combined Foundation Project and the future Fourth Train Proposal (if approved)
- the '**Fourth Train Proposal Area**' refers to the area within which Fourth Train Proposal primary activities will be undertaken; i.e. the area encompassing the Greater Gorgon Area and Barrow Island (Figure 1-1)
- the '**Greater Gorgon Area'** as defined under the *Barrow Island Act 2003* (WA), is the area that is the subject of Retention Leases WA-15-R, WA-17-R, WA-18-R, WA-19-R, WA-20-R, WA-21-R, WA-22-R, WA-23-R, WA-24-R, WA-25-R, and WA-26-R; Exploration Permits WA-253-P, WA-267-P, and WA-268-P; and graticular blocks 439, 440, 511, 512, 583, and 584 of Exploration Permit WA-205-P, or of titles derived from those titles, which are held during the term of the State Agreement by any person under such titles granted pursuant to the *Petroleum (Submerged Lands) Act 1967* (Cth).

Other technical terms used in this PER/Draft EIS are defined in the Terms and Acronyms List. A summary of the approvals history of the Foundation Project is provided in Section 3.3.

1.2 Purpose and Scope of this Document

The purpose of this PER/Draft EIS is to describe the principal components of the Fourth Train Proposal, including an assessment of the environmental impacts reasonably expected to occur, the mitigation and management measures that the GJVs propose to implement, and the environmental acceptability of the Fourth Train Proposal in the context of the objectives and requirements of the EPBC Act and EP Act. This document is intended to inform stakeholders (including the community, other interested parties, the Commonwealth Department of the Environment [DotE; previously Department of Sustainability, Environment, Water, Population and Communities (SEWPaC)], and the Western Australian Environment Protection Authority [EPA]) about the Fourth Train Proposal. Ultimately, the purpose of this document is to provide sufficient information to enable DotE and the EPA to assess the Fourth Train Proposal in the preparation of their reports to their respective Ministers, and for the Commonwealth and State Ministers to reach a decision on whether the Fourth Train Proposal can be implemented, and, if so, under what conditions.

This document presents a combined PER/Draft EIS of the Fourth Train Proposal to satisfy the requirements for assessment under the EP Act and EPBC Act, respectively. Section 1.4 describes the approach undertaken to meet the requirements of Commonwealth and State legislation.

The scope of the PER/Draft EIS covers the construction, commissioning, and operation of:

- offshore production facilities, including wells, subsea installations, and intrafield pipelines in the Greater Gorgon Area
- a Feed Gas Pipeline System transporting unprocessed hydrocarbons from the offshore production facilities to the Foundation Project's Gas Treatment Plant on Barrow Island
- a fourth 5 MTPA (nominal) LNG processing train and associated infrastructure at the Foundation Project's Gas Treatment Plant on Barrow Island
- shared use of infrastructure and utilities with the Foundation Project, including the Foundation Project's product export facilities, Materials Offloading Facility, and carbon dioxide (CO_2) and wastewater injection wells.

Decommissioning of the Fourth Train Proposal facilities is also outlined. Given the current stage of development of the Fourth Train Proposal and the likely future changes and advances in legislation, technologies, and practice, a detailed evaluation of decommissioning and its management is deferred to a future phase of the Fourth Train Proposal.

A detailed description of the Fourth Train Proposal is provided in Section 4.

Items not considered in this document's scope include:

- overseas and domestic fabrication yards
- supply bases, offsite quarries, and waste disposal facilities.

Where possible, the Fourth Train Proposal will use existing offsite facilities. All such offsite facilities are required to have, and operate under, appropriate approvals and licenses.

The scope of this document considers the incremental and different impacts, including likely direct, indirect, and facilitated impacts of the Fourth Train Proposal on its own, and its additional impacts to those assessed and approved for the Foundation Project. The scope of this document also includes an assessment, where relevant, of potential cumulative impacts of the Fourth Train Proposal and approved Foundation Project when combined with other past, present, and reasonably foreseeable future actions. Section 8 provides further detail on the impact assessment approach adopted and the types of impacts assessed.

1.3 Proposal Overview

1.3.1 Proposal Title

The formal title of the proposed action is the Gorgon Gas Development Fourth Train Expansion Proposal, referred to in this document as the Fourth Train Proposal. All associated Fourth Train Proposal offshore installation and onshore construction activities, as well as commissioning, operating, and decommissioning activities of the infrastructure described in this Section and undertaken by Chevron Australia and its contractors, are considered part of the Fourth Train Proposal.

1.3.2 Proposal Background

The opportunity for progressing a fourth liquefied natural gas (LNG) train for the Gorgon Gas Development was identified in 2010 to develop gas resources in fields in the Greater Gorgon Area additional to the gas fields associated with the Foundation Project. Under their exploration and retention leases, the GJVs are obligated to actively seek development opportunities for these additional resources. Deferring or not developing the discovered resources would not be in keeping with this obligation. Further appraisal of these gas fields determined that the commercialisation of these additional resources would be optimised by adding a fourth LNG train to the Gas Treatment Plant on Barrow Island, rather than processing the gas at a later date through the three-train Foundation Project infrastructure or transferring the gas to another existing or planned processing facility in the Pilbara.

Future capacity increases of the Gas Treatment Plant on Barrow Island to cater for potential additional gas reserves in the Greater Gorgon Area were noted in the Environmental Impact Statement/Environmental Review and Management Plan (EIS/ERMP) prepared for the initial Gorgon Gas Development (Chevron Australia 2005); however, approval was not sought at that time as these reserves had not been found or, if found, had not been confirmed. The appraisal of the gas fields covered in this Fourth Train Proposal occurred after the Gorgon Gas Development Revised and Expanded Development proposal was approved by the Commonwealth Minister for Environment, Heritage and Arts and the Western Australian Minister of Environment in August 2009. The approvals history of the Foundation Project is discussed in detail in Section 3.3.

1.3.3 Description

The Fourth Train Proposal will expand production of the Foundation Project from 15 MTPA to 20 MTPA of LNG by extracting/gathering gas from newly developed gas fields, transporting this to, and processing the gas through the Gas Treatment Plant on Barrow Island. The Fourth Train Proposal will involve the drilling of new subsea wells and installing subsea gas gathering systems in gas fields in the Greater Gorgon Area (but not in the Gorgon or Jansz–Io fields); constructing a new Feed Gas Pipeline System to connect these gas gathering systems to the Gas Treatment Plant on Barrow Island; and adding a fourth LNG train and associated infrastructure at the Gas Treatment Plant. The fourth LNG train will be designed to integrate with the three LNG trains already approved under the Foundation Project. As such, if this Fourth Train Proposal is approved, the future four-train Gas Treatment Plant may process feed gas from any of the Combined Gorgon Gas Development gas fields.

Existing product export facilities, as well as supporting infrastructure and utilities (constructed as part of the Foundation Project), will be used as far as practicable for the Fourth Train Proposal.

Section 4 describes the Fourth Train Proposal in detail.

Overview of the Foundation Project

The approved Foundation Project comprises the construction and operation of offshore and onshore components. Gas wells will be drilled and gas recovered via subsea facilities from the Gorgon and Jansz–Io gas fields located off the north-west coast of WA. The recovered unprocessed gas will then be transported via two Feed Gas Pipeline Systems to a Gas Treatment Plant located on Barrow Island where it will be processed into LNG, condensate, and domestic gas. Transfer of these products to customers will be via ship loading facilities located off the east coast of Barrow Island (for LNG and condensate) and via a pipeline to the mainland (for domestic gas).

The Foundation Project is currently under construction and is due to start production in 2015.

Further information on the Foundation Project, including its construction progress and its environmental management and performance, is provided in Section 3.

1.3.4 Location

The regional location of the Fourth Train Proposal Area is shown in Figure 1-1.

The gas fields to be developed as part of the Fourth Train Proposal are within the Greater Gorgon Area, and consist of the Geryon, Chandon, Orthrus, and Maenad gas fields. Approval is being sought in this PER/Draft EIS for hydrocarbons from these gas fields to be sent to Barrow Island for treatment at the Gas Treatment Plant. Other gas fields are planned to be developed over the life of the Gorgon Project but these fields are not included in this PER/Draft EIS for assessment.

The Fourth Train Proposal Area is located in the Carnarvon Basin within the North West Shelf, an extensive oil and gas region off the Pilbara coast of Western Australia, approximately 1200 km north of Perth and 120 km west-south-west of Dampier (Figure 1-1). Water depths in the Greater Gorgon Area reach approximately 1500 m.

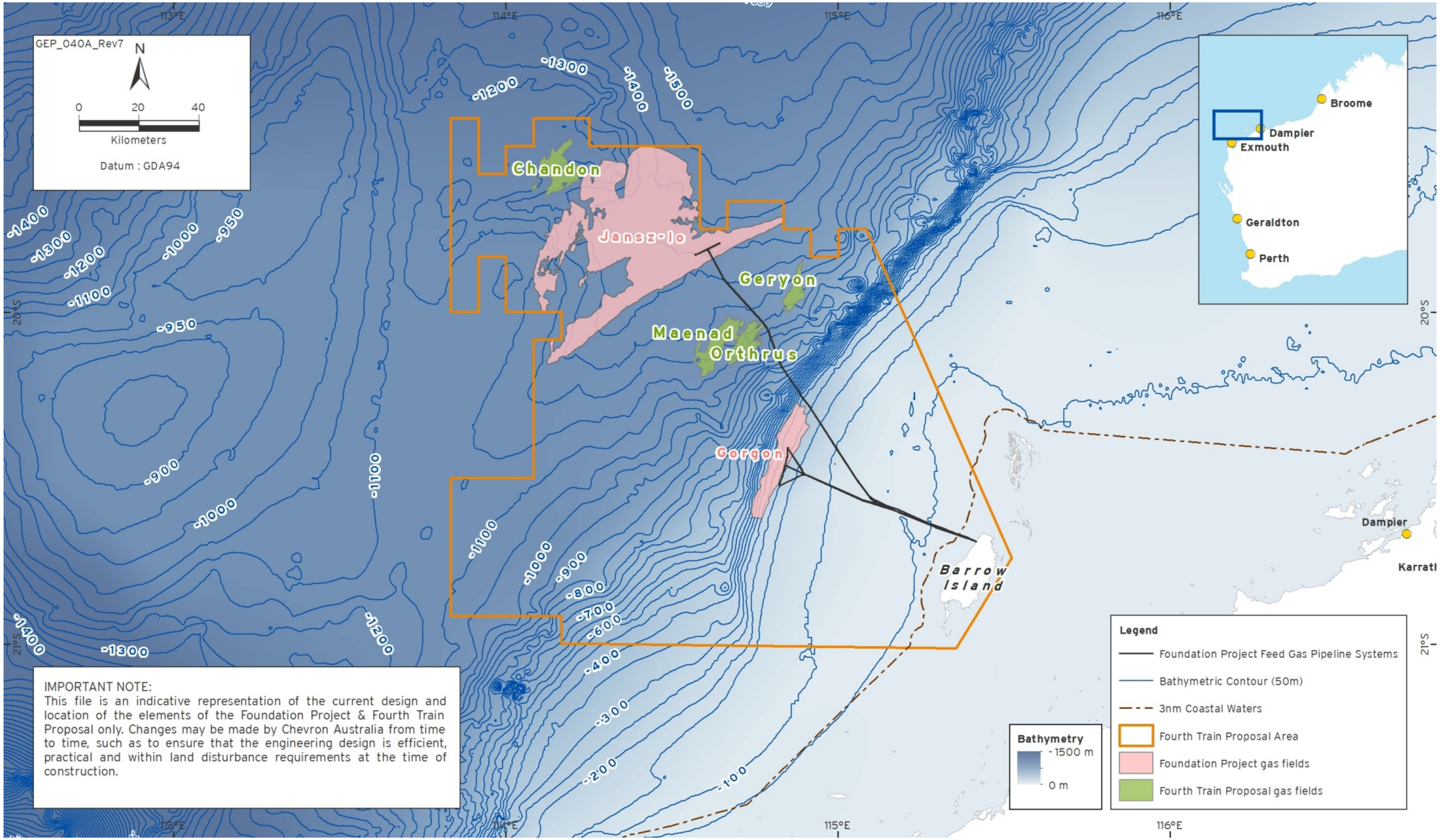

Figure 1-1: Fourth Train Proposal Location

The Feed Gas Pipeline System that will transport the gas gathered from the offshore fields to the Gas Treatment Plant traverses both the Commonwealth Marine Area and State Waters. It will cross Barrow Island over a length of approximately 14 km.

The proposed fourth LNG train will be added to the Gas Treatment Plant, which is currently being constructed as part of the Foundation Project, at Town Point on the east coast of Barrow Island.

Barrow Island is located approximately 70 km off the north-west coast of WA.

1.3.5 Fourth Train Proposal Objectives

The primary objectives of the Fourth Train Proposal are to:

- commercialise the identified recoverable gas and condensate reserves from the Greater Gorgon Area
- continue to protect the conservation values of Barrow Island and its surrounding waters
- manage environmental, health, safety, and security issues responsibly and in accordance with Chevron Corporation (Chevron) standards and recognised global industry standards
- provide an acceptable return on investment.

These objectives are in line with both Commonwealth and Western Australian (State) Government policies that earmark the resource industry as a key driver of sustainable economic growth. Ultimately, development of the Fourth Train Proposal is expected to generate economic benefits to the nation, the State, and the Pilbara Region through income derived by the government (e.g. through the payment of taxes by the GJVs and by the workers and businesses associated with the Fourth Train Proposal), and from employment and business/service income generated by the Fourth Train Proposal. Developing the Fourth Train Proposal now rather than at a future date enables the economic benefits to the nation and the State to be realised sooner. Section 14.8 describes the economic impacts of the Fourth Train Proposal in further detail.

1.3.6 Development Timeline

The Fourth Train Proposal is currently undergoing feasibility studies and preliminary engineering design. Subject to the outcome of these studies, construction of the Fourth Train Proposal is planned to commence after the Foundation Project has started operating. Construction also requires primary environmental approval, which is expected in the first quarter (Q) of 2015 (Figure 1-2).

The major construction activities for the Fourth Train Proposal are expected to take approximately five years to complete. Additional Fourth Train Proposal gas fields will be developed to maintain the supply of gas into the Gas Treatment Plant. It is expected that drilling additional wells and constructing tie-backs to the Feed Gas Pipeline via intrafield flowlines will take approximately two to three years per gas field.

Construction of the Fourth Train Proposal may be conducted in stages; in particular, gas fields included in the Fourth Train Proposal and associated infrastructure may be developed to support the three-train Foundation Project before the fourth LNG train is constructed.

If the Fourth Train Proposal is implemented as a staged development to provide additional gas for the three-train Foundation Project, the required infrastructure including the wells and control umbilicals are expected to take an additional three years (approximately) to construct per gas field. If the additional LNG Tank is required and is constructed independently of other works within the Gas Treatment Plant, this construction is expected to take approximately four years. Refer to Section 4 for additional detail on the infrastructure that may be staged.

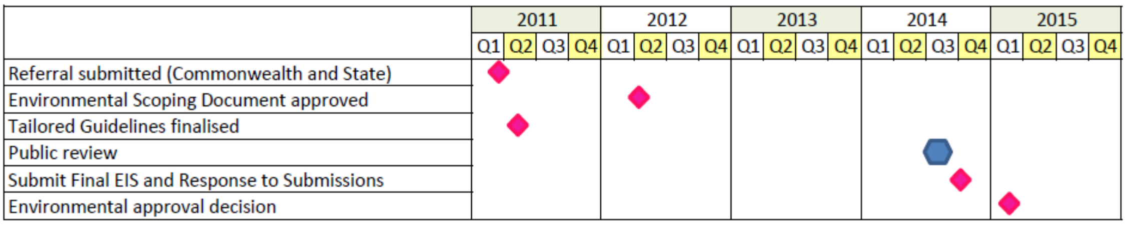

Figure 1-2: Indicative Environmental Approvals Timeline for the Fourth Train Proposal

The production life of the proposed fourth LNG train will fall within the first long-term lease period of 60 years allowed under the Gorgon Gas Processing and Infrastructure Project Agreement (State Agreement) that is Schedule 1 to the *Barrow Island Act 2003* (WA) (Section 2.1.2.2).

1.3.7 Proponent Details

Chevron Australia is the proponent for and operator of the Fourth Train Proposal on behalf of the following companies, collectively known as the Gorgon Joint Venturers (GJVs):

- Chevron Australia Pty Ltd
- Chevron (Texaco Australia Pty Ltd [TAPL]) Pty Ltd
- Shell Development (Australia) Pty Ltd
- Mobil Australia Resources Company Pty Limited
- Osaka Gas Gorgon Pty Ltd
- Tokyo Gas Gorgon Pty Ltd
- Chubu Electric Power Gorgon Pty Ltd.

The contact person at Chevron Australia for the Fourth Train Proposal is:

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Email: ask@chevron.com

1.4 Approach to Preparing this PER/Draft EIS

Following referral of the Fourth Train Proposal in April 2011, the Commonwealth and State Governments agreed to assess a single PER/Draft EIS document that satisfies the requirements of both jurisdictions. The steps in the environmental assessment process for the Fourth Train Proposal to meet both EPBC Act and EP Act requirements are shown in Figure 1-3. Steps in the approval process that are already complete (i.e. referral and scoping/guidelines) are explained in Sections 1.4.1 and 1.4.2.

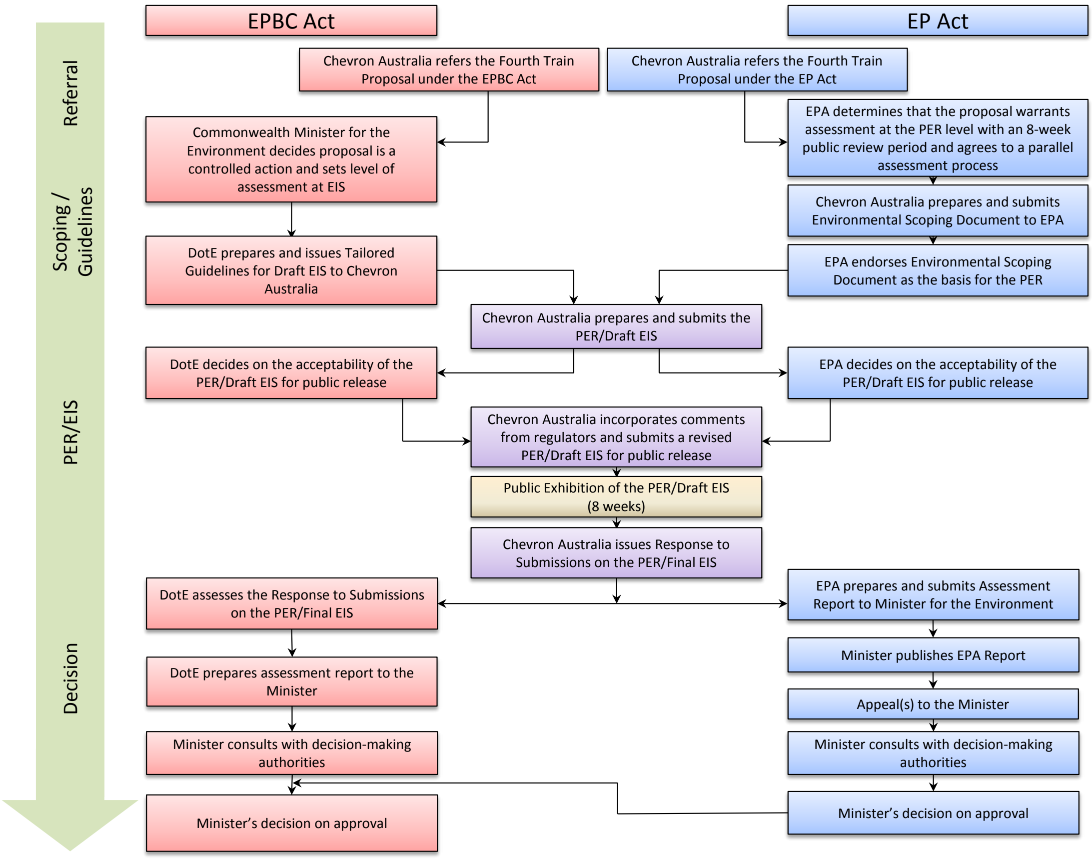

Figure 1-3: Environmental Approvals Process for the Fourth Train Proposal

The approach adopted by the GJVs to complete this PER/Draft EIS has drawn extensively on the environmental approvals documentation prepared for the Foundation Project. Where the findings of these Foundation Project deliverables are used in this PER/Draft EIS, the relevant document is referenced. Section 8 describes in further detail the approach and method used to assess the impacts of the Fourth Train Proposal.

Given the close relationship and synergies between the Fourth Train Proposal and the Foundation Project, this PER/Draft EIS was written by a team of in-house specialists and subject matter experts, supported where necessary by third-party technical expertise. As a large number of internal staff at Chevron Australia were involved in preparing this document, their individual names are not provided.

This PER/Draft EIS document was prepared during the 'generate alternatives' phase of the Fourth Train Proposal development, which is when different alternatives to achieve the objectives of the Fourth Train Proposal are investigated, evaluated, and the preferred alternative(s) selected. Therefore, the GJVs cannot provide precise engineering design details or precise locations of some of the infrastructure yet. Where options remain, these are described and included where appropriate in this assessment. Approval is being sought to encompass all options that the GJVs are still considering for the Fourth Train Proposal, as described in Section 4.

The GJVs believe that conditions equivalent to or consistent with those approved for the Foundation Project, when applied in conjunction with current regulations, will effectively manage the environmental aspects of the Fourth Train Proposal. This is discussed in Section 16.2.3.2.

1.4.1 Commonwealth Environmental Impact Assessment Process

The Fourth Train Proposal was referred to the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities under the EPBC Act on 27 April 2011

(Chevron Australia 2011). On 3 June 2011, SEWPaC deemed that the Fourth Train Proposal was a 'controlled action' under the EPBC Act, based on these controlling provisions:

- national heritage places (sections 15B and 15C)
- listed threatened species and communities (sections 18 and 18A)
- listed migratory species (sections 20 and 20A)
- Commonwealth Marine Areas (sections 23 and 24A).

SEWPaC set the level of assessment as an EIS (EPBC Reference: 2011/5942; SEWPaC 2011) and subsequently issued a set of Tailored Guidelines for the Preparation of a Draft Environmental Impact Statement of the Fourth Train Proposal (EPBC Reference: 2011/5942) (hereinafter referred to as SEWPaC's Tailored Guidelines) to Chevron Australia (SEWPaC 2011a).

As shown in Figure 1-3, DotE will assess this PER/Draft EIS document prior to its release for public review and following issue of the Response to Submissions on the PER/Final EIS (incorporating the GJVs' responses to public submissions). DotE will deliver their assessment report to the Commonwealth Minister for the Department of the Environment, who will then decide whether he/she approves the taking of the controlled action and, if so, under what conditions.

1.4.2 Western Australian Environmental Impact Assessment Process

The Fourth Train Proposal was referred to the EPA on 27 April 2011 (Chevron Australia 2011a). On 23 May 2011, the EPA determined that the Fourth Train Proposal required assessment at the level of a PER with an eight-week public review period (EPA Assessment No. 1889; EPA 2011). Comments from government agencies and from the public will assist the EPA to prepare an assessment report in which it will make recommendations to government.

In accordance with this decision, the GJVs prepared and issued an Environmental Scoping Document (Chevron Australia 2012) to seek EPA endorsement of the scope of the assessment of the Fourth Train Proposal, and provided an indicative timeline for the assessment process. The Draft Environmental Scoping Document was submitted to the Office of the EPA (OEPA) on 6 October 2011 to obtain the OEPA's, and other Decision Making Authorities' (DMAs) comments and feedback. The draft document included a summary of the environmental impacts reasonably expected from the Fourth Train Proposal, the proposed scope of work to assess these impacts in the PER/Draft EIS, an assessment schedule, and the study team. The Final Environmental Scoping Document, incorporating Chevron Australia's responses to the OEPA, the EPA Board, and other DMAs' comments, was endorsed by the EPA on 30 May 2012.

The Environmental Scoping Document was prepared to satisfy Schedule 2 of the EPA's Environmental Impact Assessment Administrative Procedures 2010 (EPA 2010) and in accordance with the EPA's Guide to Preparing an Environmental Scoping Document (EPA 2010a).

1.5 Subsequent Approvals

Section 16.2.4.1 lists the key additional Commonwealth and State approvals that may be required for the Fourth Train Proposal after approval of this PER/Draft EIS.

1.6 Relationship with Other Actions in the Region

Once operational, the Fourth Train Proposal and the Foundation Project will be operated as a single entity on Barrow Island. The Foundation Project is described in Section 3. The WA Oil facility on Barrow Island is operated by Chevron Australia; WA Oil has been exploring for oil, and producing oil from onshore facilities, since 1967. The Fourth Train Proposal may use land on Barrow Island that has already been cleared and used in the past by WA Oil and by the Foundation Project. Further details are provided in Section 4.4.

Other onshore developments within the vicinity of the Fourth Train Proposal Area include:

- existing oil and gas production facilities and associated infrastructure operated by Apache Energy at Varanus Island, located approximately 20 km north-east of Barrow Island
- Wheatstone LNG processing plant, domestic gas plant, and associated Ashburton North Strategic Industrial Area development currently under construction by Chevron Australia on the Western Australian mainland near Onslow, some 100 km south-west of Barrow Island
- existing industrial and power generation facilities on the Pilbara coast including the Pluto LNG processing facility, Karratha Gas Plant, Citic Pacific Power Station, Devils Creek Gas Project, Dampier Power Station, Cape Lambert Power Station, Yara Pilbara Fertilisers, Yurralyi Maya Power Station, and West Pilbara Power Station–Karratha
- future industrial sources including Balmoral South Power Station and pellet plants, Anketell Point Power Station, Macedon Domestic Gas Plant, and Burrup Nitrates facility.

The Fourth Train Proposal offshore elements form one of a number of offshore oil and gas developments (both planned or existing) in the North West Shelf area. Examples of developments within the vicinity of the Fourth Train Proposal Area include:

- existing surface production facilities in the John Brookes gas field
- existing subsea completion wells located in the Wonnich, Spar, East Spar, and Halyard gas fields
- the Floating Production Storage and Offloading Vessel associated with the Woollybutt subsea completion wells
- existing pipelines, and pipelines currently under construction or approved for construction that cross the Fourth Train Proposal Area including those associated with the Spar, East Spar, Halyard, John Brookes, and Wonnich gas fields, the Gorgon and Jansz Feed Gas Pipeline Systems, and the Wheatstone Feed Gas Pipeline.

Except for the development of the Gorgon and Jansz–Io fields and their associated Feed Gas Pipelines for the Foundation Project, there is no direct relationship between the Fourth Train Proposal and these other developments.

Potential cumulative impacts associated with the Fourth Train Proposal, the Foundation Project, and these other existing and reasonably foreseeable actions in the Fourth Train Proposal Area are discussed in Section 15.

1.7 Proponent's Environmental Commitment

Protecting people and the environment is a core company value for Chevron. This value is embodied within *The Chevron Way* (Chevron Corporation 2009), which is a publicly available document explaining who Chevron is, what Chevron does, and what Chevron plans to accomplish as a global energy company.

At the heart of *The Chevron Way* is the vision to be *the* global energy company most admired for its people, partnership, and performance. This includes earning the admiration of all stakeholders, including host governments and local communities, for not only the goals achieved but importantly, *how* they are achieved. How goals are achieved is embedded within the company culture where the emphasis is on keeping people and the environment injury- and incident-free. Chevron believes:

- All incidents can be prevented.
- There is always time to do the job right.
- All operating exposures can be safeguarded.
- Management is committed, visible, and accountable.

- Protecting our people, environment, and assets is good business.

Chevron Australia is committed to implement the Fourth Train Proposal in accordance with *The Chevron Way.*

1.7.1 Delivering 'Operational Excellence'

Chevron's commitment to implement *The Chevron Way* throughout its global activities, including the activities of Chevron Australia, is embodied in the term 'Operational Excellence' (OE). OE is the systematic management of safety, health, environment, reliability, and efficiency to drive progress towards world-class performance. OE aims to:

- achieve an injury-free workplace
- eliminate spills and environmental incidents, and identify and mitigate key environmental risks
- promote a healthy workplace and mitigate significant health risks
- operate incident-free with industry-leading asset reliability
- manage the efficient use of resources and assets.

Consistent with their undertaking for the Foundation Project, the GJVs are committed to developing the Fourth Train Proposal in a way that contributes to the community's aspiration for sustainable development. This includes continuing to protect the conservation values of Barrow Island; managing all environmental, health, and safety requirements responsibly; and implementing responsible practices throughout construction and operation of the Fourth Train Proposal.

1.7.2 Chevron Corporation's Operational Excellence Management System

The Chevron Australasia Strategic Business Unit (ABU) Policy 530 – Operational Excellence (Figure 1-4) sets the overall goal of protecting the safety and health of people and the environment through the implementation of OE. The Policy applies to all Chevron Australia projects, including the Foundation Project and the Fourth Train Proposal. The Policy establishes OE expectations, organised under 13 elements (as outlined in Figure 1-4). Achievement of OE is accomplished through disciplined application of an Operational Excellence Management System (OEMS). The OEMS is a standardised approach to consistently deliver and continuously improve OE; it applies to all Chevron capital projects and operational activities, including the Foundation Project and the Fourth Train Proposal.

The OEMS consists of three parts:

- **Leadership Accountability:** leaders are accountable not only for achieving results, but achieving them in the right way by behaving in accordance with Chevron's values.

- **Management System Process (MSP):** to drive progress towards world-class performance. The MSP comprises:
  - developing an OE vision and objectives
  - completing a comprehensive evaluation to identify priority areas in OE processes and performance against established objectives

  - developing three-year plans to manage priorities, and incorporating these plans into business plans and assigning accountabilities
  - implementing planned actions and monitoring plan progress and OE performance

- annually evaluating progress on performance and identifying necessary adjustments to plans.

- **OE Expectations**, which include:
    - designing and constructing facilities in an environmentally sound manner
    - environmental stewardship: working to prevent pollution and waste; striving to continually improve environmental performance; and limiting impacts from operations
    - complying and verifying conformance with company policy and all applicable laws and regulations.

Chevron has received attestation from Lloyd’s Register Quality Assurance that the OEMS is implemented throughout the organisation and is consistent with, and in some respects goes beyond the requirements of the International Organization for Standardization’s (ISO) 14001 Environmental Management System Standard (ISO 14001) and the Occupational Health and Safety Assessment Series management specification 18001. These standards are internationally recognised benchmarks for environmental and occupational health and safety performance management and demonstrate Chevron’s commitment to world-class performance.

Policy 530

Operational Excellence
Achieving World-Class Performance

Chevron
Human Energy™

It is the policy of Chevron Corporation to protect the safety and health of people and the environment and to conduct our operations reliably and efficiently. The systematic management of safety, health, environment, reliability and efficiency to achieve world-class performance is defined as Operational Excellence (OE). Our commitment to OE is embodied in The Chevron Way value of protecting people and the environment, which places the highest priority on the health and safety of our workforce and protection of our assets and the environment.

We will accomplish this through disciplined application of our Operational Excellence Management System (OEMS). Our OEMS consists of three parts: Leadership Accountability, Management System Process and OE Expectations.

The OEMS translates our priority of protecting people and the environment into world class performance. The OEMS is a comprehensive, proven means for systematic management of process, safety, personal safety & health, the environment, reliability and efficiency. Through disciplined application of the OEMS, we integrate OE processes, standards, procedures and behaviours into our daily operations. While leaders are responsible for managing the OEMS and enabling OE performance, every individual in Chevron's workforce is accountable for complying with the principles of "Do it safely or not at all" and "There is always time to do it right."

Line management has the primary responsibility for complying with this policy within their respective functions and authority limits. Line management will communicate this policy to their respective employees and will establish policies, processes, programs and standards consistent with expectations of the OEMS.

Employees are responsible for behavior consistent with all Company policies, processes, procedures, practices and laws applicable to their assigned duties and responsibilities. Accordingly, employees who are unsure of the legal or regulatory implications of their actions are responsible for seeking management or supervisory guidance.

Vision and Objectives	Developing an OE vision, world-class objectives, metrics and targets based on corporate objectives, benchmarking data and other applicable critical business drivers.
Assessment	Completing a comprehensive evaluation to identify priority areas in OE processes and performance against established objectives.
Planning	Developing three-year plans to manage priorities and incorporating those plans into business plans and assigning accountabilities.
Implemenation	Implementing planned actions and monitoring plan progress and OE performance.
Review	Annually evaluating progress on performance and identifying necessary adjustments to plans that result in the goal of achieving world-class results.

We will assess and take steps to manage potential risks to our employees, contractors, the public and the environment within the following framework of OE Expectations:

1. **Security of Personnel and Assets** Providing a secure environment in which business operations may be conducted successfully.
2. **Facilities Design and Construction** Designing and constructing facilities to prevent injury, illness and incidents and to operate reliably, efficiently and in an environmentally sound manner.
3. **Safe Operations** Operating and maintaining facilities in a manner that does not cause injuries, illnesses or incidents.
4. **Management of Change** Managing both permanent and temporary changes to prevent incidents.
5. **Reliability and Efficiency:**
   - › Reliability - Operating and maintaining facilities to sustain mechanical integrity and prevent incidents.
   - › Efficiency - Maximizing efficiency of operations and conserving natural resources.
6. **Third-Party Services** Systematically addressing and managing contractor conformance to OE through contractual agreements.
7. **Environmental Stewardship** Working to prevent pollution and waste; striving to continually improve environmental performance and limiting impacts from our operations.
8. **Product Stewardship** Managing potential risks of our products throughout the products' life-cycles.
9. **Incident Investigation** Investigating incidents to identify, broadly communicate and correct root causes of incidents to prevent future incidents.
10. **Community Awareness and Outreach** Reaching out to the community and engaging in open dialogue to build trust and long term positive relationships.
11. **Emergency Management** Having preparedness plans in place to quickly and effectively respond to and recover from any emergency.
12. **Compliance Assurance** Complying and verifying conformance with company policy and all applicable laws and regulations; applying responsible standards where laws and regulations do not exist; enabling employees and contractors to understand their safety, health and environmental responsibilities.
13. **Legislative and Regulatory Advocacy** Working ethically and constructively to influence proposed laws and regulations, and debate on emerging issues.

Roy Krzywosinski
Managing Director
23/12/2013

Figure 1-4: ABU Policy 530 – Operational Excellence

1.7.3 Environmental Record

Since 2006, Chevron Australia has drilled a number of wells off the North West Shelf of Australia, including deepwater, exploration, and production wells. All wells were drilled without significant environmental incident. All minor 'reportable' and 'recordable' environmental incidents were reported to the Regulator in accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009. Chevron Australia has also operated in an environmentally responsible manner on Barrow Island and Thevenard Island for approximately 40 years and has proven that it is possible for conservation and industry to successfully coexist.

As described in more detail in Section 3.5, the Foundation Project has been under construction on Barrow Island since late 2009 with no Material or Serious Environmental Harm occurring outside its approved impacts nor any material non-compliances that have resulted in environmental harm. Non-compliances with respect to the implementation of the Commonwealth and State Ministerial Conditions by the Foundation Project have been reported to DotE and the Chief Executive Officer of the Western Australian Department of Parks and Wildlife (DPaW) in accordance with the requirements of the Ministerial Conditions. However, these non-compliances were largely minor or procedural. Where relevant, these non-compliances have been the subject of corrective and preventive action plans. The non-compliances are documented in Compliance Reports available on Chevron Australia's website (under 'Reference Documents') at http://www.chevronaustralia.com/ourbusinesses/gorgon/environmentalresponsibility/environmentalapprovals.aspx). Unprecedented efforts have been taken by Chevron Australia to preserve the integrity of the unique features of Barrow Island. In doing so, Chevron Australia's environmental and quarantine management has earned national awards and recognition.

Chevron Australia confirms that it has not been subject to any proceedings under Commonwealth, State, or Territory law for the protection of the environment or the conservation and sustainable use of natural resources.

1.8 State and Commonwealth Considerations for Sustainability

Principles of ecologically sustainable development are incorporated as objectives in both the EPBC Act and the EP Act. Table 1-1 sets out the relevant principles and explains how they are being taken into account for the Fourth Train Proposal.

Table 1-1: Objects and Principles of the EPBC Act and EP Act

Principle	Aim	Requirement of	Relevant?	If Yes, Proposal Consideration
Integration	Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social, and equitable considerations	EPBC Act	Yes	The commercial success of the Fourth Train Proposal throughout its lifetime depends on the successful management of short-term and long-term environmental and social impacts. Through their experience with the Foundation Project, the GJVs are committed to providing the necessary financial and organisational capability to successfully achieve this outcome.
Precautionary	Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation	EPBC Act EP Act	Yes	The management framework already being implemented for the Foundation Project and proposed to be extended to incorporate the Fourth Train Proposal includes a number of activities to manage uncertainties over environmental impacts. Those that are relevant to the Fourth Train Proposal include an undertaking to manage light and noise impacts, and to monitor populations of turtles for project-attributable impacts despite a lack of full scientific understanding of potential impacts. The approach adopted to assess potential environmental impacts of the Fourth Train Proposal in this PER/Draft EIS reflects a precautionary approach.
Intergenerational equity	The present generation should ensure that the health, diversity, and productivity of the environment is maintained or enhanced for the benefit of future generations	EPBC Act EP Act	Yes	Under the Foundation Project, the GJVs have committed to a set of management measures aimed at ensuring the long-term preservation of the environmental values of Barrow Island as a Class A nature reserve. These include post-construction rehabilitation plans and decommissioning management plans. The GJVs intend to extend this same set of management measures to the Fourth Train Proposal.
Biodiversity	Conservation of biological diversity and ecological integrity should be a fundamental consideration in decision making	EPBC Act EP Act	Yes	Achievement of this principle lies at the heart of the permission granted to the GJVs under the *Barrow Island Act 2003* (WA) for the restricted use of Barrow Island for gas processing purposes. This responsibility underpins the GJVs' entire approach for developing and implementing the Foundation Project and the Fourth Train Proposal and is evidenced by the Environmental Management and Monitoring Plans, Programs, Systems, Procedures, and Reports (together referred to as EMPs) required under Ministerial Conditions for the precautionary management of environmental impacts. The objectives established to determine the predicted environmental outcomes in this PER/Draft EIS reflect this principle.

Principle	Aim	Requirement of	Relevant?	If Yes, Proposal Consideration
Valuation	Improved valuation, pricing, and incentive mechanisms should be promoted (e.g. ‘polluter pays’ principle, consideration of life cycle costs)	EPBC Act EP Act	Yes	As the operator of the Fourth Train Proposal on behalf of the GJVs, Chevron Australia’s internal decision-making processes and tools will be used for the Fourth Train Proposal. The environmental implications (including their associated costs where relevant) are incorporated into these systematic decision-making processes, which aim to deliver world-class performance in safety, health, environment, reliability, and efficiency through OE (see Section 1.7.1). For example, market prices were taken into account along with technical, economic, health and safety, operability, and reliability criteria when selecting the proposed design options and alternatives for the Fourth Train Proposal (e.g. Section 11).
Waste minimisation	All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment	EP Act	Yes	Reasonable and practicable measures will be taken to reduce wastes generated by the Fourth Train Proposal (Section 5). These measures are driven by Chevron Australia’s ‘Operational Excellence’ business philosophy, which includes the aim of managing the efficient use of resources (see Section 1.7.1), and by a key element of the ABU Policy 530 (Figure 1-4): namely ‘working to prevent pollution and waste; striving to continually improve environmental performance; and limiting impacts from operations’. This principle is also reflected in the various EMPs that were approved for the Foundation Project, and that will be adopted, where applicable and with relevant amendments, for the Fourth Train Proposal. These EMPs include the Solid and Liquid Waste Management Plan and activity-specific EMPs (e.g. the Horizontal Directional Drilling Management and Monitoring Plan).

1.9 Structure of this Document

This PER/Draft EIS comprises:

- **Executive Summary** – summarises the content of the PER/Draft EIS including the background and need for the Fourth Train Proposal, environmental and social factors, key potential impacts, illustrative mitigation and management measures, and the predicted environmental and social outcome of implementing the Fourth Train Proposal
- **Section 1, Introduction** (this Section) – introduces the Fourth Train Proposal, its proponents, and the proponents' environmental commitment; explains the objective and scope of the PER/Draft EIS; and introduces the approach adopted to complete the assessment to meet both Commonwealth and State EIS and PER requirements respectively
- **Section 2, Legislative Framework** – outlines the principal Commonwealth and State regulations, policies, plans, and guidelines relevant to the Fourth Train Proposal
- **Section 3, Foundation Project Overview** – introduces the approved Foundation Project including a summary of its key components, the status of construction activities, its approvals history, its environmental management framework, and a summary of performance and experience in managing its environmental impacts
- **Section 4, Proposal Description and Alternatives** – describes the components and activities of the Fourth Train Proposal relevant to this PER/Draft EIS, and includes an analysis of the alternatives considered by the GJVs
- **Section 5, Emissions, Discharges, and Wastes** – describes the predicted emissions, discharges, and wastes expected to be generated by the Fourth Train Proposal along with those of the Foundation Project and other existing sources on Barrow Island, where relevant; assesses the change in emissions, discharges, and wastes introduced by the Fourth Train Proposal compared to those approved for the Foundation Project, with reference to standards and guidelines; and presents the results of hydrocarbon spill modelling
- **Section 6, Environmental and Social Baseline** – describes the receiving environment (terrestrial, marine, and social) that the Fourth Train Proposal has the potential to impact
- **Section 7, Stakeholder Engagement** – describes consultation with stakeholders to date, as well as planned stakeholder engagement
- **Section 8, Assessment Method** – explains the approach and method adopted to assess the impacts of the Fourth Train Proposal in this PER/Draft EIS
- **Section 9, Terrestrial Environment – Impacts and Management** – assesses the potential impacts of the Fourth Train Proposal on the terrestrial environment and describes the mitigation and management measures to be implemented
- **Section 10, Coastal and Nearshore Environment – Impacts and Management** – assesses the potential impacts of the Fourth Train Proposal on the coastal and nearshore environment under State jurisdiction and describes the mitigation and management measures to be implemented
- **Section 11, Greenhouse Gas Emissions and Energy Management** – describes the predicted emissions of greenhouse gases from the Fourth Train Proposal, the options considered to reduce these emissions, and the mitigation and management measures to be implemented
- **Section 12, Quarantine Management** – describes how impacts associated with the potential introduction of non-indigenous species onto Barrow Island and into its surrounding waters will be mitigated and managed

- **Section 13, Matters of National Environmental Significance – Impacts and Management** – assesses the potential impacts of the Fourth Train Proposal on relevant controlling provisions of the EPBC Act and describes the mitigation and management measures to be implemented
- **Section 14, Social, Cultural, and Economic Impacts and Management** – assesses the potential impacts of the Fourth Train Proposal on social, cultural, and economic factors and describes the mitigation and management measures to be implemented
- **Section 15, Cumulative Impacts** – discusses the potential cumulative impacts resulting from the Fourth Train Proposal and the approved Foundation Project when combined with other past, present, and reasonably foreseeable future actions
- **Section 16, Environmental Management Framework** – describes the environmental management framework to be implemented for the Fourth Train Proposal.

Additional information, including the technical studies completed to support this PER/Draft EIS, is provided in accompanying Appendices, as listed in Table 1-2.

Table 1-2: Fourth Train Proposal Technical Appendices

Appendix	Topic		Report	Title
A	Project Characteristics		-	Project Characteristics
B	Regulatory Submissions		B1	EPA Checklist for Documents Submitted for Environmental Impact Assessment (EIA) on Marine and Terrestrial Biodiversity
			B2	State (Environmental Scoping Document) Requirements for the Contents of this PER
			B3	Commonwealth (Tailored Guidelines) Requirements for Contents of this Draft EIS
			B4	Public Environmental Review – Environmental Scoping Document
C	Stakeholder Engagement		-	Key Stakeholder List
D	Technical Studies	Air Pollutants	D1	Gorgon Gas Development Fourth Train Proposal Air Quality Assessment
		Air Toxics	D2	Gorgon Expansion Project Phase 2 Acid Gas Vent Dispersion Modelling
		Light Spill	D3	Gorgon Light Emissions Study – Fourth Train Proposal
		Noise Impacts	D4	Cumulative Noise Impact Study for the Gorgon Expansion Project Barrow Island LNG Plant
		Hydrocarbon Spills and Leaks	D5	Assessment of Environmental Risk – Hydrocarbon Spill

Appendix	Topic		Report	Title
E	Environmental Baseline	Survey Details	E1	Key Foundation Project Survey, Audit and Environmental Reporting
		Flora and Vegetation	E2	Conservation Significant Species Considered for Assessment in this PER/Draft EIS
		Non-Indigenous Species	E3	Restricted Distribution Flora Species on Barrow Island
		Protected Species	E4	Detected Non-Indigenous Terrestrial Species Currently on Barrow Island
F	Environmental Risk Assessment		F1	Risk Assessment Consequence Criteria
			F2	Consolidated Risk Assessment Results
G	Incidents		-	Foundation Project Incidents Relevant to the Assessment of the Fourth Train Proposal

1.9.1 Document Structure for Matters of Commonwealth and State Jurisdiction

This PER/Draft EIS covers the environmental assessment requirements of both the Commonwealth and State jurisdictions. Table 1-3 and Table 1-4 summarise where Commonwealth and State requirements, respectively, are presented in this document; further details are provided in Appendices B2 [State (Environmental Scoping Document) Requirements for the Contents of this PER] and B3 [Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS]. A copy of the final approved version of the Environmental Scoping Document is provided in Appendix B4 [Public Environment Review – Environmental Scoping Document].

Table 1-3: Adherence to SEWPaC's Tailored Guidelines for Draft EIS

Guideline Section Ref.	Requirement	Where addressed in this PER/Draft EIS
-	Assessment of relevant matters protected under the EPBC Act must be presented in a stand-alone section	Section 13
1	Executive Summary that outlines the key findings of the EIS	Executive Summary
2	General background information about the proposed action, including its background, current status, its relationship with other actions in the region, and a description of the legislative and policy framework relevant to the proposed action	Sections 1, 2, and 4
3	Details of any consultation about the proposed action	Section 7
4	Description of any prudent and feasible alternatives to the proposed action	Section 4
5	Description of the aspects of the proposed action that may have relevant impacts on matters protected by the controlling provisions of the Proposal	Sections 4 and 5

Guideline Section Ref.	Requirement	Where addressed in this PER/Draft EIS
6	Description of the environment including: • identification of all threatened species, ecological communities, migratory species, and National Heritage places listed under the EPBC Act that are likely to be impacted by the Fourth Train Proposal, including in the event of a hydrocarbon spill • description of the characteristics of the marine environment • discussion of the likely presence of any unique, rare, threatened, endangered, or vulnerable flora and fauna species and communities, or listed migratory species, relevant to the proposed action • description of the heritage values of any National or World Heritage places • identification of any existing or proposed reserves within or in proximity to the area that is likely to be impacted by the Fourth Train Proposal	Sections 6, 9, 10, and 14
7	Description of the relevant impacts of the Fourth Train Proposal on matters protected by the controlling provisions of the Proposal	Section 13 with cross-references to Sections 5, 9, and 10
7	Analysis of the likelihood of a range of spill scenarios including hydrocarbon spill trajectory modelling, a description of relevant impacts, and consequences for all protected matters likely to be impacted should a blowout or spill occur, and the response measures that would be undertaken in the event of a blowout or other leaks/spills	Sections 5 and 13, with cross-references to Section 10
8	Description of relevant impacts of the proposed action to the Commonwealth Marine Environment	Sections 13, 5, and 14
8	Description of the economic and social matters relevant to the proposed action	Section 14
9	Explanation of the overall environmental management philosophy and management system that will be applied to the proposed action	Sections 16 and 5 (the latter for reference to emergency contingency plans)
10	Description of the proposed safeguards, mitigation measures and monitoring programs to address relevant impacts of the Fourth Train Proposal on matters of National Environmental Significance (NES)	Sections 13, 5, 9, 10, and 16
11	Description of any strategies proposed to offset (compensate for) any impacts that cannot be avoided or mitigated	Section 16
12	Information on other requirements for approval or conditions that apply to the controlling provisions for the proposed action	Section 16
13	Description of the environmental record of the proponent	Section 1
14	An overall conclusion on the environmental acceptability of the Fourth Train Proposal	Executive Summary

Table 1-4: Adherence to State Requirements for this PER/Draft EIS

Requirement [1]	Where addressed in this PER/Draft EIS
Comprehensive description of the proposal including:	
• identification of the proponent	Section 1.3.7
• identification of the proposal location	Section 1.3.4
• justification and objectives of the proposed development	Section 1.3.5
• legislative framework including existing zoning and environmental approvals, decision-making authorities, and involved agencies	Sections 2 and 16
• alternatives considered including location options	Section 4.2
• description of the proposal in sufficient detail to support this document	Section 4
• summary of key characteristics of the proposal	Table 4-2 and Table 4-7 in Section 4
• timing and staging of the proposal	Section 1.3.6 and Figure 1-2
Plans, specifications, and charts showing location and elements of the proposal including:	
• map showing the proposal in the local context – overlay of the proposal against main environmental constraints	See various figures in Section 6
• map showing the proposal in the regional context	Figure 1-1
• a process chart/mass balance diagram showing inputs, outputs, and waste streams	Figure 5-1
Description of the existing environment in a local and regional context	Section 6
Discussion of impacts associated with relevant environmental factors (as agreed from Scoping Document)	Sections 9 to 15
Summary table describing results for each relevant environmental issue/factor	Executive Summary
Table showing how consideration has been given to the principles of environmental protection	Table 1-1
Description of the environmental management system that will be implemented	Sections 1.7 and 16
Description of the public participation and consultation activities undertaken during the preparation of this PER/Draft EIS	Section 7
Conclusion indicating the proponents' view of the environmental costs and benefits of the proposal, a synthesis of the preceding relevant information, and whether the proposal is expected to achieve an overall net environmental benefit	Executive Summary

1. *Refers to requirements set out in Guidelines for Preparing a Public Environmental Review (EPA 2010b) and Environmental Scoping Document (Chevron Australia 2012).*

1.10 References Cited in Section 1

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Mobil Australia Resources Limited. 2005. *Referral of a Proposal to the Environmental Protection Authority under Section 38(1) of the* Environmental Protection Act *– Jansz Feed Gas Pipeline*. 7 February 2005. Mobil Australia, Perth, Western Australia.

Mobil Exploration and Producing Australia Pty Ltd. 2006. *Referral of Proposed Action – Jansz Feed Gas Pipeline*. [Referral under EPBC Act to Department of Environment Water, Heritage and the Arts]. 17 June 2005. Mobil Australia, Perth, Western Australia.

Section 2: Table of Contents

List of Tables

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2. Legislative Framework

The Gorgon Gas Development Fourth Train Proposal (Fourth Train Proposal) is subject to both Australian (Commonwealth) and Western Australian (State) legislation. The principal Commonwealth and State Acts are summarised in Section 2.1. Other agreements, standards, guidelines, and international treaties and conventions that are likely to be relevant to the Fourth Train Proposal are summarised in Section 2.2.

2.1 Commonwealth and Western Australian Legislation

Key Commonwealth and State environmental and activity-specific legislation relevant to the assessment of environmental impacts of the Fourth Train Proposal is listed in Table 2-1. The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Western Australian *Environmental Protection Act 1986* (EP Act), as the principal Acts for environmental protection, are described in Sections 2.1.1.1 and 2.1.2.1, respectively. In addition to these Acts, the Gorgon Gas Processing and Infrastructure Project Agreement (State Agreement) and its ratifying Act, the *Barrow Island Act 2003* (WA) (Barrow Island Act), govern the use of Barrow Island by the GJVs; these are described in Section 2.1.2.2.

Table 2-1: Primary Legislation Relevant to the Assessment of Fourth Train Proposal Impacts

Commonwealth	State
• *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* • *Australian Heritage Council Act 2003* • *Australian Maritime Safety Authority Act 1990* • *Clean Energy Act 2011* • *Energy Efficiency Opportunities Act 2006* • *Environment Protection and Biodiversity Conservation Act 1999* • *Environment Protection (Sea Dumping) Act 1981* • *Hazardous Waste (Regulations of Exports and Imports) Act 1989* • *Historic Shipwrecks Act 1976* • *National Greenhouse and Energy Reporting Act 2007* • *Navigation Act 1912* • *Offshore Petroleum and Greenhouse Gas Storage Act 2006* • *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* • *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* • *Quarantine Act 1908*	• *Aboriginal Heritage Act 1972* • *Barrow Island Act 2003* • *Bushfires Act 1954* • *Conservation and Land Management Act 1984* • *Contaminated Sites Act 2003* • *Dangerous Goods Safety Act 2004* • *Environmental Protection Act 1986* • *Fish Resources Management Act 1994* • *Heritage of Western Australia Act 1990* • *Land Administration Act 1997* • *Litter Act 1979* • *Local Government Act 1995* • *Marine and Harbours Act 1981* • *Maritime Archaeology Act 1973* • *Petroleum (Submerged Lands) Act 1982* • *Petroleum and Geothermal Energy Resources Act 1967* • *Petroleum Pipelines Act 1969* • *Planning and Development Act 2005* • *Pollution of Waters by Oil and Noxious Substances Act 1987* • *Shipping and Pilotage Act 1967* • *Soil and Land Conservation Act 1941* • *Western Australian Marine Act 1982* • *Western Australian Marine (Sea Dumping) Act 1981* • *Wildlife Conservation Act 1950*

2.1.1 Principal Commonwealth Legislation

2.1.1.1 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act is the principal statute providing a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities, and heritage places—these are defined under the Act as matters of National Environmental Significance (NES). The EPBC Act focuses Commonwealth interest on the protection of matters of NES, with the states and territories having responsibility for environmental protection generally. The key objectives of the EPBC Act include:

- provide for the protection of the environment, especially those aspects of the environment that are matters of NES
- promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources
- promote the conservation of biodiversity
- provide for the protection and conservation of heritage
- promote a cooperative approach to the protection and management of the environment involving governments, the community, landholders, and indigenous peoples
- assist in the cooperative implementation of Australia's international environmental responsibilities
- recognise the role of indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity
- promote the use of indigenous peoples' knowledge of biodiversity with the involvement of, and in cooperation with, the owners of the knowledge.

The EPBC Act also sets out the national environmental impact assessment and approvals framework for environmental impacts on matters of NES. This Commonwealth approvals process is triggered by an action that will, or is likely to, have a significant impact on a matter of NES, of which these are relevant to the Fourth Train Proposal:

- national heritage places
- listed threatened species and communities
- listed migratory species
- Commonwealth Marine Areas.

Implementation of the EPBC Act is administered by the Commonwealth DotE.

2.1.1.2 Offshore Petroleum and Greenhouse Gas Storage Act 2006

The *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth) (OPGGS Act) provides the regulatory framework for the exploration and recovery of petroleum and for the injection and storage of greenhouse gas substances in offshore areas. The National Offshore Petroleum Safety and Environment Management Authority (NOPSEMA) administers the OPGGS Act provisions relating to occupational health and safety, structural integrity, and environmental management. The OPGGS Act contains a broad requirement for titleholders to operate in accordance with 'good oilfield practice'. The OPGGS Act also requires activities to be carried out in a manner that does not interfere with other rights, including conservation of the resources of the sea and seabed.

The Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth) (Environment Regulations) are regulations made under the OPGGS Act. The object of the Environment Regulations is to ensure that any petroleum activity or greenhouse gas activity in an offshore area is carried out in a manner:

- that is consistent with the principles of ecologically sustainable development set out in section 3A of the EPBC Act
- by which the environmental impacts and risks of the activity will be reduced to as low as reasonably practicable
- by which the environmental impacts and risks of the activity will be of an acceptable level.

NOPSEMA's environmental management authorisation process was endorsed by the Commonwealth Minister for the Environment as a Program on 7 February 2014. Activities undertaken in accordance with this Program and that fall within a class of actions approved by the Minister for the Environment, will not require referral, assessment, and approval under the EPBC Act. If a Proponent already has an EPBC Act referral or assessment under consideration by the DotE prior to commencement of this Program, the Proponent will have the option to withdraw the referral. If the referral is withdrawn the Proponent may be required to have an Offshore Project Proposal accepted by NOPSEMA. Alternatively, a Proponent may continue with the EPBC Act process. The Fourth Train Proposal was referred under the EPBC Act and the level of assessment was set in 2011 (Section 1.4.1). The GJVs are continuing with the existing EPBC Act process for the Fourth Train Proposal.

2.1.2 Principal State Legislation

2.1.2.1 Environmental Protection Act 1986

The EP Act and its associated regulations are the principal authorities for environmental protection in Western Australia (WA). The Act sets out to prevent, control, and abate pollution and environmental harm, for the conservation, preservation, protection, enhancement, and management of the environment. The EP Act is administered by DPaW, the Department of Environment Regulation (DER), and the EPA.

The two parts of the EP Act that are of particular relevance to the Fourth Train Proposal are Part IV, which governs the environmental impact assessment of proposals, and Part V, which deals with prescribed facilities and activities that may potentially cause pollution and environmental harm. The environmental impact assessment provisions of the EP Act in Part IV are triggered by proposals that are likely, if implemented, to have a significant effect on the environment.

The EPA has developed a series of guidance statements for the assessment of environmental impacts in accordance with the EP Act. The guidance statements are designed to assist project proponents and the public to understand the requirements for protection of the environment under the EP Act. Section 2.2.2 provides a summary of the guidance statements that are likely to be relevant to the Fourth Train Proposal.

2.1.2.2 Barrow Island Act and State Agreement

The State Agreement was signed by the Premier of Western Australia and representatives of the GJVs on 9 September 2003 and was subsequently ratified, with its implementation authorised by enactment of the Barrow Island Act. The State Agreement and Barrow Island Act set out the rights and obligations of both the GJVs and the State Government regarding the development of gas processing facilities on Barrow Island. In particular, the State Agreement and the Barrow Island Act:

- allow for the authorisation of proposals to transport offshore gas and other petroleum by pipeline for processing on Barrow Island
- limit the area of uncleared land to be available for tenure on Barrow Island for gas processing purposes
- allow for the authorisation of underground disposal of carbon dioxide recovered during gas processing on Barrow Island

- have regard for the need to minimise environmental disturbance on Barrow Island and provide support for conservation programs.

2.1.2.3 Conservation and Marine Reserves

Barrow Island is reserved under the *Land Administration Act 1997* (WA) as a Class A nature reserve for the purposes of 'Conservation of Flora and Fauna'. Barrow Island's classification as a Class A nature reserve is regulated under the *Conservation and Land Management Act 1984* (WA) (CALM Act). However, the Barrow Island Act makes provision for land on Barrow Island to be used for gas processing purposes.

The State Waters surrounding Barrow Island are part of the Barrow Island Marine Management Area, which contains the Barrow Island Marine Park and the Bandicoot Bay Conservation Area. The area around the Montebello Islands is part of the Montebello Islands Marine Park. The Montebello/Barrow Island Marine Parks are reserved under the CALM Act.

2.2 Other Relevant Environmental Management Instruments

2.2.1 International Agreements, Guidelines, and Standards

Australia is signatory to numerous international treaties, conventions, and agreements that obligate the Commonwealth Government to prevent pollution and to protect specified habitats, flora, and fauna. Those that are likely to be relevant to the assessment of Fourth Train Proposal impacts include, but are not limited to:

- Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986, commonly referred to as the China–Australia Migratory Bird Agreement or CAMBA (entry into force for Australia in 1988)
- Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment 1974, commonly referred to as the Japan–Australia Migratory Bird Agreement or JAMBA (entry into force for Australia in 1981)
- Agreement between the Government of Australia and the Government of Republic of Korea for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment 2006, commonly referred to as the Republic of Korea–Australia Migratory Bird Agreement or ROKAMBA (entry into force for Australia in 2007)
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal 1989 (entry into force for Australia in 1992)
- Convention on Biological Diversity 1992 (entry into force for Australia in 1993)
- Convention on the Conservation of Migratory Species of Wild Animals 1979, commonly referred to as the Bonn Convention (entry into force for Australia in 2006)
- International Convention for the Prevention of Pollution from Ships 1973 (MARPOL 73/78) as modified by the Protocol of 1978 (entry into force for Australia in 2004)
- International Convention on Oil Pollution Preparedness, Response and Co-operation 1990 (entry into force for Australia in 1995)
- International Convention on the Control of Harmful Anti-fouling Systems on Ships 2001 (entry into force for Australia in 2008)
- International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Convention) as modified by the Protocol of 1996 (entry into force for Australia in 2006)

- Convention on Wetlands of International Importance especially as Waterfowl Habitat 1971, commonly referred to as the Ramsar Convention (entry into force for Australia in 1975)
- The Montreal Protocol on Substances that Deplete the Ozone Layer 1987 (entry into force for Australia in 1989)
- United Nations Convention on the Law of the Sea 1982 (entry into force for Australia in 1994)
- United Nations Framework Convention on Climate Change 1992 (entry into force for Australia in 1994)
- Kyoto Protocol to the United Nations Framework Convention on Climate Change 1997 (entry into force for Australia in 2008).

2.2.2 Commonwealth, State, and Local Policies and Plans

Several Commonwealth, State, and local policies, measures, and environment-related plans and programs likely to be relevant to the Fourth Train Proposal are described in Table 2-2.

Table 2-2: Relevant Policies, Position Statements, Plans, Programs, or Measures

Commonwealth	State and Local
• National Strategy for Ecologically Sustainable Development (Ecologically Sustainable Development Steering Committee 1992) • Australia's Biodiversity Conservation Strategy 2010–2030 (Natural Resource Management Ministerial Council 2010) • National Waste Policy: less waste, more resources (Environment Protection and Heritage Council 2009) • Commonwealth Marine Reserves - Management (DotE n.d.) • Marine Bioregional Plan for the North-west Marine Region (SEWPAC 2012) • National System for the Prevention and Management of Introduced Marine Pest Incursions (Department of Agriculture, Fisheries and Forestry [DAFF] n.d.) • National Environment Protection (Air Toxics) Measure (National Environment Protection Council [NEPC] 2004) • National Environment Protection (Ambient Air) Measure (as varied) (NEPC 2003) • National Environment Protection (National Pollutant Inventory) Measure (NEPC 1998) • National Environment Protection (Movement of Controlled Waste between States and Territories) Measure (as varied) (NEPC 2012)	• Western Australia State Sustainability Strategy (Government of Western Australia 2003) • Western Australian State Planning Strategy (Western Australian Planning Commission [WAPC] 1997) • State Planning Policy No. 2.6 – State Coastal Planning Policy (WAPC 2013) • A 100-Year Biodiversity Conservation Strategy for Western Australia: Blueprint to the Bicentenary in 2029 (Draft) (Department of Environment and Conservation [DEC] 2006) • State Environmental (Ambient Air) Policy (Draft Policy for Public and Stakeholder Comment) (EPA 2009) • Western Australia Environmental Offsets Policy 2011 (including the Environmental Offsets Reporting Form) (EPA 2011) • Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007–2017 (DEC 2007) • Shire of Ashburton Local Planning Policy No. 13: Transient Workforce Accommodation (Shire of Ashburton 2013) • Shire of Ashburton Local Planning Scheme No. 7: Consultation for Planning Proposals – Local Planning Policy (Shire of Ashburton 2009) • Shire of Ashburton Local Planning Scheme No. 7: Social Impact Assessment – Local Planning Policy (Shire of Ashburton 2009a)

2.2.3 Commonwealth, State, and Local Guidelines

Table 2-3 lists a number of Commonwealth, State, and local guidance statements, environmental guidelines, and codes of practice that are expected to be relevant to the Fourth Train Proposal. The New South Wales (NSW) DEC's Approved Methods for Modelling and Assessment of Air Pollutants (NSW DEC 2005) are also relevant to the Fourth Train Proposal in the absence of a State equivalent.

Table 2-3: Relevant Environmental Guidelines

Commonwealth	State and Local
• Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand 2000) • Intergovernmental Agreement on the Environment (Commonwealth Government of Australia 1992) • Adopted Exposure Standards for Atmospheric Contaminants in the Occupational Environment (Safe Work Australia 1995) • National Water Quality Management Strategy: Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) – Stormwater Harvesting and Reuse (Natural Resource Management Ministerial Council *et al*. 2009)	• Aboriginal Heritage Due Diligence Guidelines, Version 3.0 (Department of Indigenous Affairs and Department of Premier and Cabinet 2013) • Environmental Assessment Guidelines No. 3 – Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment 2009 (EPA 2009a) • Environmental Assessment Guidelines No. 5 – Environmental Assessment Guidelines for Protecting Marine Turtles from Light Impacts (Draft) (EPA 2010) • Environmental Assessment Guidelines No. 7 – Marine Dredging Proposals (EPA 2011a) • Environmental Assessment Guidelines No. 12 – Consideration of subterranean fauna in environmental impact assessment in Western Australia (EPA 2013) • Guidance Statement No. 19 – Environmental Offsets – Biodiversity (EPA 2008) • Guidance Statement No. 20 – Sampling of Short Range Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009b) • Guidance Statement No. 33 – Environmental Guidance for Planning and Development (EPA 2008a) • Guidance Statement No. 41 – Assessment of Aboriginal Heritage (EPA 2004) • Guidance Statement No. 51 – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004a) • Guidance Statement No. 54a – Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia (EPA 2007) • Guidance Statement No. 55 – Implementing Best Practice in Proposals submitted to the Environmental Impact Assessment Process (EPA 2003) • Guidance Statement No. 56 – Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004b) • Pilbara Coastal Waters Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (Department of Environment 2006) • State Water Quality Management Strategy No. 6 (Government of Western Australia 2004)

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3. Foundation Project Overview

3.1 Introduction

This section:

- provides a brief overview of the Gorgon Foundation Project, including a summary of the key components, status of construction activities, and the Project approvals
- outlines the Environmental Management Framework that has guided and governed the management of the Gorgon Foundation Project
- summarises Chevron Australia Pty Ltd's (Chevron Australia) performance in managing its environmental impacts during construction of the Gorgon Foundation Project, together with the results of environment monitoring programs, where available.

For clarification purposes, the following definitions are provided:

- the **'Fourth Train Proposal'** refers to the Gorgon Gas Development Fourth Train Expansion Proposal, the development being proposed in this PER/Draft EIS, which is yet to gain approval
- the **'Foundation Project'** refers to Gorgon Gas Development Foundation Project, as amended from time to time, which comprises:
    - the **'initial Gorgon Gas Development'**, the development proposed in the Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP) (Chevron Australia 2005) and subsequently approved under EPBC Reference: 2003/1294 and Ministerial Implementation Statement No. 748 (Statement No. 748)
    - the **'Revised and Expanded Gorgon Gas Development'**, the development proposed in the PER (Chevron Australia 2008) and subsequently approved under EPBC Reference: 2008/4178 and Ministerial Implementation Statements No. 800 and 865 (Statement No. 800 and Statement No. 865)
    - the **'Jansz–Io Development Project and Jansz Feed Gas Pipeline'**, the development assessed via EPBC Referral assessment processes and Environmental Impact Statement/Assessment on Referral Information (ARI) (Mobil Australia 2005; Mobil Exploration 2006) and subsequently approved under EPBC Reference: 2005/2184 and Ministerial Implementation Statement No. 769 (Statement No. 769)
    - the **'Gorgon Gas Development Additional Construction Laydown and Operations Support Area'** (Additional Support Area), use of additional uncleared land for the Gorgon Gas Development as approved under Ministerial Implementation Statement No. 965 and regulated through variations to EPBC References: 2003/1294 and 2008/4178.
- the **'Combined Gorgon Gas Development'** refers to the combined Foundation Project and the future Fourth Train Proposal (if approved)
- the '**Fourth Train Proposal Area**' refers to the area within which Fourth Train Proposal primary activities will be undertaken – i.e. the area encompassing the Greater Gorgon Area and Barrow Island (Figure 1-1)
- the '**Greater Gorgon Area'** as defined under the *Barrow Island Act 2003* (WA), comprises the areas that are the subject of Retention Leases WA-15-R, WA-17-R, WA-18-R, WA-19-R, WA-20-R, WA-21-R, WA-22-R, WA-23-R, WA-24-R, WA-25-R, and WA-26-R; Exploration Permits WA-253-P, WA-267-P, and WA-268-P; and graticular blocks 439, 440, 511, 512, 583, and 584 of Exploration Permit WA-205-P, or of titles derived from those titles, which are held during the term of the Gorgon Gas Processing and Infrastructure Project

Agreement (the State Agreement) by any person under such titles granted pursuant to the *Petroleum (Submerged Lands) Act 1967* (Cth).

Other technical terms used in this PER/Draft EIS are defined in the Terms and Acronyms List.

3.2 Foundation Project Components

The Foundation Project includes marine and terrestrial components to develop the Gorgon and Jansz–Io gas fields located off the north-west coast of Western Australia (WA). The individual infrastructure components of the Foundation Project include:

- production wells and subsea facilities, including cluster manifolds and intrafield flowlines in the Gorgon and Jansz–Io gas fields in the Commonwealth Marine Area
- two Feed Gas Pipeline Systems transferring the production fluids from the Gorgon and Jansz–Io gas fields to Barrow Island. The shore crossing of the Feed Gas Pipeline Systems onto Barrow Island has been drilled underneath North Whites Beach (on the west coast of Barrow Island) using a horizontal directional drilling technique; the pipelines traverse underground across Barrow Island for approximately 7 km to the Gas Treatment Plant located at Town Point on the east coast of Barrow Island comprising:
  - 3 × 5 Million Tonnes Per Annum (MTPA; nominal) Liquefied Natural Gas (LNG) Trains with 6 × 80 MW (nominal) Gas Turbine Compressors using dry low nitrogen oxide burner technology and waste heat recovery units
  - 5 × 116 MW (nominal) conventional Gas Turbine Generators with dry low nitrogen oxide burner technology
  - 2 × 180 000 m^3 (nominal) LNG Tanks
  - 4 × 35 000 m^3 (nominal) Condensate Tanks
- a Carbon Dioxide Injection System to inject reservoir carbon dioxide (CO_2). The reservoir CO_2 will be removed from the Foundation Project's gas stream and will be injected into the Dupuy Formation beneath Barrow Island and will comprise a below-ground pipeline approximately 10 km long
- nine injection wells at four drill centres on Barrow Island, four pressure management wells required to manage reservoir pressure in the Dupuy Formation (which is approximately 2.5 km beneath Barrow Island), and two pressure management water injection wells for the reinjection of water produced from the lower Dupuy Formation by the pressure management wells. The water will be reinjected into the Barrow Group from a vertical depth of 1200 to 1600 m
- Marine Facilities off the east coast of Barrow Island at Town Point comprising:
  - Materials Offloading Facility approximately 2.1 km long and an associated dredged access channel
  - LNG Jetty approximately 2.1 km long and an associated dredged turning basin and access channel
- marine upgrade of the existing West Australian Petroleum Pty Ltd (WAPET) Landing
- associated terrestrial infrastructure forming part of the Project
- a domestic gas processing and delivery system comprising a domestic gas processing facility at the Gas Treatment Plant and an approximately 70 km long pipeline from Barrow Island to the Dampier to Bunbury Natural Gas Pipeline on the mainland.

Figure 3-1 illustrates the location of the Foundation Project infrastructure.

3.2.1 Progress to Date on Implementing the Foundation Project

The Foundation Project commenced construction in late 2009. Significant progress has been made, with the achievement of the following milestones to date:

- the modules for the LNG Plant started arriving on Barrow Island in mid-2012
- offshore well drilling has started for the Gorgon gas field and is complete for the Jansz–Io gas field
- offshore pipe-lay preparation works have been completed
- offshore pipe-lay activities, including installation of umbilicals and rock to stabilise the offshore Feed Gas Pipeline System, are mostly completed
- the shore crossing at the horizontal directional drilling site has been completed
- the onshore Feed Gas Pipeline route has been cleared, the pipeline trench has been excavated, and pipe-lay activities have commenced
- bulk earthworks at the Gas Treatment Plant site have been completed
- construction of the LNG tank has commenced and is ongoing, with hydrotesting of one LNG tank completed
- Butler Park (Construction Village) has been completed and is occupied
- dredging works (i.e. of the turning basin and access channels) have been completed
- the Materials Offloading Facility is fully operational
- baseline marine surveys for the domestic gas pipeline have been completed and domestic gas pipeline construction activities has commenced
- LNG Jetty and caisson installation is progressing.

The Foundation Project has been awarded a number of environmental accolades including:

- 2011 Engineers Australia – Environmental Engineering Excellence Award: Gorgon Project's Quarantine Management System
- United Nations (UN) Association of Australia 2012 World Environment Awards, Best Practice Program: Quarantine Management System
- 2012 Society of Petroleum Engineers (SPE)/Australian Petroleum Production and Exploration Association (APPEA) Health, Environment and Safety Innovation Awards for the Project's Innovative approach to ecological impact assessment of Flatback Turtles on Barrow Island
- 2012 Engineers Australia – Australian and WA Environmental Engineering Excellence Award: Gorgon Project's shore crossing
- 2013 Engineers Australia – Environmental Engineering Excellence Award: Gorgon Project's dredging program and construction of the Materials Offloading Facility.

The Foundation Project is planned to be constructed, commissioned, and operated in a phased approach, with sequential construction of the three LNG trains.

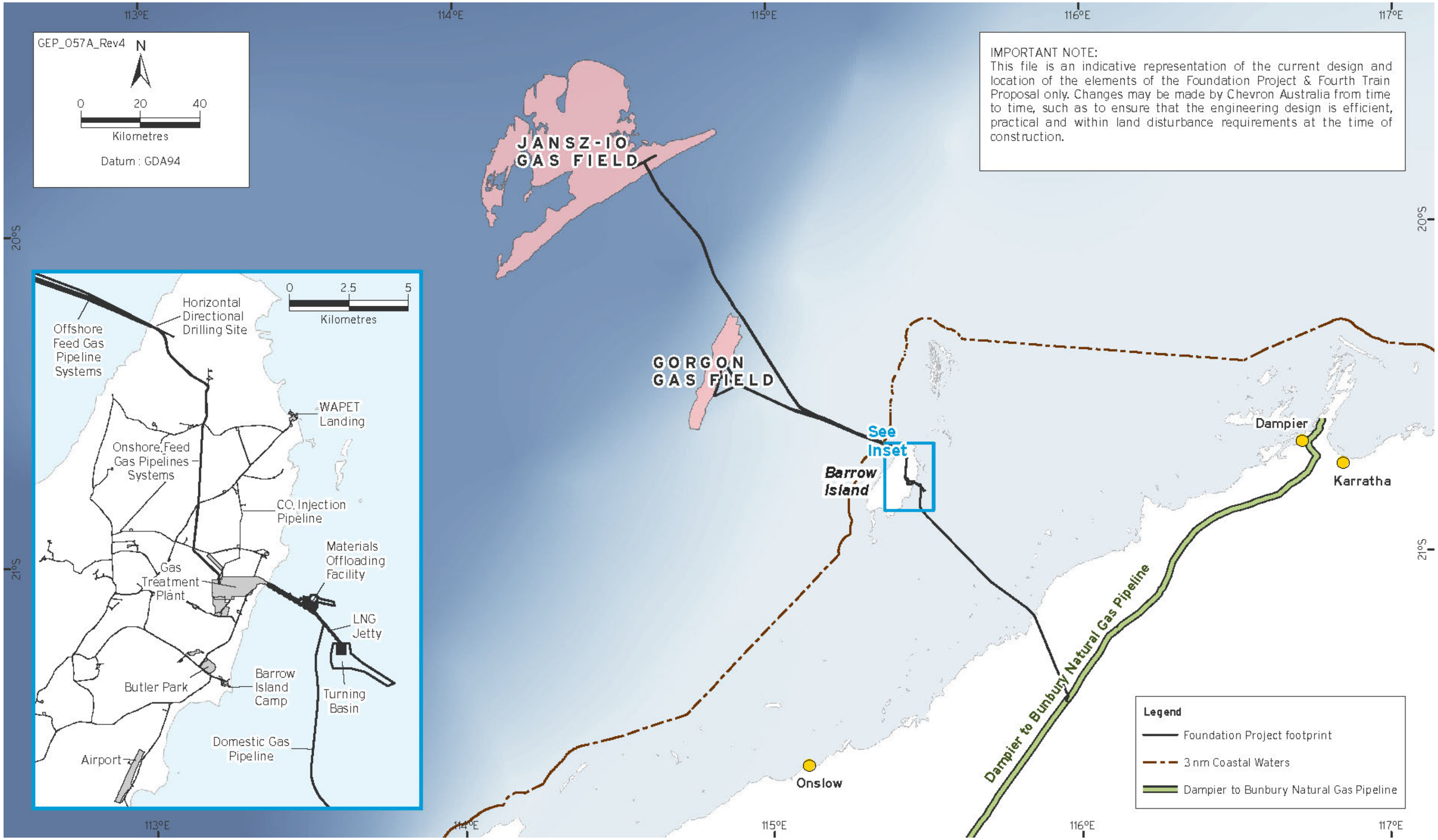

Figure 3-1: Location of the Foundation Project Infrastructure

3.3 Foundation Project Strategic Approval

In 2001, the Western Australian (State) Government determined that a strategic level evaluation of the proposed (now approved) initial Gorgon Gas Development was required to make an informed decision on whether to provide in-principle approval for the restricted use of Barrow Island for a Gas Treatment Plant and associated infrastructure.

This evaluation consisted of an Environmental, Social, and Economic (ESE) Review, which was submitted to the State Government for consideration in February 2003 (ChevronTexaco Australia 2003). The State Government sought advice on environmental matters from the EPA, and advice on social, economic, and strategic aspects of the initial Gorgon Gas Development from the then WA Department of Industry and Resources (DoIR), (now the Department of Mines and Petroleum [DMP]). Advice was also sought from the Conservation Commission of WA, in whom the Barrow Island Nature Reserve (Section 2.1.2.3) is vested.

In-principle approval to access Barrow Island was granted by the State Cabinet on 8 September 2003, with the State Agreement being signed by the Premier and representatives of the GJVs the following day (Chevron Australia 2005). The State Agreement and the *Barrow Island Act 2003* (WA) govern the undertakings between the GJVs and the State Government resulting from the ESE Review process, and grant in-principle access to Barrow Island to the GJVs for gas processing purposes bounded by a range of conditions and obligations. Section 2.1.2.2 provides further detail on this legislation. Details on the Environmental Impact Assessment (EIA) process for the Foundation Project is described in Section 3.4.2.1.

3.4 Environmental Management Framework for the Foundation Project

In obtaining State and Commonwealth Government approvals for the Foundation Project, the GJVs committed to development in a way that contributes to the community's aspiration for sustainable development. This includes protecting the conservation values of Barrow Island; managing all environmental, health, and safety requirements in compliance with regulations; and implementing responsible practices throughout all phases of the Foundation Project.

Environmental management of the Foundation Project has been guided and governed by Chevron Australia's Environmental Management Framework, which is illustrated in Figure 3-2 and which comprises:

- Chevron Corporation's Operational Excellence Management System (OEMS)
- Environmental Assessment and Monitoring Program
- Subsidiary Documents.

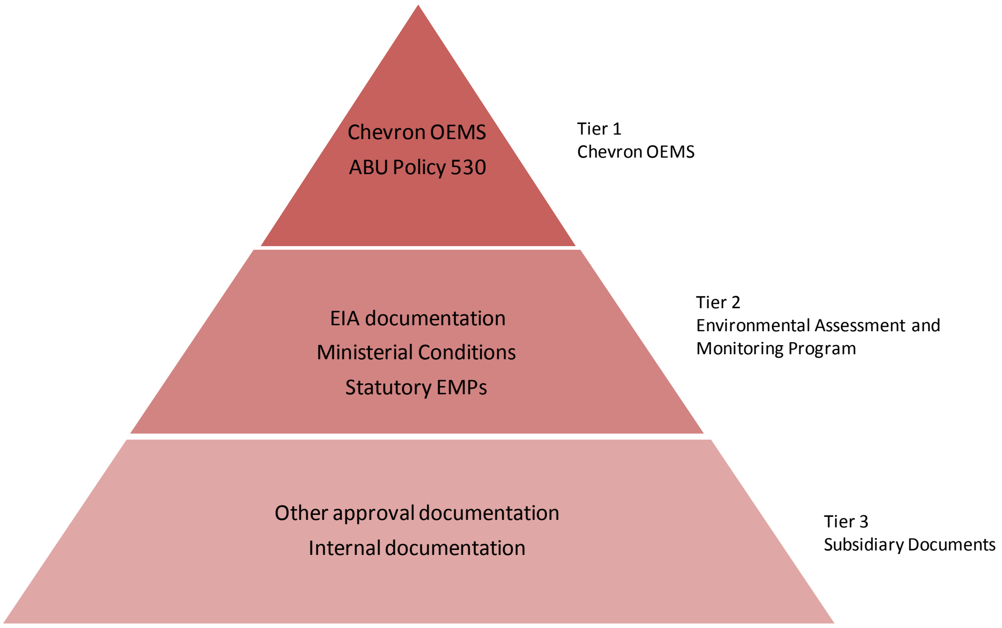

Figure 3-2: Environmental Management Framework for the Foundation Project

3.4.1 Chevron Policy and OEMS

The OEMS is the standardised approach that applies across the Australasia Business Unit (ABU) to continuously improve the management of safety, health, environment, reliability, and efficiency to achieve world-class performance. The OEMS, as currently being implemented for the Foundation Project, is described in Section 1.7.

Chevron's Australian Business Unit Policy 530, as detailed in Section 1.7.2, sets the overall goal of protecting the health and safety of people and the environment through the implementation of Operational Excellence (OE).

3.4.2 Environmental Assessment and Monitoring Program

Tier 2 of the Environmental Management Framework (Figure 3-2) incorporates the Environmental Impact Assessment (EIA) process for the Foundation Project and the principal environmental management documents, including Ministerial Conditions and statutory Environmental Management and Monitoring Plans, Programs, Systems, Procedures and Reports (collectively referred to as EMPs). The environmental approval documentation for the Foundation Project, the Ministerial Conditions, and the currently approved EMPs can be accessed from Chevron Australia's website at: http://www.chevronaustralia.com/our-businesses/gorgon/environmental-responsibility/environmental-approvals.

3.4.2.1 EIA Documentation

The initial Gorgon Gas Development was assessed through an Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP) assessment process (Chevron Australia 2005, 2006). It was approved by the Commonwealth Minister for the Environment and Water Resources on 3 October 2007 (EPBC Reference: 2003/1294) (as amended) and the State Minister for Environment on 6 September 2007 by way of Ministerial Implementation Statement No. 748 (Statement No. 748).

In September 2008, the GJVs sought both Commonwealth and State approval through a Public Environmental Review (PER) assessment process (Chevron Australia 2008) for the Revised and Expanded Gorgon Gas Development to make some changes to 'Key Proposal Characteristics' of the initial Gorgon Gas Development, as outlined below:

- addition of a nominal five MTPA LNG train, increasing the number of LNG trains from two to three

- expansion of the Carbon Dioxide Injection System, increasing the number of injection wells and surface drill locations
- extension of the causeway and the Materials Offloading Facility into deeper water.

On 26 August 2009, the Commonwealth Minister for the Environment, Heritage and the Arts issued approval for the Revised and Expanded Gorgon Gas Development (EPBC Reference: 2008/4178), and varied the conditions for the initial Gorgon Gas Development (EPBC Reference: 2003/1294 as amended).

The State Minister for Environment approved the Revised and Expanded Gorgon Gas Development on 10 August 2009 by way of Ministerial Implementation Statement No. 800 (Statement No. 800). Statement No. 800 superseded Statement No. 748 as the approval for the initial Gorgon Gas Development and therefore provided approval for both the initial Gorgon Gas Development and the Revised and Expanded Gorgon Gas Development. A subsequent amendment to Statement No. 800 was issued to the GJVs by the State Minister for Environment on 7 June 2011 under Ministerial Implementation Statement No. 865 (Statement No. 865). Statement No. 865 specifically amends certain conditions in Statement No. 800 relating to dredging and dredge spoil disposal. Other conditions in Statement No. 800 remain unaffected by Statement No. 865.

The Jansz–Io Development Project and Jansz Feed Gas Pipeline were assessed via EIS/Assessment on Referral Information (ARI) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) referral assessment processes (Mobil Australia Resources 2005; Mobil Exploration and Producing Australia 2006). The Jansz–Io Development Project and the Jansz Feed Gas Pipeline was approved by the Commonwealth Minister for the Environment and Water Resources on 22 March 2006 (EPBC Reference: 2005/2184) and the State Minister for Environment on 28 May 2008 by way of Ministerial Implementation Statement No. 769 (Statement No. 769).

In December 2013, the GJVs sought State approval for the Additional Support Area and to amend the existing Commonwealth approval to regulate the Additional Support Area. On 2 April 2014 the State Minister for Environment approved the Additional Support Area by way of Ministerial Implementation Statement No. 965 which applied the conditions in Statement No. 800 to the Additional Support Area. On 15 April 2014 the Commonwealth Minister for the Environment approved the variations to the existing EPBC References: 2003/1294 and 2008/4178 to regulate the Additional Support Area.

Since the initial Gorgon Gas Development was approved, minor changes to the Foundation Project have been made and the necessary approvals sought and received. As the Foundation Project is still under construction, further changes to the Foundation Project may still be made, and subsequent approvals sought.

3.4.2.2 Ministerial Conditions

As described in Section 3.4.2.1, the Commonwealth and State Ministers set a series of Ministerial Conditions. The Foundation Project Ministerial Conditions require a number of Ministerial Deliverables to be developed to manage and monitor the impacts of the Project. The Ministerial Conditions also require the establishment of Expert Panels and the completion of Environmental Performance Reports and Compliance Assessment Reports for the Foundation Project to be submitted to the Ministers. Reports have been submitted that have satisfied the requirements of the Office of the EPA (OEPA), the Western Australian DEC (now DPaW), DMP, NOPSEMA, and the Commonwealth DotE. The Environmental Performance Reports are available on request from Chevron Australia or from Chevron Australia's website at: http://www.chevronaustralia.com/our-businesses/gorgon/environmental-responsibility/environmental-approvals.

3.4.2.2.1 Expert Panels

As part of Statements No. 800 and No. 769, the GJVs were required to establish a Quarantine Expert Panel (QEP). As part of Statement No. 800, the GJVs were required to establish a Marine Turtle Expert Panel (MTEP) and a Construction Dredging Environmental Expert Panel (CDEEP). All three Expert Panels were established before the end of 2008.

The objective of these panels is to assist with the successful planning and execution of the Foundation Project by providing advice to the GJVs and the State Minister in relation to the defined subject matters. Specifically, each panel will provide advice, relevant to their subject matter, on management and monitoring, including advice on the development and implementation of the relevant systems and plans prepared and submitted in accordance with State and Commonwealth conditions of approval. Each Expert Panel is led by an independent chairperson and comprises Commonwealth and State Government department representatives, independent subject matter experts, and the GJV representatives.

3.4.2.3 Statutory EMPs

EMPs required under the Ministerial Conditions for the Foundation Project detail the specific actions and responsibilities to address environmental risks of the Foundation Project. A set of EMPs (Table 3-1) is currently being implemented for the Foundation Project, while other EMPs required for later stages of the Foundation Project (e.g. associated with operation and/or decommissioning of the Foundation Project) are still to be developed. All EMPs will be submitted for approval to State and Commonwealth Governments as required under the relevant Ministerial Conditions.

The Foundation EMPs are amended or revised as a result of various drivers for change, such as audit findings, changes in scopes of work, and management measures. In these instances, the EMPs are resubmitted for assessment and approval to the Commonwealth and/or State Government, as required under the relevant Ministerial Conditions. Table 3-1 details the EMPs including their jurisdiction, objectives, scope, and current status of approval. The table also includes hyperlinks to the current approved revisions of Foundation Project EMPs that are required to be made publicly available under Ministerial Conditions.

Table 3-1: Foundation Project, Programs, Systems, Procedures, and Reports as required under the Ministerial Conditions as relevant to the Fourth Train Proposal

EMP	Ministerial Condition: Statement No. 800	Ministerial Condition: Statement No. 769	Ministerial Condition: EPBC Reference: 2003/1294 and 2008/4178	Ministerial Condition: EPBC Reference: 2005/2184	Objectives	Scope	Current Status
Terrestrial and Subterranean Baseline State and Environmental Impact Report	6	6	5		• Define and map the pre-development baseline state for the ecological elements within the areas that are expected to or may be at risk of Material or Serious Environmental Harm due to any works associated with the terrestrial facilities • Define and map the ecological elements within the Terrestrial Disturbance Footprint • Define and map the ecological elements of Reference sites to be used as part of the Terrestrial and Subterranean Environment Monitoring Program, which are not at risk of Material or Serious Environmental Harm due to construction or operation of the terrestrial facilities	The ecological elements covered by this EMP comprise: • flora • vegetation • fauna (including subterranean fauna and short-range endemics) • habitat • ecological communities • groundwater • surface water landforms • physical landforms Terrestrial facilities are: • Gas Treatment Plant • Carbon Dioxide Injection System • associated Terrestrial Infrastructure forming part of the Foundation Project • areas impacted for seismic data acquisition • Onshore Feed Gas Pipeline System	Approved for construction, implemented for the Foundation Project, and currently being updated for operations

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Terrestrial and Subterranean Environment Protection Plan and associated Procedures • Fauna Handling and Management Common User Procedure • Traffic Management Common User Procedure • Vegetation Clearing and Audit Common User Procedure	7	7	6		• Reduce the adverse impacts from the construction and operation of the terrestrial facilities as far as practicable • Ensure that construction and operation of the terrestrial facilities does not cause Material or Serious Environmental Harm outside and below the Terrestrial Disturbance Footprint • Provide guidance to qualified field staff on fauna management including during clearing activities, trenching, and excavations • Limit injury or death of fauna in relation to vehicle and equipment movement undertaken on Barrow Island • Specify how vegetation clearing and rehabilitation data are collected and reported, and detail the frequency and form of the clearing and rehabilitation audit process	• Construction and operation activities related to the terrestrial facilities as described under the Terrestrial and Subterranean Baseline State and Environmental Impact Report	Approved for construction, implemented for the Foundation Project, and the Terrestrial and Subterranean Environment Protection Plan is approved for operations

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Terrestrial and Subterranean Environment Monitoring Program	8	8	7		• Establish a statistically valid ecological monitoring program to detect any Material or Serious Environmental Harm to the ecological elements described under the Terrestrial and Subterranean Baseline State and Environmental Impact Report outside the Terrestrial Disturbance Footprint	• Construction activities related to the ecological elements and terrestrial facilities as described under the Terrestrial and Subterranean Baseline State and Environmental Impact Report	Approved for construction, implemented for the Foundation Project, and currently being updated for operations
Terrestrial and Marine Quarantine Management System (QMS) and associated Procedures • **Non-indigenous Species Management Procedure** • **Weed Hygiene Common User Procedure**	10	10	8		• Prevent the introduction of Non-indigenous Terrestrial Species and Marine Pests • Detect Non-indigenous Terrestrial Species (including weed introduction and/or proliferation) and Marine Pests • Control and, unless otherwise determined by the Minister, eradicate detected Non-indigenous Terrestrial Species (including weeds) and Marine Pests • Mitigate adverse impacts of any control and eradication actions on indigenous species taken against detected Non-indigenous Terrestrial Species (including weeds) and Marine Pests	Construction and operation activities related to the terrestrial facilities as described under the Terrestrial and Subterranean Baseline State and Environmental Impact Report, and the following marine facilities: • Materials Offloading Facility • LNG Jetty • Offshore Feed Gas Pipeline System (in State Waters only) and marine component of the shore crossing • Domestic Gas Pipeline • marine upgrade of the existing WAPET Landing	Approved for construction, implemented for the Foundation Project, and the Weed Hygiene Common User Procedure has been approved for operations

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Short Range Endemics and Subterranean Fauna Monitoring Plan	11				• Further survey to identify the short-range endemics (SREs) and subterranean fauna species that have previously only been located within the Gas Treatment Plant site or the Additional Support Area until the species is found outside the Gas Treatment Plan site and Additional Support Area	• To survey areas not previously surveyed to identify whether SREs and subterranean fauna species, which have previously only been located within the Gas Treatment Plant site or the Additional Support Area, are located elsewhere on Barrow Island	Approved for construction and implemented for the Foundation Project
Fire Management Plan	12	11	9		• Ensure the Foundation Project does not cause Material or Serious Environmental Harm outside the Terrestrial Disturbance Footprint as a result of Foundation Project-attributable fires • Fire risk reduction measures to be built into the design of the facilities to protect Chevron Australia's assets from impact from fire on Barrow Island	• Construction and early operation activities related to the terrestrial facilities as described under the Terrestrial and Subterranean Baseline State and Environmental Impact Report	Approved for construction, implemented for the Foundation Project, and currently being updated for operations with endorsement secured for early operations

<table>
<tr><th rowspan="3">EMP</th><th colspan="4">Ministerial Condition</th><th rowspan="3">Objectives</th><th rowspan="3">Scope</th><th rowspan="3">Current Status</th></tr>
<tr><th colspan="2">Statement No.</th><th colspan="2">EPBC Reference:</th></tr>
<tr><th>800</th><th>769</th><th>2003/1294 and 2008/4178</th><th>2005/ 2184</th></tr>
<tr><td>Coastal and Marine Baseline State and Environmental Impact Report (Scope of Works)</td><td>14</td><td>12</td><td>11.1</td><td></td><td>• Outline the methods to be used in preparing the Coastal and Marine Baseline State and Environmental Impact Report</td><td>Methods are to cover:
• survey methods for each of the ecological elements as listed in the CMBSEIR below
• location and establishment of survey sites
• timing and frequency of surveys
• habitat classification schemes
• mapping methodologies, including coral assemblages
• treatment of survey data
• method for hydrodynamics data acquisition and reporting</td><td>Approved for construction and implemented for the Foundation Project</td></tr>
</table>

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Coastal and Marine Baseline State and Environmental Impact Report (Materials Offloading Facility, Jetty, WAPET Landing, Dredge Spoil Disposal Ground)	14	12	11		• Describe and map the ecological elements within the Zones of High Impact and the Zones of Moderate Impact and representative areas in the Zones of Influence (as mapped within Statement No. 800), associated with the generation of turbidity and sediment deposition from dredging and dredge spoil disposal required for marine facilities • Describe and map the extent and distribution of Coral Assemblages within the Zones of High Impact and the Zones of Moderate Impact that are to be used to calculate the Area of Loss of Coral Assemblages according to a formula prescribed in Statement No. 800 • Describe and map the benthic ecological elements that are at risk of Material or Serious Environmental Harm due to construction or operation of the marine facilities • Describe and map the benthic ecological elements at Reference Sites that are not at risk of Material or Serious	Ecological elements are: • hard and soft corals • macroalgae • non-coral benthic macroinvertebrates • seagrass • mangroves • surficial sediment characteristics • demersal fish • water quality (including measures of turbidity and light attenuation) Marine facilities are: • Materials Offloading Facility • LNG Jetty • Dredge Spoil Disposal Ground • Offshore Feed Gas Pipeline System (in State Waters only) and marine component of the shore crossing • Domestic Gas Pipeline • marine upgrade of the existing WAPET Landing	Approved for construction and implemented for the Foundation Project

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
					Environmental Harm due to construction or operation of the marine facilities • Describe the ecological elements within the Zones of High Impact and the Zones of Moderate Impact and representative areas in the Zones of Influence, associated with the generation of turbidity and sediment deposition from dredging and dredge spoil disposal required for marine facilities • Describe the ecological elements that are at risk of Material or Serious Environmental Harm due to construction or operation of the marine facilities • Describe the ecological elements of Reference Sites that are not at risk of Material or Serious Environmental Harm due to construction or operation of the marine facilities		

<table>
<tr><th rowspan="3">EMP</th><th colspan="4">Ministerial Condition</th><th rowspan="3">Objectives</th><th rowspan="3">Scope</th><th rowspan="3">Current Status</th></tr>
<tr><th colspan="2">Statement No.</th><th colspan="2">EPBC Reference:</th></tr>
<tr><th>800</th><th>769</th><th>2003/1294 and 2008/4178</th><th>2005/ 2184</th></tr>
<tr><td>Long-term Marine Turtle Management Plan</td><td>16</td><td></td><td>12</td><td></td><td>Address the long-term management of the marine turtles that utilise the east coast beaches and waters where there are Foundation Project-related stressors to marine turtles
Establish baseline information on the populations of marine turtles that utilise the beaches adjacent to the east coast facilities identified under the Terrestrial and Subterranean Baseline State and Environmental Impact Report and the Coastal and Marine Baseline State and Environmental Impact Report
Establish a monitoring program to measure and detect changes to the Flatback Turtle population
Specify design features, management measures and operating controls to manage, and where practicable, avoid adverse impacts to marine turtles, with specific reference to reducing light and noise emissions as far as practicable</td><td>Construction and operations activities on the east coast of Barrow Island for the following terrestrial facilities:
Gas Treatment Plant
Construction and operations activities related to the following marine facilities:
Materials Offloading Facility
LNG Jetty
Dredge Spoil Disposal Ground
Domestic Gas Pipeline
Marine upgrade of the existing WAPET Landing
In addition to the requirements of the Conditions that the Long-term Marine Turtle Management Plan addresses, the GJVs have prepared the Long-term Marine Turtle Management Plan so it also addresses the management of impacts to marine turtles from activities associated with the installation of the Onshore Domestic Gas Pipeline system and associated horizontal directional drilling on the west coast of Barrow Island.</td><td>Approved for construction, implemented for the Foundation Project, and currently being updated for operations</td></tr>
</table>

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<tr><th rowspan="3">EMP</th><th colspan="4">Ministerial Condition</th><th rowspan="3">Objectives</th><th rowspan="3">Scope</th><th rowspan="3">Current Status</th></tr>
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<tr><th>800</th><th>769</th><th>2003/1294 and 2008/4178</th><th>2005/ 2184</th></tr>
<tr><td>Marine Facilities Construction Environmental Management Plan</td><td>17</td><td></td><td>13</td><td></td><td>Reduce the impacts from the construction of marine facilities (excepting from the generation of turbidity and sedimentation from dredging and spoil disposal) as far as practicable
Ensure that construction of the marine facilities does not cause Material or Serious Environmental Harm outside the Marine Disturbance Footprint associated with those facilities
Dredging and spoil disposal activities are considered within a separate Dredging and Spoil Disposal Management and Monitoring Plan</td><td>Marine construction activities up to the mean high water mark at Town Point related to the following marine facilities:
Materials Offloading Facility
LNG Jetty
Marine component of the Barge (WAPET) Landing upgrade</td><td>Approved for construction and implemented for the Foundation Project</td></tr>
<tr><td>Dredging and Spoil Disposal Management and Monitoring Plan</td><td>20</td><td></td><td>14</td><td></td><td>Ensure that the works associated with construction of the marine facilities do not lead to impacts in excess of the limits set by the Minister as a result of the construction, dredging or spoil disposal activities, and where practicable avoid adverse impacts to marine turtles and EPBC Act-listed marine fauna</td><td>Construction dredging activities related to the marine facilities described under the Marine Facilities Construction Environmental Management Plan</td><td>Approved for construction and implemented for the Foundation Project</td></tr>
</table>

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Horizontal Directional Drilling Management and Monitoring Plan	22	13	15		• Reduce the impacts of horizontal directional drilling activities on the Terrestrial Disturbance Footprint and the Marine Disturbance Footprint associated with those activities as far as practicable • Ensure that horizontal directional drilling activities do not cause Material or Serious Environmental Harm outside the Terrestrial Disturbance Footprint and the Marine Disturbance Footprint associated with those activities or exceed the coral loss limit set by the Minister	• The management of terrestrial and marine impacts associated with horizontal directional drilling shore crossing activities for the Gorgon and Jansz Feed Gas Pipeline Systems from the onshore horizontal directional drilling site at North Whites Beach, Barrow Island, to the tail end of the inserted horizontal directional drilling pipelines approximately 800 m from shore	Approved for construction and implemented for the Foundation Project
Offshore Feed Gas Pipeline Installation Management Plan	23	14	2003/1294: 16, 16A and 16B 2008/4178: 16	1, 2	• Reduce the impacts of pipeline installation activities on the Terrestrial Disturbance Footprint and the Marine Disturbance Footprint as far as practicable • Ensure that pipeline installation activities do not cause Material or Serious Environmental Harm outside the Terrestrial Disturbance Footprint and the Marine Disturbance Footprint associated with the offshore facilities	• Construction activities associated with the installation and pre-commissioning of the Feed Gas Pipeline System in Commonwealth and State Waters	Approved for construction and implemented for the Foundation Project

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Offshore Feed Gas Pipeline Pre-lay Activities Environment Plan			2003/1294: 16A and 16B 2008/4178: 16		• Ensure offshore impacts are managed prior to the commencement of construction of the offshore facilities in Commonwealth Marine Area and that the approved plan is implemented • Minimise the potential for impacts on listed threatened marine turtles and cetaceans during pipeline construction in the Commonwealth Marine Area	• Pre-lay activities (i.e. the installation of rock foundations) for the Offshore Feed Gas Pipeline System in the Commonwealth Marine Area • Construction activities associated with the following: ▪ lighting ▪ noise ▪ marine vessel and aircraft interaction procedures ▪ construction methodology ▪ any seabed blasting, trenching, or rock dumping required and measures to mitigate such effects on listed marine turtles and cetaceans ▪ the monitoring of any impacts on marine turtles and cetaceans	Approved for construction and implemented for the Foundation Project

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Marine Environmental Quality Management Plan	23A				• Establish and spatially define a set of Environmental Values (EVs), Environmental Quality Objectives (EQOs), and associated levels of ecological protection for marine waters of the Barrow Island Port area and any other areas of State Coastal Waters (except for waters within gazetted Marine Conservation Reserves where Management Plans are in place and interim EVs, EQOs and levels of ecological protection have been endorsed by the EPA), where there is a potential for the operation of the Foundation Project to affect marine environmental quality • Protect the EVs, and achieve the EQOs and associated levels of ecological protection for marine waters defined above for the life of the Foundation Project	• Operational activities that have the potential to affect the marine environmental quality in the Barrow Island Port area and any other areas of State Coastal Waters (except as outlined within the objectives)	New Plan currently under preparation and not yet required for approval

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Post-Development Coastal and Marine State and Environmental Impact Survey Report	24	15	17		• Determine if changes have occurred to marine ecological elements, including the Area of Loss of Coral Assemblages expressed as hectares, compared with pre-development baseline marine environmental state established in the Coastal and Marine Baseline State and Environmental Impact Report	• Post-development surveys related to the construction of marine facilities described under the Coastal and Marine Baseline State and Environmental Impact Report	New Report currently under preparation
Coastal Stability Management and Monitoring Plan	25		18		• Ensure that the Materials Offloading Facility and the LNG Jetty (excluding WAPET Landing) do not cause significant adverse impacts to the beaches adjacent to those facilities • Establish a monitoring program to detect adverse changes to the beach structure and beach sediments that could have implications for marine turtles nesting on the beaches adjacent to the marine facilities	• Construction activities related to the Materials Offloading Facility and the LNG Jetty	Approved for construction and implemented for the Foundation Project

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Reservoir Carbon Dioxide Injection Monitoring Program	26		19		• Implement a monitoring program that sets out how the annual reporting requirements for the performance of the Carbon Dioxide Injection System will be met in respect of monitoring any seepage of injected carbon dioxide to the surface or near-surface environments, including those that may support subterranean fauna, including the Barrow Cave Gudgeon *Milyeringa justitia* (formerly reported as the Blind Gudgeon, *Milyeringa veritas)*[1] • Conduct a survey focused on the assessment of the habitat of the Barrow Cave Gudgeon and develop a plan for practicable action proposed to avoid or mitigate the risk of significant impact to the environment inhabited by the Barrow Cave Gudgeon	• Monitoring the injection of reservoir CO_2 during operation of the Foundation Project	Not yet required; this EMP will be approved prior to this work commencing

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Greenhouse Gas Abatement Program	27				• Demonstrate that currently applied best practices in terms of greenhouse gas emissions have been adopted in the design and operations of the Gas Treatment Plant. The greenhouse gas emissions per tonne of LNG produced should be normalised to the standard conditions and benchmarked against publicly available data for other national and overseas LNG processing facilities • Periodically review and where practicable, adopt, advances in technology and operational processes aimed at reducing greenhouse gas emissions per tonne of LNG produced	• The greenhouse gas emission sources arising from the start-up, commissioning, and operation of the Gas Treatment Plant on Barrow Island	Approved and for the Foundation Project
Best Practice Pollution Control Design Report	28				• Demonstrate that the proposed works adopt the best-practice pollution control measures to minimise emissions from the Gas Treatment Plant • Set out the base emission rates for major sources for the Gas Treatment Plant and the design emission targets • Address normal operations, shutdown, start-up, and equipment failure conditions	• Major sources of atmospheric pollutants and air toxics related to the start-up and operations of the Gas Treatment Plant	The Plan has been developed under the requirements of the Ministerial Conditions to the satisfaction of the DEC (now DER) and submitted and approved as part of the Works Approval for the Gas Treatment Plant (W5178/2012/1)

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Air Quality Management Plan	29				• Ensure air quality meets appropriate standards for human health in the workplace • Ensure air emissions from the Gas Treatment Plant operations do not pose a risk of Material or Serious Environmental Harm to the flora, vegetation communities, fauna, and subterranean fauna of Barrow Island	• Atmospheric pollutants and air toxics emissions associated with the start-up, commissioning, and operation of the Gas Treatment Plant	The Plan has been developed under the requirements of the Ministerial Conditions to the satisfaction of the DEC (now DER) and submitted and approved as part of the Works Approval for the Gas Treatment Plant (W5178/2012/1)
Solid and Liquid Waste Management Plan and associated sub-Plan **Reverse Osmosis Brine Disposal Environmental Management and Monitoring Plan** (via Ocean Outfall)	30 30. 2. ii	16	20 20.2ii		• Ensure all Foundation Project-related solid and liquid wastes are either removed from Barrow Island or, if not, that all practicable means are used to ensure that waste disposal does not cause Material or Serious Environmental Harm to Barrow Island and its surrounding waters • Ensure discharges from any wastewater treatment plant, reverse osmosis plant, or other process water are disposed of via deep well injection, unless otherwise authorised by the Minister • Ensure any deep well injection of Foundation Project-related liquid wastes is conducted in a	• Construction and operation activities related to the terrestrial facilities on Barrow Island as described under the Terrestrial and Subterranean Baseline State and Environmental Impact Report • The disposal of reject reverse osmosis brine by ocean outfall	Approved for construction. The Reverse Osmosis Brine Disposal Environmental Management and Monitoring Plan has been updated for operations. The Solid and Liquid Waste Management Plan has been approved for operations

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
					manner that will not cause Material or Serious Environmental Harm to subterranean fauna and their habitats on Barrow Island • Obtain Ministerial authorisation to dispose of reverse osmosis brine to sea instead of via deep well injection • Outline the water source, supply, and disposal options considered for the Foundation Project and detail the selected system • Demonstrate that brine disposal via ocean outfall undertaken in accordance with this Plan will not cause Material or Serious Environmental Harm to Barrow Island and its surrounding waters		

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Aboriginal Cultural Heritage Management Plan	31	17			• Assist in the management of cultural heritage values associated with the Foundation Project located on Barrow Island and the Western Australian mainland • Include surveys for potential cultural heritage sites within the Terrestrial Disturbance Footprint • Ensure that provisions for the lawful retrieval and relocation of any heritage material that lies within the Terrestrial Disturbance Footprint are made in consultation with Aboriginal stakeholders	• Construction activities related to the terrestrial facilities described under the Terrestrial and Subterranean Baseline State and Environmental Impact Report	Approved for construction and implemented for the Foundation Project
Post-Construction Rehabilitation Plan and associated sub-Plan **Topsoil Management Plan**	32				• Ensure that the rehabilitation of terrestrial areas following construction is properly planned in a manner that promotes self-sustaining ecosystems, which are able to be managed as part of their surroundings, consistent with the conservation objectives of a Class A Nature Reserve • Design rehabilitation of native vegetation to ultimately develop into viable ecological systems that are comparable and compatible with surrounding native vegetation and its land	• Sites disturbed as part of the construction of terrestrial facilities described under the Terrestrial and Subterranean Baseline State and Environmental Impact Report and areas within the Terrestrial Disturbance Footprint, but which are not required for the future construction and operation of the Foundation Project	Approved and implemented for the Foundation Project

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
					uses, and restore as closely as practicable the pre-disturbance biodiversity and ecosystem functional values • Ensure planning, implementation, monitoring, and reporting on rehabilitation is carried out consistent with industry best practice • Ensure management of rehabilitation continues until affected areas are self-sustaining • Better inform any ongoing rehabilitation and post-closure rehabilitation • Provide guidance on the management and use of topsoil recovered from the Butler Park (Construction Village), Gas Treatment Plant and Additional Support Area sites		

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Project Site Rehabilitation Plan	33	18			• Ensure that the rehabilitation of terrestrial areas following decommissioning is properly planned in a manner that promotes self-sustaining ecosystems, which are able to be managed as part of their surroundings, consistent with the conservation objectives of a Class A Nature Reserve • Design rehabilitation of native vegetation to ultimately develop into sustainable ecological systems that are comparable and compatible with surrounding native vegetation and its land uses, and restore as closely as practicable the pre-disturbance biodiversity and functional values • Ensure planning, implementation, and reporting on rehabilitation is carried out in a manner consistent with industry best practice • Ensure management of rehabilitation continues until affected areas are self-sustaining	• Decommissioning activities related to the terrestrial areas described under the Post-Construction Rehabilitation Plan	Not yet required; this Plan will be prepared and approved within five years after the commencement of operations

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Decommissioning and Closure Plan	34	19	21		• Unless otherwise agreed with the Minister, the area occupied by the terrestrial and marine infrastructure facilities is returned to its undisturbed state • Unless otherwise agreed with the Minister, the site does not pose a risk to wildlife or personnel greater than surrounding undisturbed areas	• Decommissioning activities related to the terrestrial and marine infrastructure facilities	Not yet required; this Plan will be prepared and approved at least four years before the anticipated date of decommissioning and closure, or at a time otherwise agreed by the Minister
Jansz Feed Gas Pipeline Preparatory Works (Northern Scarp) Environment Plan				1, 2	• Ensure that the seabed preparatory works for the Jansz Feed Gas Pipeline System at the Northern Scarp location are conducted in a manner that protects environmental values and reduces impacts to the environment as far as practicable • Minimise the potential for impacts on listed threatened marine turtles and cetaceans during pipeline construction in the Commonwealth Marine Area	• Seabed preparatory works at the Northern Scarp • Construction activities associated with the following: ▪ lighting ▪ noise ▪ marine vessel and aircraft interaction procedures ▪ construction methodology ▪ any seabed blasting, trenching, or rock dumping required and measures to mitigate such effects on listed marine turtles and cetaceans ▪ the monitoring of any impacts on marine turtles and cetaceans	Approved for construction and implemented for the Foundation Project

EMP	Ministerial Condition				Objectives	Scope	Current Status
	Statement No.		EPBC Reference:				
	800	769	2003/1294 and 2008/4178	2005/ 2184			
Offshore Domestic Gas Pipeline Installation Management Plan	23		16		• Reduce the impacts of pipeline installation activities on the Terrestrial Disturbance Footprint and the Marine Disturbance Footprint as far as practicable • Ensure that pipeline installation activities do not cause Material or Serious Environmental Harm outside the Terrestrial Disturbance Footprint and the Marine Disturbance Footprint associated with the offshore facilities	• Installation of the Domestic Gas pipeline, offshore from the LNG Jetty on the east coast of Barrow Island to the Australian mainland shore crossing, and within the intertidal zone on the mainland	Approved for construction and implemented for the Foundation Project
Gorgon Gas Development Drilling and Completion Program Environment Plan			2003/1294: 16A and 16B		• Ensure drilling activities are conducted in a manner that protects environmental values and reduces impacts to the environment to as low as reasonably practicable (ALARP), and therefore are acceptable	• Drilling and completion of gas wells in the Gorgon Gas Field	Approved for construction and implemented for the Foundation Project
Jansz–Io Drilling Environment Plan				1, 2	• Describe the measures taken to ensure that the Jansz–Io drilling activities are undertaken in a manner that protects environmental values and reduces impacts to the environment to ALARP, and therefore are acceptable	• Drilling and completion of gas wells in the Jansz–Io Gas Field	Approved for construction and implemented for the Foundation Project

1 *The Barrow Cave Gudgeon (*Milyeringa justitia*) was formerly reported as the Blind Gudgeon (*Milyeringa veritas*). The taxonomy of the Blind Gudgeon has recently been revised, with* M. veritas *no longer considered present on Barrow Island. The very similar* M. justitia*, or Barrow Cave Gudgeon, is described by Larson* et al. *(2013) as occurring within the groundwater on Barrow Island.*

3.4.2.3.1 Adaptive Management

The approved Foundation Project EMPs are designed with an integrated environmental approach which includes adaptive management processes. Changes to approved Foundation Project EMPs are identified through ecological monitoring, incident response and audits, and the environmental performance reporting process (Figure 3-3).

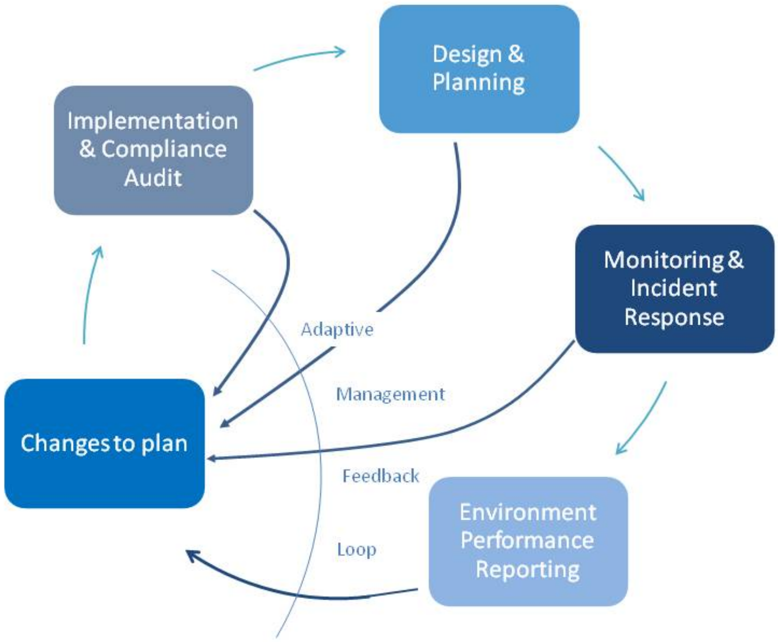

Figure 3-3: Adaptive Management Feedback Process

Auditing of performance against EMPs and the incident response process have both assisted in the identification of potential gaps in the EMPs. This information has then been used to advise updates to the EMPs through use of the adaptive management process.

Monitoring has been undertaken on a number of environmental factors to provide information on the scale of impacts throughout the construction process for the approved Foundation Project (Section 3.5). The monitoring programs have evolved through lessons learnt during the monitoring campaigns to produce more targeted and comparable monitoring results in subsequent campaigns. A number of the monitoring programs include management triggers which have been derived from baseline monitoring program data. The management trigger levels are taken from indications of causal significance provided by the standard deviation of the data gathered. The management actions which are triggered are:

- **Alert** – management actions which may include further investigations into the reason for the change and/or further field surveys to help identify the cause of the trend (one standard deviation limit)
- **Review** –conduct further management actions which may include review of the risks associated with the parameter with the aim of trying to diagnose the cause of the change. This management action may require further field surveys to diagnose the trend (two standard deviations limit)
- **Action** - take immediate action to act upon known proposal-related stressors if these are deemed to represent a significant threat to the functioning of the population. Actions may include, but not be limited to, additional management measures such as compensatory measures, reviews of the risks associated with the changed parameter with the aim of

trying to understand and mitigate the cause of the change, or further mitigation measures (three standard deviations limit)

The Long-term Marine Turtle Management Plan that uses these data analysis methods has recently been awarded the 'Innovation Award – Environment' at the SPE/APPEA Health, Safety and Environment Innovation Awards of September 2012.

The Foundation Project Ministerial Conditions require environmental performance reporting and analysis annually, with a five-year overview cycle. These annual and five-yearly reports cover a wide range of topics, many of which form part of the adaptive management feedback loop (Schedule 3; Statement No. 800). The content requirements for the environmental performance reports also include proposed environmental management improvements, as well as 'a review of whether there are any reasonably practicable management measures, operating controls or design features that can be implemented to reduce or eliminate the alteration of the light horizon on the east coast beaches of Barrow Island as a result of the implementation of the proposal' (Statement No. 800). The GJVs may also be required by the Minister to update any EMPs to include any reasonably practicable improvements identified in the Environmental Performance Report.

EMPs and Subsidiary Documents may also be updated from time to time to reflect any changing circumstances, experience, and lessons. These changes will also be adopted by the Fourth Train Proposal where its activities and designs allow. This means that the mitigation and management measures in future approved versions of EMPs and relevant Subsidiary Documents would take precedence over the mitigation and management measures presented in this PER/Draft EIS.

3.4.3 Subsidiary Documents

In addition to the EMPs described above, as planning and design associated with commissioning and operations are finalised, a set of Subsidiary Documents are required for the implementation of the Foundation Project (Figure 3-2).

Subsidiary Documents for the Foundation Project include:

- approval documentation, which is required under legislation and/or which imposes relevant legal obligations on Chevron Australia and/or GJVs, but which is not legally binding under the Ministerial Conditions, e.g. approvals required under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth) and under Part V of the *Environmental Protection Act 1986* (WA)(EP Act), including Works Approval and licenses
- internal documentation, which is required for Chevron Australia's internal purposes but which is not legally binding under legislation.

Approval documents have been developed to satisfy the EP Act and other regulatory requirements. These documents will be submitted for regulatory approval (as required) to the relevant agencies.

In addition, Chevron Australia requires contractors and suppliers to implement a management system that fully embraces the policy and objectives of the OEMS and to develop and implement their own activity- and/or site-specific EMPs, Procedures, Work Method Statements etc. These internal documents build on and reflect the environmental protection measures contained within the EMPs for the Foundation Project described in Table 3-1.

Subsidiary Documents will manage environmental impacts specifically related to the Foundation Project's various works programs, and will build on and reflect the mitigation and management measures contained within the EMPs described in Table 3-1.

3.5 Environmental Monitoring

Environment monitoring programs track environmental performance from the execution of the Foundation Project. Environmental monitoring is undertaken by appropriately trained and qualified personnel, and in accordance with the relevant Foundation Project approval documents. Further details about the monitoring programs outlined below can be obtained from the Foundation Project's Annual Environmental Performance Reports available from Chevron Australia's website as mentioned in Section 3.4.2.2.

3.5.1 Terrestrial Monitoring

The terrestrial monitoring programs are detailed in the Terrestrial and Subterranean Environment Monitoring Program (Chevron Australia 2014). The monitoring programs focus on the following ecological elements:

- seabirds (Silver Gulls, Wedge-tailed Shearwaters, Bridled Terns)
- land birds (White-winged Fairy-wren [Barrow Island])
- mammals (Barrow Island Euro, Boodies, Spectacled Hare-wallabies, Golden Bandicoots)
- vegetation (including targeted flora and dust impacts)
- subterranean and short-range endemic species
- surface water landforms, soil and groundwater and topsoil.

A brief overview of each program and results obtained up to August 2013 for each element is provided in the subsections below. A comprehensive summary of results pertaining to each of the survey programs is provided in the Annual Environmental Performance Reports (Chevron Australia 2010, 2011, 2012, 2013). To date, the Foundation Project terrestrial monitoring programs have not identified any Foundation Project-attributable impacts that have resulted in Material or Serious Environmental Harm to the terrestrial and subterranean environment that are different or additional to the impacts approved for that Project. Monitoring has provided information on the effect of natural variables on terrestrial ecological elements. In most programs, the prevailing weather conditions, particularly the amount of rainfall, have been detected as having a key contributory effect to the monitoring findings.

3.5.1.1 Seabirds

Seabird monitoring focuses on three key species—Silver Gulls, Wedge-tailed Shearwaters, and Bridled Terns. Monitoring of Silver Gulls aims to detect potential changes in breeding activity, as this species is known to respond positively to disturbances that result in increased food availability (e.g. poor waste management). Results indicate that between the 2009–2010, 2010–2011, and 2011–2012 seasons there was a decline in the number of observed Silver Gulls at the At Risk and the Reference zones. This may be related to larger scale or regional variations in abundance. The key conclusion is that there has been no effect on in Silver Gull abundance or distribution associated with construction activities of the Foundation Project (Chevron Australia 2011a, 2012, 2013). Monitoring results for both Bridled Terns and Wedge-tailed Shearwaters have shown no Foundation Project-attributable impacts, with both species displaying variation that is considered to be within the normal demographic variability, even after taking into account the significant cyclonic events recorded during February 2011 (Chevron Australia 2011b, 2011c, 2012, 2013).

3.5.1.2 Land Birds

The Gorgon Gas Development has the potential to impact negatively on the White-winged Fairy-wren (Barrow Island), beyond the direct loss in abundance associated with habitat clearing for construction of the Gas Treatment Plant and its associated infrastructure. The monitoring aims to establish a statically valid ecological monitoring program to detect any Material or Serious Environmental Harm to the ecological elements outside the terrestrial disturbance footprint, collect information on the density and diagnose observed declines in abundance that are attributable to the Gorgon Gas Development and Jansz Feed Gas Pipeline (Chevron Australia 2012, 2013).

Monitoring occurs across Barrow Island in both the At Risk and Reference zones. Population estimates have varied since 2009, with the lowest estimate recorded during the 2010 season with increases estimated in 2011 and 2012 (Chevron Australia 2012, 2013). The increase in fairy-wren numbers observed in 2011 and 2012 is likely a result of higher than average rainfall preceding the monitoring periods (Chevron Australia 2011d, 2012, 2013). This suggest that factors external to construction of the Foundation Project, such as rainfall, vegetation and survey timing, are potentially responsible for the abundance of the White-winged Fairy-wrens on Barrow Island (Biota Environmental Sciences 2012; Chevron Australia 2013). Future surveys are planned by the Foundation Project, which will allow the development of time-series control charts to detect longer-term trends in abundance across Barrow Island. The Mammal and White-winged Fairy-wren (Barrow Island) Ongoing Noise Monitoring Program (Construction) 2011 is discussed in Section 3.5.4.

3.5.1.3 Mammals

Mammal monitoring focuses on four key species—Barrow Island Euro, Boodies, Spectacled Hare-wallabies, and Golden Bandicoots. The Foundation Project monitors species in both an At Risk zone (equivalent to the Foundation Project construction terrestrial disturbance footprint [TDF]) and a Reference zone (equivalent to outside the Foundation Project construction TDF).

Based on the current state of knowledge of activities and experience gained on Barrow Island, the primary risks to fauna are associated with physical interaction related to vehicle traffic and with land clearing; these are important activities that are actively considered in the management of fauna interactions. While casualties (particularly mammals) have occurred, these casualties are unlikely to have lasting impacts on the population levels of species, based on known estimates of species abundance on Barrow Island.

A Mammal Distance Sampling Program is undertaken to monitor the Barrow Island Euro and Spectacled Hare-wallaby. Density estimates of the Barrow Island Euro have remained relatively stable across the three years of observation under the Program. The Spectacled Hare-wallaby density estimates have varied since the Program commenced; however, there is no evidence to suggest these variations are attributable to the Foundation Project (Chevron Australia 2013).

A Mammal Trapping Program primarily monitors the Boodie and the Golden Bandicoot, but also monitors the Spectacled Hare-wallaby. Between 2011 and 2012 the mean trends reflecting the change in abundance for each of the three species were broadly similar across both the At Risk and Reference zones. Abundances either increased or decreased, but were within control limits, except for Spectacled Hare-wallaby abundance, which exceeded the upper control limit in the At Risk zone. Since 2014 the Mammal Trapping Program has been split into two separate species-specific surveys, with one targeting the Boodie and the other targeting the Golden Bandicoot.

The monitoring of the Barrow Island mammal populations in both At Risk and Reference zones indicates that the construction of the Foundation Project to date is not affecting the population viability of the Barrow Island Euro, Spectacled Hare-wallaby, Golden Bandicoot, and the Boodie.

The mitigation and management measures are regularly reviewed to identify and address possible gaps and or implement improvements, and to take into account changes, such as natural fluctuations in mammal populations and monitoring results. The Mammal and White-winged Fairy-wren (Barrow Island) Ongoing Noise Monitoring Program (Construction) 2011 is discussed in Section 3.5.4.

3.5.1.4 Vegetation

3.5.1.4.1 Vegetation Monitoring Program

The Barrow Island Vegetation Monitoring Program commenced in 2009. The monitoring results previously identified a decline in vegetation health in both the At Risk and Reference zones in 2010 and 2012. However, mean health scores in both the At Risk and Reference zones recovered slightly in 2011, and in 2013 increased to the highest levels recorded. These results indicate that the changes to vegetation health are not attributable to the Foundation Project (Chevron Australia 2013). Additionally, the results from the Vegetation Monitoring Program demonstrate that there was no significant change or loss of vegetation (including structural composition and/or species-richness), no difference in floristic composition, and little taxonomic diversity between the At Risk and Reference sites (Chevron Australia 2013).

3.5.1.4.2 Targeted Flora Monitoring

Two flora species are currently targeted for flora surveys and monitoring programs to identify Foundation Project-attributable impacts and to determine individual and population flora health. The species monitored under the Targeted Flora Monitoring Program are *A. bivenosa x sclerosperma* subsp. *sclerosperma* (previously identified as *Acacia robeorum*) and *Erythrina vespertilio*. *Acacia synchronicia*, which had previously been identified as *Acacia* sp. (*sclerosperma* complex) and had previously been monitored under the Targeted Flora Monitoring Program, was excluded from the 2012–2013 monitoring as it is not considered threatened. The results from the monitoring program demonstrate that construction of the Foundation Project is not having an adverse effect on either *A. bivenosa x sclerosperma* subsp. *sclerosperma* or *Erythrina vespertilio*.

3.5.1.4.3 Dust Impact Vegetation Monitoring Program

The impact of dust on vegetation is monitored by measuring a range of health and community characteristics at locations adjacent to infrastructure sites on Barrow Island.

Chevron Australia (2012) noted a trend of declining vegetation health and increased dust in the 2009, 2010a and 2010b assessments. This trend corresponded with seasonally dry weather conditions and was not considered to be a result of Foundation Project-related activities (Chevron Australia 2012). The study noted that this trend was reversed for the 2011a assessment, and was most likely driven by significantly above average rainfall that occurred between the 2010b and 2011a surveys. The 2011b data indicates a slight, but not significant, trend towards declining plant health and increased dust. However, this trend is likely to be a result of the low rainfall throughout the dry season between the 2011a and 2011b surveys (Chevron Australia 2012). The 2012a surveys showed a significant increase in average plant health, which was followed by varied results (although not significant) across monitoring sites for the 2012b and 2013a surveys (Chevron Australia 2013).

The strong correlation observed between rainfall, plant health, and dust load since monitoring commenced in 2009, indicates that rainfall is most likely the main factor affecting the health of plants (Chevron Australia 2012, 2013). Temporal analysis demonstrates that plant health and dust loads have no clear relationship independent of that associated with rainfall patterns (Chevron Australia 2013). The impact of dust on vegetation cover is considered low, suggesting the short-term impact of higher dust scores and the measured lower plant health score is not affecting the vegetation in the short term. Current dust management practices appear adequate; however, dust monitoring has continued because increased plant dust loads have been measured (Chevron Australia 2011, 2012).

3.5.1.5 Subterranean and Short-range Endemic Species

The subterranean and SRE surveys that have been and will be undertaken in areas outside the Gas Treatment Plant site and Additional Support Area are aimed at detecting those species that were previously only recorded within these two sites, in accordance with the Short Range

Endemics and Subterranean Fauna Monitoring Plan (Chevron Australia 2014a). Searches for subterranean fauna involve sampling bores across Barrow Island , while searches for SRE species or their burrows is undertaken in vegetation similar to that where the specimen was located. Ten species of subterranean fauna previously subject to targeted surveying have been identified outside the Gas Treatment Plant site and Additional Support Area, leaving four species requiring ongoing targeted searches. One SRE spider also requires further survey work to identify it outside the Gas Treatment Plant site and Additional Support Area (Chevron Australia 2014a).

3.5.1.6 Groundwater

The Groundwater Monitoring Program on Barrow Island monitors 'At Risk' bores (within the Gas Treatment Plant site and surrounding the deep well injection site) and 'Background' bores (outside the Gas Treatment Plant), as detailed in the Terrestrial and Subterranean Environment Monitoring Program (Chevron Australia 2014). An initial baseline assessment of quarterly groundwater sampling was undertaken prior to the commencement of construction up until January 2010 (Golder Associates 2010). The primary purpose of this assessment was to characterise groundwater quality and levels, and enable the assessment of subterranean communities. The information collected provides a baseline for assessing the potential future impacts of the Gas Treatment Plant development.

Ongoing groundwater monitoring during construction aims to determine if construction works are having an impact on groundwater quality and levels.

Hexavalent chromium was reported in December 2011; it was detected at the Gas Treatment Plant at concentrations above the limit of reporting and the adopted assessment level of the DER Fresh Water Assessment Level criteria (DEC 2010). Subsequent monitoring showed increasing concentrations, but during the June 2013 monitoring, no hexavalent chromium was detected in the bore or at any of the At Risk bores. Chevron Australia assessed the resulting potential environmental impact to stygofauna as low to negligible. This assessment was made because the concentrations of hexavalent chromium have been found at or below the marine water quality guidelines (the groundwater at the Gas Treatment Plant is brackish), there is no known evidence that stygofauna are adversely impacted by very low concentrations of hexavalent chromium, and concentrations have returned to below the limit of reporting (Chevron Australia 2013).

Quarterly monitoring results collected during the reporting period from March 2010 to August 2013 did not indicate any significant trend in analytes compared to measured groundwater baseline values and/or adopted assessment levels.

Based on the groundwater monitoring results to date, construction has not adversely impacted groundwater as a habitat for stygofauna in the immediate vicinity of monitoring well locations (Golder Associates 2012, Chevron Australia 2013).

The Foundation Project will continue to implement the ongoing Groundwater Monitoring Program on Barrow Island in accordance with the Terrestrial and Subterranean Environment Monitoring Program (Chevron Australia 2013) to detect any potential Foundation Project-attributable impacts.

In addition to the ongoing quarterly monitoring described above, additional targeted groundwater modelling and monitoring was performed to determine any measurable impacts beyond the disturbance footprint attributable to using sea water for compaction and dust suppression. The six-month program at the Gas Treatment Plant site showed no evidence of changes in salinity or water level as a result of the use of sea water; therefore, in consultation with DEC (now DPaW), it was determined that this targeted monitoring was no longer required.

3.5.1.7 Surface Water Landform Monitoring

Surface water landform monitoring is conducted using Light Detection and Ranging (LiDAR) remote sensing technology to identify any changes that may be Foundation Project-attributable. Detectable changes are related to the level or height of surface water on Barrow Island. Currently, 14 drainage features are monitored annually. For these monitoring techniques to be effective, several repeat datasets or image captures are required. LiDAR data captured between 2009 and 2012 revealed that there was no significant impact on surface water landforms as a result of the Foundation Project (Chevron Australia 2012, 2013).

3.5.2 Marine and Coastal Monitoring

The marine monitoring programs are detailed in the Long-term Marine Turtle Management Plan (Chevron Australia 2014b), the Dredging and Spoil Disposal Management and Monitoring Plan (Chevron Australia 2011e), the Offshore Feed Gas Pipeline Installation Management Plan (Chevron Australia 2014c), the Horizontal Directional Drilling Management and Monitoring Plan (Chevron Australia 2011f), and the Coastal Stability Management and Monitoring Plan (Chevron Australia 2009). The monitoring programs focus on:

- marine turtles
- benthic cover and composition, macroalgae and seagrass biomass and taxonomy, and macroinvertebrate abundance in the vicinity of the horizontal directional drilling site and offshore feed gas pipeline route
- water quality, coral health and spawning in the vicinity of the dredging and spoil disposal program
- coastal stability.

3.5.2.1 Marine Turtles

The Long-term Marine Turtle Management Plan (Chevron Australia 2014b) required under the Ministerial Conditions establishes a number of monitoring and research programs that focus primarily on Flatback Turtles using the east coast beaches of Barrow Island to nest.

These monitoring programs involve establishing baseline information on the populations of marine turtles, and implementing a monitoring program to measure and detect changes to the populations. The monitoring and research programs are:

- Flatback Turtle tagging
- Flatback Turtle nest success
- marine turtle track counts
- Flatback Turtle satellite tracking
- hatchling orientation
- marine turtle strandings
- Flatback Turtle hatchling congregation in offshore light spill
- hatchling dispersal and survivorship
- variation in sand temperatures among beaches
- light monitoring on beaches.

Coastal stability monitoring of five marine turtle nesting beaches is discussed in Section 3.5.2.4. Noise and vibration monitoring of marine turtles in discussed in Sections 3.5.5 and 3.5.6, respectively.

3.5.2.1.1 Flatback Turtle Tagging Program

The Flatback Turtle Tagging Program, which involves tagging and microchipping individual nesting females, has operated at Mundabullangana (the mainland Reference site) and on a number of east coast beaches on Barrow Island since 2005. The Flatback Turtle Tagging Program monitors a number of parameters including individual reproductive behaviour; nesting rookery size; demographics; adult turtle nest beach usage; survivorship and recruitment; and variation in abundance and spatial and temporal distribution of adult Flatback Turtles. Data from the 2012–2013 tagging program continues the stable trend in the number of nesting female Flatback Turtle for both Barrow Island and Mundabullangana (Chevron Australia 2013). Variations in abundance and spatial and temporal distribution of nesting adult Flatback Turtles did not detect any direct Foundation Project-attributable impacts (Chevron Australia 2011g, 2012, 2014b). However, a change to beach usage and spatial distribution of nesting adult Flatback Turtles at Terminal Beach and Bivalve Beach was observed in the 2012–2013 monitoring. This change is likely associated with the changes in beach profile and sediment redistribution that occurred along both beaches (Chevron Australia 2013).

3.5.2.1.2 Marine Turtle Track Census Program / Flatback Turtle Satellite Tracking

Results from the Marine Turtle Track Census Program (Chevron Australia 2011h) during the peak of the 2011–2012 nesting season, indicate that the Barrow Island marine turtles are still returning to their natal nesting beaches. During the 2011–2012 nesting season, very low levels of nesting activity also occurred on seven beaches on the north-east and west coasts of Barrow Island, where Flatback Turtle emergences had not been previously recorded. This may indicate an extension of the range for nesting females to alternative sites (Chevron Australia 2012). Similar proportions of Flatback Turtle in this reporting period compared to previous periods have been found nesting on beaches within a 2 km radius of construction activities since 2008–2009 (Chevron Australia 2013). Additionally, the monitoring results for the Green Turtle from the 2012 Marine Turtle Track Census Program have shown the proportion of Green Turtles nesting within 2 km of Foundation Project activities was not significantly different compared to previous monitoring periods. These results suggest that Flatback and Green Turtle activity has not been significantly affected by Foundation Project construction activities to date.

Satellite telemetry of internesting Flatback Turtles identified any changes in turtle behaviour during the offshore dredging program and construction of the Materials Offloading Facility, and found that the tracked turtles demonstrated similar movement and dive behaviour to that recorded before and during dredging activities. The 2010–2011 results showed a preference to congregate at the bottom of the dredging areas when the dredge vessels were not present. This was different from previous years when Flatback Turtles would travel towards the mainland for part of their internesting periods. The tracked turtles were found to avoid the dredging vessels operating in these areas during internesting, and, following nesting, they migrated to their foraging area in the Kimberley Region (Chevron Australia 2011i). There were two notable deviations in the 2011–2012 season from the previous results, being the preference of an internesting area within the north-east end of the LNG Jetty and at the south-east end of the Materials Offloading Facility (Chevron Australia 2012). This corresponded with the decrease in the proportion of their internesting time spent within the dredged zone.

3.5.2.1.3 Flatback Incubation Success Program / Nest Success

A number of Flatback Turtle nests laid on Bivalve, Terminal (either side of the Materials Offloading Facility location), and Mushroom beaches at Barrow Island, and at Mundabullangana on the mainland, were also monitored each nesting season to collect information on nest environment characteristics, nest incubation, and hatchling and emergence rates. In 2010–2011 an average of 87% of the eggs in the nests hatched, with the mean emergence success rate approximately 85%, which was similar to previous monitoring seasons (Chevron Australia 2011j). Lower hatch success was experienced in the 2011–2012 season across Barrow Island, with 68% of eggs hatching and 62% emerging from the nest, but this lower rate is not considered to be Foundation Project-attributable. Low hatch success during the 2011–2012 season was attributed to inundation of some of the monitored clutches by high water in January 2012 (Chevron Australia 2012). The 2012–2013 season on Barrow Island then experienced a significantly higher overall hatch success rate and significantly higher emergence numbers for the Flatback Turtle than recorded in the baseline seasons (Chevron Australia 2013).

3.5.2.1.4 Hatchling Orientation / Dispersal and Survivorship

The Hatchling Orientation Monitoring Program measures the dispersal pattern of Flatback Turtle hatchlings as they emerge from the nest and begin orienting towards the ocean. The results of the Hatchling Orientation Monitoring Program indicate that hatchling orientation (disorientation or misorientation) has not been affected by construction on Barrow Island to date and emergent Flatback and Green Turtle hatchlings are successfully migrating towards the ocean (Chevron Australia 2011k, 2014b). Hatchling dispersion and survivorship in water is also monitored for the Foundation Project. Further monitoring is required to determine whether there have been any Foundation Project-attributable impacts (Chevron Australia 2012).

3.5.2.1.5 Light Monitoring Program

The need to collect/measure light emissions lead to the development of an innovative light (sky) camera that has been successfully deployed. The equipment used and the analysis of its data continues to be refined and it is expected that this practice will be adopted elsewhere. Baseline light emissions data were collected in November 2009. The monitoring was conducted to monitor the existing ambient night-time light levels on Barrow Island and the Mundabullangana Flatback Turtle nesting beaches, to quantify and monitor changes to the light horizon as it is perceived by marine turtles on the east coast of Barrow Island during construction and operation of the Foundation Project, and to provide data that will facilitate the monitoring of short- and long- term construction and operational lighting impacts of the Foundation Project on the marine turtle populations. Data were collected from Barrow Island prior to the commencement of the turtle nesting season and at the peak of the hatchling emergence season.

Highest sky glow measurements were made in October 2010, associated with the rock crushing activities at the Gas Treatment Plant site. One main source of light on the east coast at the time was the Chevron Australia Camp. Following feedback from both the October 2010 light survey and a routine Foundation Project light audit, adaptive management of the lights within the Chevron Australia Camp area resulted in a 60% reduction in light levels by February 2011 (Chevron Australia 2011).

Analysis of the 2011–2012 season's data compared with data obtained during the 2010–2011 season showed that the mean light magnitudes have decreased between February 2011 and January 2012. Light sources from the Gas Treatment Plant, Materials Offloading Facility, and Chevron Australia Camp also showed a small, but not statistically significant, reduction in light levels between the 2010–2011 and 2011–2012 seasons (Chevron Australia 2012). The results from the 2012–2013 season showed varying results from the previous seasons, with light levels slightly increasing, decreasing, or showing no measurable change at the different beaches monitored. The LNG Jetty and Materials Offloading Facility contributed the most directly visible short-wavelength light to the east coast beaches on Barrow Island during the 2012–2013 season (Chevron Australia 2013).

Reviews of the effectiveness of lighting management have been undertaken in 2010, 2011, 2012, and 2013. There has been no evidence of environmental impact on marine turtles due to construction lighting (Chevron Australia 2010, 2011, 2012, 2013).

3.5.2.1.6 Congregation in Offshore Lights

The sea-finding direction that hatchlings take once they emerge from their egg clutches—a monitoring technique used to understand whether light may be affecting hatchling behaviour on beaches—has shown that hatchlings have been successfully migrating towards the ocean since monitoring commenced (Chevron Australia 2014b). Few hatchlings were observed in light spill around the Materials Offloading Facility during the 2011–2012 season, compared to tracks identified from the Marine Turtle Track Census Program (Chevron Australia 2012). A study was undertaken during 2011 to monitor whether Flatback Turtle hatchlings in the nearshore waters of Barrow Island were attracted to the lights on offshore marine vessels (Chevron Australia 2011l). Results found that few hatchlings were found in light spill; suggesting there was little evidence of hatchlings congregating around the marine vessel lights (Chevron Australia 2011l). This was confirmed in a second study in 2012, where no significant difference was found in the number of hatchlings attracted to areas of light spill compared to areas with no light spill (Chevron Australia 2012). The 2013 Environmental Performance Report recorded a limited number of hatchlings within offshore light spill, which was less than 1% of the overall numbers of emerging hatchlings at Barrow Island (Chevron Australia 2013).

3.5.2.1.7 Marine Turtle Strandings Monitoring Program

The Marine Turtle Strandings Monitoring Program collects records of dead or injured turtles and stranding events from natural, unnatural, and unknown causes (Chevron Australia 2013).

The 2013 Environmental Performance Report identified hatchlings (of unidentified species) in the water near offshore lighting and recorded one unidentified adult or juvenile turtle that had been struck by a vessel. The remainder of the adult or juvenile turtles and hatchlings recorded as injured, dead, or stranded were attributed to natural causes, particularly predation (Chevron Australia 2013). There is no evidence from the strandings data to suggest that there has been a significant impact on marine turtle populations of Barrow Island attributable to the construction of the Foundation Project (Chevron Australia 2013).

3.5.2.1.8 Variation of Sand Temperatures among Beaches

Beach temperature monitoring is also undertaken to present and compare current sand temperature data with baseline data collected since 2004 and to analyse the role of factors which influence sand temperature (Chevron Australia 2012, 2013).

The 2011–2012 and 2012–2013 monitoring results found that the Barrow Island sand temperatures during the nesting/hatching season for Flatback and Green Turtles were significantly hotter in the second and third years of construction than the sand temperatures recorded in the baseline seasons, and were highly correlated with air temperature. The high sand temperatures on the Flatback and Green Turtle nesting beaches monitored by this program were likely to have produced sex ratios biased towards females. However, the limitations of the application of this temperature data should be understood, so as to accurately estimate primary sex ratios for Flatback and Green Turtles on Barrow Island beaches (Chevron Australia 2012). The 2012–2013 monitoring determined sex ratios on Bivalve Beach and Terminal Beach were likely to vary spatially and temporally (Chevron Australia 2013).

3.5.2.1.9 Status of Marine Turtle Populations on Barrow Island

All population and demographic parameters for the Flatback Turtle, including annual nesters at Barrow Island and Mundabullangana and hatchling orientation at Bivalve and Terminal beaches, were within the key demographic parameters for the five-year baseline monitoring phase (2005–2006 to 2009–2010), and remained so during the three years after baseline period. However, there were three exceptions:

- mean clutch frequency was marginally lower
- annual Barrow Island nester abundance was significantly higher

- the standardised daily track counts at Bivalve Beach were marginally higher, consistent with the higher nester abundance.

Chevron Australia has also collected information for other marine turtles (Green and Hawksbill Turtles) that use Barrow Island. Track census information suggests that Green Turtles and Hawksbill Turtles continue to use the beaches around Barrow Island at a similar level to those recorded during baseline periods (Chevron Australia 2011h). The monitoring suggests that Green Turtle activity on Barrow Island has not been significantly impacted by construction activities on the Foundation Project to date (Chevron Australia 2012).

Furthermore, monitoring to date indicates that Green Turtle hatchling orientation has not been affected by the Foundation Project construction on Barrow Island. The current levels of artificial light from construction are not resulting in hatchling orientation beyond that observed at baseline levels (Chevron Australia 2011m).

In the MTEP's advice to the State Minister for Environment and the Proponent 'during the initial stages of construction has been that overall results indicate that the Flatback Turtle rookeries on the east coast of Barrow Island are stable with high remigration rates that are within recorded natural variation'. The MTEP also advised that it 'is of the view that the Proponent has demonstrated that the implementation of the Long-term Marine Turtle Management Plan meets, or intends to meet, the requirements Condition 16 of Statement No. 800'. In April 2012, the MTEP advised that it 'strongly supports the monitoring efforts of the Proponent and continues to encourage the publication of important research and monitoring methodology such as that developed for fan angles, control charts, and light pollution monitoring, in appropriate peer-reviewed journals'. The MTEP is further of the view that the 'implementation of the Long-term Marine Turtle Management Plan has maintained the high standard endorsed in the first annual review of its implementation.'

3.5.2.2 Dredging and Dredge Spoil Disposal Monitoring

A marine monitoring program was undertaken off the east coast of Barrow Island and at Reference Sites to demonstrate compliance with Conditions 18, 20, and 21 of Statement No. 800. Dredging and dredge spoil disposal activities management are covered in the Dredging and Spoil Disposal Management and Monitoring Plan (Chevron Australia 2011e).

The monitoring program began approximately three months before the commencement of dredging and dredge spoil disposal activities in March 2010, and continued on an approximately fortnightly basis until December 2011, 28 days after the completion of the dredging and dredge spoil disposal program. The focus of the monitoring program was on coral health and water quality.

The results of the monitoring program indicated that the marine works associated with construction, dredging, and dredge spoil disposal activities did not exceed the limits set out under Statement No. 800 and as revised in Statement No. 865 for permanent loss of coral assemblages or net detectable coral mortality.

The Post-Development Survey has highlighted the need to ensure that any baseline survey program has a robust design (including sites, replication, method etc.) with sufficient quality data collected so that any statistical comparison between 'before' and 'after' environmental state has the ability to provide a conclusive result.

3.5.2.3 Horizontal Directional Drilling Marine Monitoring

The Horizontal Directional Drilling Management and Monitoring Plan (Chevron Australia 2011f) requires monitoring of ecological elements at sites within the Marine Disturbance Footprint and at Reference Sites.

Telemetered water quality loggers (data loggers) were used by the Foundation Project to provide turbidity measurements as an indicator of any Foundation Project-attributable impacts on water quality. Data loggers were chosen as they were considered the most reliable method available for collecting turbidity measurements, given the environmental conditions. Satellite imagery, such as that being used to monitor impacts from dredging, cannot be used as the coastal area off Whites Beach is too shallow for the necessary calculations to be made. One data logger was in place for two years and the other for 12 months.

The data loggers recorded high variations in turbidity due to the effects of weather, swell, and tides in the relatively shallow conditions In June 2011, Chevron Australia received approval from DEC (now DPaW) to remove the water quality data loggers and amend the Horizontal Directional Drilling Management and Monitoring Plan (Chevron Australia 2011f) to reflect this (DEC 2011).

Analysis of field survey data determined no significant impacts occurred as a result of horizontal directional drilling activities to ecological elements including benthic cover, macroalgae and seagrass biomass, and macroinvertebrate species composition and abundance (Oceanica Consulting 2012, 2012a).

3.5.2.4 Coastal Stability Monitoring

The Coastal Stability Management and Monitoring Plan (Chevron Australia 2009) required under the Ministerial Conditions establishes a monitoring program during the construction and operation of the Materials Offloading Facility and the LNG Jetty at Town Point.

The focus of the program is to detect adverse changes to the beach structure and beach sediments of the adjacent beaches. The data from the monitoring program will be used with the information gathered from the long-term marine turtle monitoring to determine if the presence of the Materials Offloading Facility and the LNG Jetty is impacting marine turtles nesting on the beaches (Chevron Australia 2009).

Coastal stability monitoring commenced in 2008 with beach profiling and sampling of beach sediments on five marine turtle nesting beaches on the east coast of Barrow Island. This baseline data determined the existing beach structure and beach sediment characteristics for the beaches adjacent to Town Point (Terminal, Bivalve) and at Reference beaches (Inga, Yacht Club North, Yacht Club South) on the east coast of Barrow Island (Chevron Australia 2011).

Construction activities associated with the Materials Offloading Facility and the LNG Jetty commenced in May 2010. Beach profiling and sampling of beach sediments undertaken after the marine construction activities commenced were included in the post-commencement of construction data, analysed and reviewed, and then compared to the baseline data (from 2008) to measure against the criteria established for measuring significant impacts (Chevron Australia 2011).

The monitoring activities found beach profiling and sampling of beach sediments on the five east coast beaches showed little change over the reporting period. Where changes were recorded, they were considered likely to be in response to natural changes and/or coastal processes (Chevron Australia 2011, 2013). This was confirmed by the 2011–2012 and 2012–2013 monitoring (Chevron Australia 2012, 2013).

In accordance with the Ministerial Conditions, Coastal Stability Management Triggers have been established. The management triggers are values for beach volume, beach slope, and sediment characteristics such as particle size that may ‘trigger’ additional management measures (Chevron Australia 2011). Condition 25.6 of Statement No. 800 and Condition 18.6 of EPBC Reference: 2003/1294 and 2008/4178 state the actions required if monitoring shows that beach profile and sand grain size change beyond the performance standards.

As detailed within the Foundation Project’s Annual Environmental Performance Reports (Chevron Australia 2010, 2011, 2012, 2013), exceedances of management triggers occurred in several transects during the reporting period. These exceedances resulted in an Alert management measure, requiring the review of existing data and other relevant information to assess if the management trigger exceedance was Foundation Project-attributable and resulted in a significant adverse impact to the beaches adjacent to the Materials Offloading Facility and the LNG Jetty. The exceedances did not result in a breach of performance standards and the changes in beach structure were considered not to have an adverse impact on marine turtles or to only result in a remote likelihood of this occurring. No mitigation measures were required to be applied (Chevron Australia 2010, 2011, 2012, 2013).

3.5.2.5 Offshore Feed Gas Pipeline Installation Monitoring

The Foundation Project Ministerial Conditions require the GJVs to have a monitoring program to detect changes to ecological elements outside the Marine Disturbance Footprint for the Offshore Feed Gas Pipelines in State Waters. As a result, Chevron Australia is undertaking annual monitoring of seagrass, macroalgae, and non-coral macroinvertebrates during the installation of the feed gas pipeline system (Chevron Australia 2011). The monitoring sites that are used are described in the Coastal and Marine Baseline State and Environmental Impact Report: Offshore Feed Gas Pipeline and Marine Component of the Shoreline Crossing (Chevron Australia 2011n). Surveys are conducted each March to align with previous surveys occurring that month so the results can be seasonally compared (Chevron Australia 2011).

Conditions 16A and 16B of EPBC Reference: 2003/1294 and Condition 1 of EPBC Reference: 2005/2184 requires the reporting of cetacean sightings and the monitoring of any impacts on marine turtles and cetaceans. Vessel Masters or delegates have been allocated the responsibility for marine fauna observation on the installation vessels. They maintain watch for marine fauna during daylight hours when the marine vessels are moving at greater speeds than 5 knots. Sightings of marine megafauna (whales, dolphins, marine turtles, Dugongs, Whale Sharks) are recorded and reported to DotE (Chevron Australia 2011o).

All cetacean sightings are recorded using the online database available from the Australian Antarctic Data Centre Whale and Dolphin Sighting website (http://data.aad.gov.au/aadc/whales/report_sighting.cfm), and all sightings reports are added to the National Sightings and Strandings' database.

3.5.3 Terrestrial and Marine Quarantine Management

The Terrestrial and Marine Quarantine Management System (QMS) (Chevron Australia 2014d) is in place to prevent the introduction or proliferation of any Non-indigenous Terrestrial Species and Marine Pests to or within Barrow Island or its surrounding waters, as a consequence of the Foundation Project. The QMS includes the following components:

- Weed Hygiene Common User Procedure
- Non-indigenous Terrestrial Species Management Procedure
- Non-indigenous Terrestrial Species and Marine Pest Detection Program, comprising:
    - Non-indigenous Terrestrial Surveillance Programs, including the Vertebrate Non-indigenous Species Surveillance Program, the Invertebrate Non-indigenous Species Surveillance Program, the Plant Non-indigenous Species Surveillance Program
    - Marine Pest Surveillance Program
- Quarantine Audits.

The QMS has earned awards and recognition during its implementation, including the 2011 Australian Petroleum Production and Exploration Association's Environment Award, the 2011 WA Engineering Excellence Environment Award and most recently, the QMS won the 2012 United Nations Association of Australia Best Practice Program. The EPA concluded '...that the quarantine management system proposed, subject to it being implemented as proposed, is likely to be world's best practice and therefore it is unlikely to be possible to recommend additional practical controls beyond that system' (EPA 2009). As detailed within the Foundation Project's Annual Environmental Performance Reports, there have been quarantine intercepts and incidents, recorded and reported accordingly (Chevron Australia 2010, 2011, 2012, 2013). These intercepts demonstrate that the QMS is working, and, to date, has prevented any incursions of Non-indigenous Terrestrial Species or Marine Pests from occurring as a result of the Foundation Project. No significant quarantine procedural deviations have been recorded on Barrow Island as a result of the Foundation Project.

In accordance with Ministerial Conditions, improvements have been made to the QMS as a result of 'best practice', in consultation with the QEP, DPaW, and DotE since 2010.

In its December 2011 advice to the State Minister for Environment and the Proponent, the QEP advised that it 'is of the view that the principles on which the Gorgon Quarantine Management System has been developed continue to be well-founded and the barriers established appear effective in achieving a low risk of introduction or proliferation of Non-indigenous Terrestrial Species and Marine Pests to or within Barrow Island or the waters surrounding Barrow Island'. The QEP also advised that it 'has reviewed the implementation and effectiveness of the Gorgon Quarantine Management System and is satisfied that the Proponent has provided evidence that demonstrates the Gorgon Quarantine Management System is meeting, or intends to meet, the requirements of Condition 10 of Statements No. 800 and No. 769'.

Continuous improvement of the QMS has also been informed by detailed analysis of the lead indicators of quarantine performance, resulting in a better understanding of quarantine threats and the implementation of preventive measures. Further information pertaining to the QMS is provided in Section 12.

3.5.4 Noise Monitoring (Construction) – Mammals and White-winged Fairy-wrens (Barrow Island)

The Noise and Vibration Monitoring Plan, as stated in the Terrestrial and Subterranean Environment Monitoring Program (Chevron Australia 2013), requires an ongoing noise monitoring program that quantifies and monitors changes to noise levels during the construction phase of the Foundation Project at selected locations on Barrow Island that are known to be inhabited by mammal species and the White-winged Fairy-wren (Barrow Island) (Chevron Australia 2011). Prior to construction commencing for the Foundation Project baseline noise monitoring was undertaken to quantify noise levels at selected locations on Barrow Island, known to be inhabited by mammal species and the White-winged Fairy-wren (Barrow Island) (Chevron Australia 2012). The noise monitoring program measures two week periods of broadband and narrowband noise to coincide with mammal mating and the White-winged Fairy-wren (Barrow Island) nesting seasons across Barrow Island.

The monitoring program has found a general increase in noise levels at sites in the vicinity of construction activities associated with the Foundation Project. Locations that are situated close to the Gas Treatment Plant and Materials Offloading Facility construction sites, haul roads, and the airport have experienced increases in noise levels in the 2010–2011, 2011–2012, and/or 2012–2013 seasons. Noise levels at the other monitoring locations have either decreased or have not changed significantly (Chevron Australia 2012, 2013). There is no evidence that construction-related activities have had any direct impact on the abundance of mammals or White-winged Fairy-wrens (Barrow Island) to date (Chevron Australia 2011, 2012, 2013).

3.5.5 Noise Monitoring (Construction) – Marine Turtles

The noise monitoring program, as stated in the Long-term Marine Turtle Management Plan (Chevron Australia 2014b), quantifies and monitors changes to noise levels at selected beaches on Barrow Island during construction of the Foundation Project.

The monitoring program measures two week periods of broadband and narrowband noise; these times coincide with turtle nesting and turtle hatching times between December and March each year at eight beach locations on Barrow Island.

The noise data collected during the 2011–2012 season did not detect any Foundation Project-attributable impacts and only a marginal increase in noise levels has been experienced at beach monitoring locations since the baseline data were collected in 2009. Further, the data on Flatback Turtle population estimates show that the proportion of turtle sightings across Barrow Island beaches did not differ across seasons.

The noise monitoring program for marine turtles is currently suspended (in consultation with the MTEP) because of difficulties in detecting any onshore noise effects on turtles from Foundation Project activities, as a result of high natural background measurements from ocean waves (Chevron Australia 2013).

3.5.6 Vibration Monitoring (Construction) – Marine Turtles

The vibration monitoring program, as stated in the Long-term Marine Turtle Management Plan (Chevron Australia 2014b), quantifies and monitors changes to vibration levels at selected beaches on Barrow Island during construction of the Foundation Project.

Vibration sensors are placed on five beaches (two at Terminal Beach, two at Bivalve Beach, one at Flacourt Beach, one at Whites Beach, and two at Bed Beach) during turtle nesting and turtle hatching times between December and March each year. The vibration sensors record one day (24 hours) of continuous vibration monitoring at five-second intervals during each monitoring period. Vibration is measured on the beach surface (0 m), and subsurface (-0.5 m, which represents the depth of turtle egg chambers).

There has been no evidence of significant increases in vibration levels since baseline monitoring was undertaken in 2009, with all vibration levels measured on the east and west coast beaches of Barrow Island found to be very low (always below 0.1 m/s). The results are typical of ground-borne vibration levels measured on beaches in the north-west region of Western Australia (Chevron Australia 2012). An increase in vibration levels has not been detected during construction activities at monitoring locations adjacent to the Materials Offloading Facility and Gas Treatment Plant (Chevron Australia 2012).

Vibration monitoring for marine turtles was suspended (in consultation with the MTEP) because of difficulties in detecting onshore vibration effects on turtles from Foundation Project activities, as a result of high natural background measurements from ocean waves (Chevron Australia 2013).

3.5.7 Ambient Air Quality Monitoring

3.5.7.1 Ongoing Ambient Air Quality Monitoring Program (Construction)

The objective of the ongoing Ambient Air Quality Monitoring Program for the construction phase of the Foundation Project is to periodically monitor dust levels to compare against the results of ongoing vegetation surveys for assessment of the potential effects of dust on vegetation (Chevron Australia 2011).

Dust deposition gauges were established adjacent to dust sources predicted to potentially impact surrounding vegetation. Currently, 41 dust deposition gauges are installed in 11 areas across Barrow Island to monitor dust fallout from several terrestrial facilities (Chevron Australia 2011, 2012, 2013).

Sampling during construction activities has been carried out monthly since February 2010. The results from the ongoing Ambient Air Quality Monitoring Program suggest ongoing construction activities and vehicular traffic are the likely sources of particulates (Chevron Australia 2012, 2013). Depositional rates were usually highest at the Gas Treatment Plant, Butler Park (Construction Village), and Barge Landing sites and correlated with prevailing wind directions (Chevron Australia 2012, 2013). The results of this Program have been compared to the results from the ongoing Dust Impact Vegetation Monitoring Program. The results from the Dust Impact Vegetation Monitoring Program, as discussed in Section 3.5.1.4.3, indicate that rainfall is most likely the main factor affecting plant health, with the impact to vegetation cover from dust considered low.

3.5.7.2 Ambient Air Quality Monitoring Program – Start-up, Commissioning, and Operations

The Ambient Air Quality Monitoring Program, designed to support the Ambient Air Quality Management Plan for the start-up, commissioning, and operations phase of the Foundation Project, aims to determine levels of atmospheric pollutants and air toxic emissions in the atmosphere. This will establish whether ambient air quality meets suitable key performance standards for human health in the workplace, and whether air emissions from the Gas Treatment Plant site operations pose a risk of Material or Serious Environmental Harm to the flora, vegetation communities, terrestrial fauna, and subterranean fauna on Barrow Island. The Ambient Air Quality Monitoring Program – Start-up, Commissioning, and Operations commenced in December 2012 to collect baseline data (Chevron Australia 2013).

3.6 Barrow Island Act 2003 Schedule 1 Obligations

The State Agreement places a number of obligations relating to environmental protection on the Foundation Project. Outlined below is a brief summary of the various obligations.

3.6.1 Additional Gorgon Joint Venture Undertakings

In addition to the requirements to manage the impacts of the Foundation Project under Statement No. 800, the GJVs committed to a number of additional initiatives to ensure environmental protection, which are described in the preamble to Statement No. 800. The value of these undertakings is AU$90 million (indexed). In September 2009, the undertakings were incorporated into the State Agreement by a tabled Variation Agreement. An outline of the initiatives is provided below.

3.6.1.1 North West Shelf Flatback Turtle Conservation Program

The 30-year North West Shelf Flatback Turtle Conservation Program is being undertaken to increase the protection of the populations of marine turtles in areas away from Barrow Island. The program will include activities to:

- survey, monitor and research marine turtle populations
- mitigate loss by reducing interference to key feeding and breeding locations
- establish information and education programs to support protection.

The North West Shelf Flatback Turtle Conservation Program is administered by DPaW. Funds are provided to DPaW by the GJVs on receipt of invoice. The GJVs have appointed their representative to the Advisory Board for this Program and have confirmed their support for the proposed independent Chair.

3.6.1.2 North West Shelf Flatback Turtle Intervention Program

If the monitoring undertaken as part of the North West Shelf Flatback Turtle Conservation Program described above clearly demonstrates that the Foundation Project is having a significant adverse impact on the Flatback Turtle population, the GJVs will take or fund further actions to improve recruitment to the turtle population, potentially including the establishment of hatcheries.

The Gorgon Marine Turtle Monitoring Program (Section 3.5.2.1) has not detected any significant adverse Foundation Project-attributable impact on the Flatback Turtle population to date. Additional funds will be capped at AU$5 million as stated in the preamble of Statement No. 800 under the heading North West Shelf Flatback Turtle Intervention Program.

3.6.1.3 Threatened Species Translocation and Reintroduction Program

A Threatened Species Translocation and Reintroduction Program for selected species of fauna from Barrow Island to other Pilbara islands and mainland locations is being undertaken by DPaW. The State will be responsible for the translocation and reintroduction outcomes as stated in the preamble of Statement No. 800 under the heading of Threatened Species Translocation and Reintroduction Program. The Threatened Species Translocation and Reintroduction Program is extended as per the requirements of Statement No. 965.

3.6.1.4 Eradication of Non-indigenous Terrestrial Species.

In addition to the quarantine management conditions, the GJVs provide a financial guarantee of AU$10 million (as stated in the preamble of Statement No. 800 under the heading Eradication of Non-indigenous Species) to cover State Government costs for the eradication of Non-indigenous Terrestrial Species established on Barrow Island, other than through natural causes, and following commencement of the Foundation Project.

As a result of the robust quarantine management system design and implementation, there have been no incursions of Non-indigenous Terrestrial Species to Barrow Island to date (Section 3.5.3). Thus, there has been no need for any eradication-related actions by the GJVs or the State Government.

3.6.1.5 Dredging

The GJVs have funded State Government agency costs capped at AU$2.5 million, in addition to the amount payable by the GJV participants under Clause 12 of the Gorgon Gas Processing and Infrastructure Agreement, associated with the surveillance of marine activities during dredging and marine construction, and the ongoing evaluation of the marine environment response and recovery.

The required funds were provided to DEC (now DPaW) on receipt of invoice. DPaW has implemented a marine surveillance program and has provided the CDEEP with a briefing on the preliminary findings.

3.6.2 Barrow Island Coordination Council (BICC)

Under Schedule 1 of the *Barrow Island Act 2003* (WA), the GJVs are required to make arrangements with the Barrow Island Joint Venture (holder of Petroleum Lease (L1H) on Barrow Island) to form and operate the BICC. The purpose of the BICC is specified in Clause 13 of Schedule 1 of the Act and includes the following:

- provide a single point of contact and interaction with the government agency responsible for administration of the *Conservation and Land Management Act 1984* (WA) (now DPaW) regarding the management of issues related generally to the BICC participants' operations on the Island
- liaising with DPaW with respect to the *Conservation and Land Management Act 1984* (WA) management plan for Barrow Island, to the extent that it relates generally to the operations of the BICC participants on the Island
- planning and coordinating the BICC's role in emergency response and where necessary remediation
- establishing, monitoring and reviewing quarantine procedures in relation to the BICC participants' operations on the Island
- coordinate fire management on Barrow Island outside the terrestrial disturbance footprint, and
- any other matter to be agreed to by the BICC participants.

The BICC was formed and became operational on 13 October 2009 and consists of representatives from both the Gorgon Joint Venture and the Barrow Island Joint Venture. The

BICC submits reports annually to the Minister for State Development and DPaW. The annual report is a report of all BICC activities in the preceding 12 months.

3.6.3 Net Conservation Benefits

The State Agreement requires the GJVs to pay AU$60 million (indexed) in instalments to fund Net Conservation Benefits for the Foundation Project's 15 MTPA development. Net Conservation Benefits are defined in the *Barrow Island Act 2003* (WA) as 'demonstrable and sustainable additions to, or improvements in, biodiversity conservation values of Western Australia targeting, where possible, the biodiversity conservation values affected or occurring in similar bioregions to Barrow Island'. Under the varied Clause 11 of Schedule 1 of the *Barrow Island Act 2003* (WA), an expansion to the Gorgon Gas Development will result in a proportionate increase in Net Conservation Benefits funding. This increase in funding will be negotiated with the Government of Western Australia. The proportionate increase in funding required as a result of the Foundation Project changing from a two-train to a three-train proposal was AU$20 million.

In February 2012, the State Minister for Environment announced that four projects will be funded from the Foundation Project's Net Conservation Benefits; these are:

- AU$8.5 million over seven years for the Dirk Hartog Island National Park ecological restoration project –managed by DEC (now DPaW). DPaW will contribute another AU$4.8 million
- AU$5.7 million over five years for conservation of western Pilbara fauna – managed by the WA Museum. The WA Museum will contribute another AU$1.2 million
- AU$7.19 million over five years for managing the conservation significance of coral reef ecosystems in the Pilbara/Ningaloo region: Pilbara Marine Conservation Partnership – managed by the University of Western Australia (UWA) and the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Wealth from Oceans Flagship. UWA and CSIRO will contribute another AU$4.22 million
- AU$2.04 million over five years for a decision support system for prioritising and implementing biosecurity on Western Australia's islands – managed by DEC (now DPaW) and James Cook University. DPaW and James Cook University will contribute another AU$1.94 million.

The State Government has announced that monies for these projects will be spent over the next seven years to help secure the biodiversity conservation values of Western Australia.

3.6.4 Department of Parks and Wildlife Funding

Under the State Agreement, the GJVs are required to pay costs associated with a permanent management presence on Barrow Island of government agency officers responsible for the administration of the *Conservation and Land Management Act 1984* (WA) (now DPaW). The payments for costs are capped under Schedule 1 at AU$1 million a year (indexed) during the major construction phases and AU$750 000 a year (indexed) during other times. To date, the GJVs have provided the required payments to DPaW. The Fourth Train Proposal, which is also subject to Schedule 1, will continue to meet these obligations.

3.7 Offsets

A condition relating to environmental offsets was introduced for the Foundation Project under Statement No. 965 for the Additional Support Area. The condition requires the GJVs to provide an additional contribution to the Threatened Species Translocation and Reintroduction Program, as discussed in Section 3.6.1.3, if rehabilitation of the Additional Support Area has not substantially commenced within a period specified by the conditions of Statement No. 965.

3.8 Conclusion

Since the Foundation Project commenced construction in late 2009, no Serious or Material Environmental Harm outside that approved under the Ministerial Conditions has been recorded. The Environmental Management Framework has been effective in managing and mitigating Foundation Project-attributable impacts. The Environmental Performance Assessment Reports and Compliance Assessment Reports submitted by Chevron Australia have satisfied the requirements of the OEPA, DPaW, and DotE. Information presented in these Reports and summarised in Sections 3.5 and 16.2.1 support Chevron Australia's position that there are processes in place to review progress, record, and implement any experience gained to date.

Experience gained from the Foundation Project is detailed in Section 16.2.1, including from the implementation of specific EMPs and monitoring programs. This has been used to inform this PER/Draft EIS and verify that the mitigation and management measures are sufficient. This is particularly with respect to the assessment of potential impacts from stressors, and the identification of mitigation and management measures to reduce the potential for impacts to ecological elements.

Based on the experience in implementing the Foundation Project to date, the GJVs are confident that the Environmental Management Framework has provided, and will continue to provide, an effective method for protecting the environmental and conservation values of Barrow Island and its surrounding waters.

3.9 References Cited in Section 3

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Section 4: Table of Contents

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4. Proposal Description and Alternatives

4.1 Introduction

The GJVs propose to expand the Gorgon Project by developing additional gas fields in the Fourth Train Proposal Area, which includes the Greater Gorgon Area, and by adding a fourth liquefied natural gas (LNG) train. This involves an expansion of the facilities installed (or to be installed) as part of the approved Foundation Project for the development of additional gas fields in the Fourth Train Proposal Area and the addition of a fourth LNG train.

Gas fields included in the Fourth Train Proposal and their associated infrastructure may be developed to support the three-train Foundation Project before the fourth LNG train is constructed. Once the fourth LNG train is constructed, gas from the Fourth Train Proposal gas fields and the approved Foundation Project gas fields (Gorgon and Jansz–Io) will be treated via the fourth train as well as the three trains that are part of the approved Foundation Project. Note that the treatment of gas from Fourth Train Proposal gas fields by the approved Foundation Project is not currently approved, and approvals is being sought through this PER/Draft EIS.

Major changes to the approved Foundation Project facilities that are proposed for the Fourth Train Proposal are outlined in this section. However, minor changes to the approved Foundation Project facilities that are made for reasons of design or efficient sharing of infrastructure may be implemented (e.g. as the design of the Fourth Train Proposal progresses) where they may not have a substantial environmental impact (e.g. refurbishment of a reverse osmosis unit to extend its operating life).

Due to the early stage of project definition, precise engineering design details and exact locations for some of the Fourth Train Proposal infrastructure have not yet been decided by the GJVs. Design or construction options that are being investigated by the GJVs are described in this section, where relevant, to outline the scope of works required for environmental impact assessment in later sections of this document. Additional detailed design and construction information, where relevant, will be provided by the GJVs in subsequent environmental management plans and works approval applications.

This section describes the infrastructure included in the Fourth Train Proposal and outlines the key processes required to construct, operate, and decommission the infrastructure. Also included are various options that are being considered for implementation on the Fourth Train Proposal. Where options exist, a cross-reference is included to the relevant section(s) of this PER/Draft EIS that assess the worst-case impacts from those various option(s).

4.1.1 Fourth Train Proposal Overview

Approval is sought for the construction, commissioning, operation, and decommissioning of the Fourth Train Proposal, including these main components:

- production wells targeting the hydrocarbon reserves in four gas fields located in the Fourth Train Proposal Area (other than reserves from the Gorgon or Jansz–Io gas fields) (Figure 4-1)
- subsea infrastructure to extract and gather the gas and condensate from the subsea wells and transfer it to a Feed Gas Pipeline System
- a Feed Gas Pipeline System to transfer the gathered gas and condensate to the Gas Treatment Plant on Barrow Island
- an LNG train and associated terrestrial infrastructure at the Gas Treatment Plant on Barrow Island, which will process gas from the Fourth Train Proposal and Gorgon and Jansz–Io gas fields.

The production wells, subsea infrastructure, and the offshore Feed Gas Pipeline System will be installed in the Commonwealth Marine Area. The offshore Feed Gas Pipeline System crosses into State jurisdiction, 3 nm from Barrow Island.

Figure 4-2 shows the Fourth Train Proposal components on and near Barrow Island, in relation to the approved Foundation Project.

Wherever practicable, the Fourth Train Proposal will share approved Foundation Project facilities and sites. In particular, existing LNG and condensate export facilities, constructed as part of the approved Foundation Project, will be used to export the hydrocarbon products generated by the Fourth Train Proposal. Some approved Foundation Project facilities or sites may require modifications and/or additions to accommodate the requirements of the Fourth Train Proposal. Where major changes to these facilities may have a substantial impact on the environment, assessment of the environmental impacts from those changes has been included in this PER/Draft EIS. These facilities are already approved for use by the Foundation Project; however, approval is being sought by this PER/Draft EIS for the Fourth Train Proposal to use or alter these shared facilities.

The Fourth Train Proposal may be constructed in stages, and gas fields included in the Fourth Train Proposal and their associated infrastructure may be developed to support the three-train Foundation Project before the fourth LNG train is constructed.

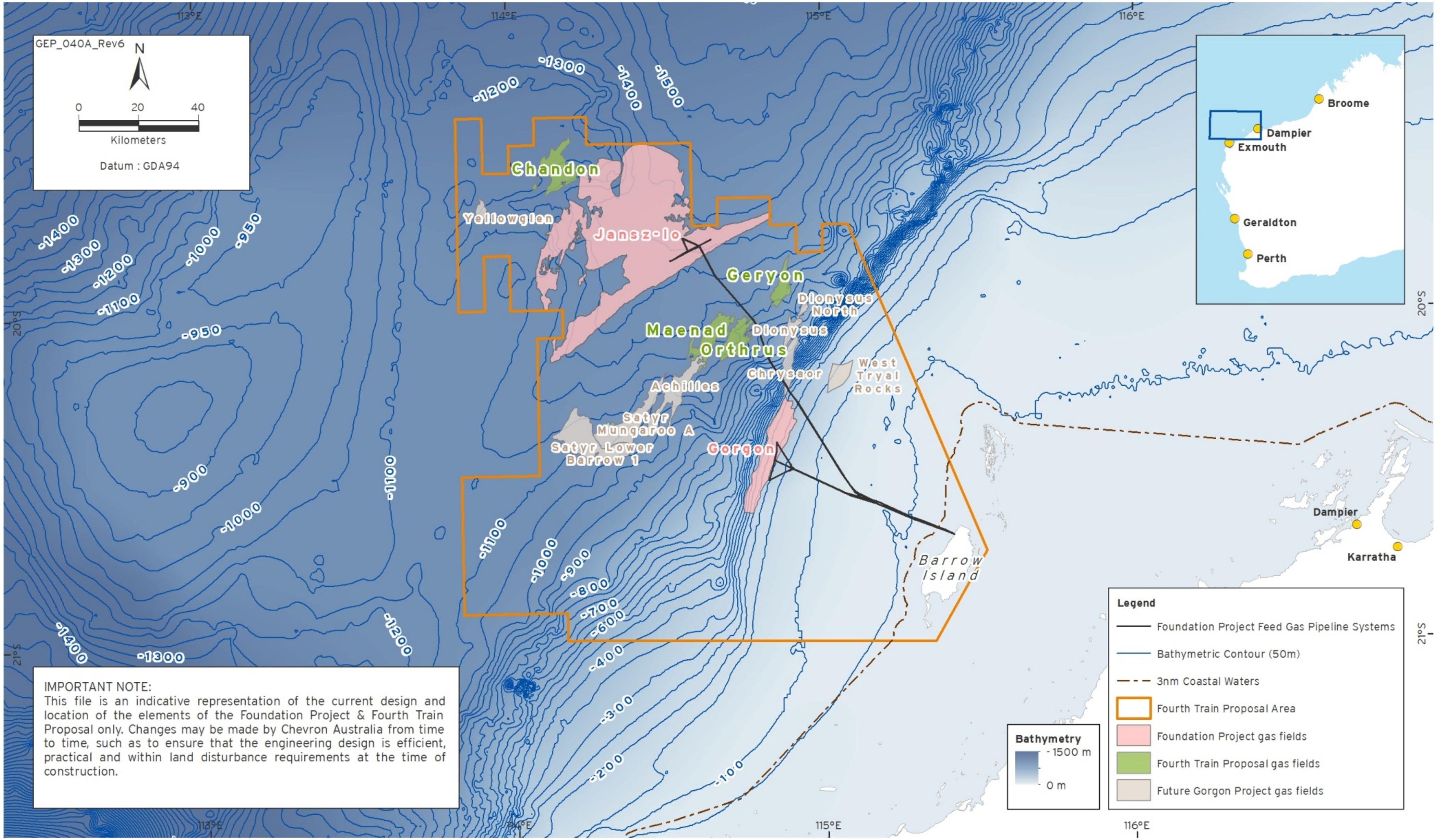

Figure 4-1: Location of the Gas Fields to be Developed for the Fourth Train Proposal

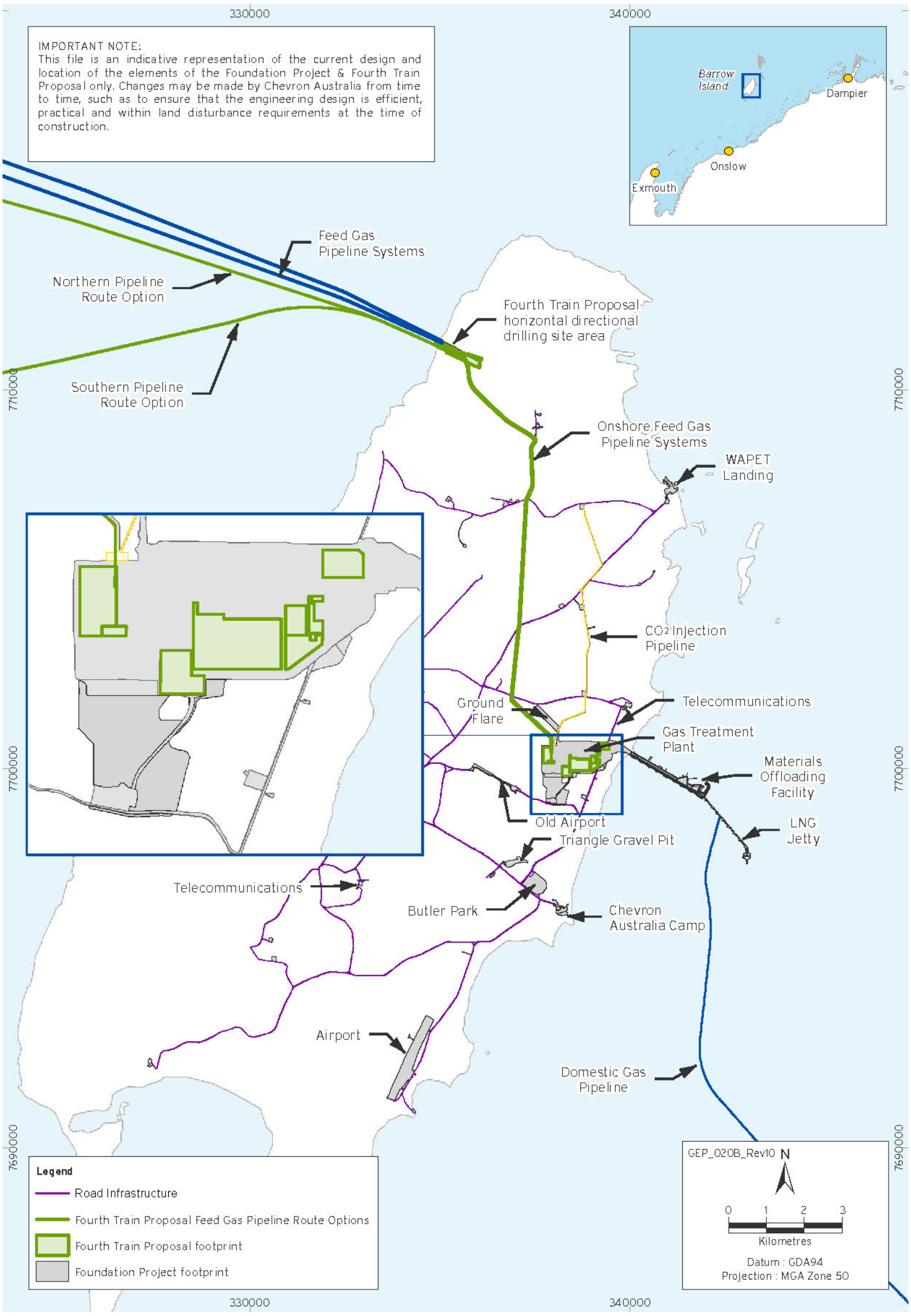

Figure 4-2: Overview of the Key Fourth Train Proposal Components on or near Barrow Island in Relation to the Approved Foundation Project

4.2 Alternatives to the Proposed Development

Barrow Island was selected as the preferred development location for processing gas from the Greater Gorgon Area following a strategic review of alternative development sites (ChevronTexaco Australia 2003). The Gorgon Gas Processing and Infrastructure Project Agreement (State Agreement) and its ratifying Act, the *Barrow Island Act 2003* (WA) outline the obligations and conditions of the Gorgon Gas Development. Following the strategic review and ratification of the *Barrow Island Act 2003* (WA), a number of environmental approvals were granted for the Gorgon Gas Development Foundation Project, which has been acknowledged by the GJVs and WA Government as being a phased development.

To date, this phased approach has included the Initial Gorgon Gas Development, the Jansz–Io Development Project, the Revised and Expanded Proposal, and the Additional Support Area (Section 3.4.2.1). The Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP; Chevron Australia 2005) prepared for the Initial Gorgon Gas Development included information relating to the intent to further develop gas in the Greater Gorgon Area through future capacity increases of the processing facilities on Barrow Island. The opportunity to accelerate the development of gas resources in the Greater Gorgon Area was identified in 2010.

During the preparation of this PER/Draft EIS, the following alternatives to the Fourth Train Proposal were considered:

- Developing the gas resource. Two options were considered, including processing the gas using existing gas processing facilities or infrastructure in the Pilbara Region, or processing the gas at new location in the Pilbara Region.
- Defer or not develop. 'Defer' is defined as delaying the development of the gas reserves until capacity in the approved Foundation Project's Gas Treatment Plant becomes available. 'Not develop' is defined as the status quo, meaning that there would be no development of the gas resource.

4.2.1 Developing the Gas Resource

4.2.1.1 Existing Gas Processing Facilities or Infrastructure

Processing the gas at existing facilities and infrastructure (e.g. the Burrup Peninsula, Ashburton North Strategic Industrial Area) was considered during the preparation of this PER/Draft EIS.

A key environmental benefit of using existing infrastructure is that it reduces the requirement for new infrastructure, thus reducing the overall physical footprint and associated short-, medium-, and long-term environmental impacts of developing the gas resource. The use of existing facilities on the Australian mainland would require the installation of substantial offshore infrastructure to transport the gas from the gas fields to existing mainland gas treatment facilities. Therefore, developing the gas fields shown in Figure 4-1 would require an additional Feed Gas Pipeline System to be installed to extract and gather the gas from these gas fields.

Barrow Island is the closest existing gas processing facility to these gas fields and therefore the marine disturbance footprint would be less than compared to piping the gas to existing facilities on the Australian mainland. In addition, Barrow Island is the most suitable location for processing the gas, given the compatibility of the commercial agreements (and associated Joint Venture Participants) that cover the gas fields shown in Figure 4-1 and the onshore and offshore facilities and gas processing infrastructure associated with the Foundation Project.

The existence of the approved Foundation Project on Barrow Island is beneficial in understanding and mitigating impacts and reducing uncertainty, resulting in a well-informed and comprehensive environmental impact assessment of the Fourth Train Proposal.

Incorporating a fourth train into the approved Foundation Project provides economies of scale. A short-term benefit is that it can reduce costs during construction, which is labour and resource intensive. Medium- to long-term benefits are that the Fourth Train Proposal can use existing Foundation Project facilities and infrastructure, reducing costs during operations.

Maximising synergies with the approved Foundation Project also has environmental benefits. The short-term environmental benefit is that it reduces the scale of construction activities and their related impacts on Barrow Island. Medium- to long-term environmental benefits of this synergistic approach are that it reduces emissions, discharges, and wastes, and results in a reduced disturbance footprint on Barrow Island.

4.2.1.2 New Location

The advantage of processing the gas at a new location in the Pilbara is that it would avoid any environmental impacts associated with the Fourth Train Proposal on Barrow Island, as outlined in this PER/Draft EIS. However, if the gas is processed at a new location, the opportunity to use the approved Foundation Project facilities and infrastructure would not be possible, potentially resulting in a greater net environmental impact in the short, medium, and long term. Short-term disadvantages of a new location are that it would require the construction of new gas processing facilities, accommodation, utilities, and other supporting infrastructure, resulting in a higher level of emissions, discharges, and wastes compared to the Fourth Train Proposal.

If the gas is processed at a new location on the mainland, additional social impacts may also be expected. Short-term disadvantages of a new location are that construction activities could disturb cultural heritage sites, reduce recreational opportunities (e.g. fishing), and impact on public amenities (e.g. medical facilities). A long-term disadvantage is that the presence of a new facility could adversely impact tourism. The remote location and absence of a permanent residential population on Barrow Island means that limited social impacts can be expected from the Fourth Train Proposal.

Other disadvantages of processing the gas at a new location include the inability to use the approved Foundation Project Carbon Dioxide Injection System, which would result in higher greenhouse gas emissions.

4.2.2 Defer or Not Develop Alternative

4.2.2.1 Deferring the Development

The primary disadvantage of delaying the development of the gas reserves until capacity in the approved Foundation Project Gas Treatment Plant becomes available (i.e. when hydrocarbon reserves in the Foundation Project's Gorgon and Jansz–Io gas fields decline) is that the economic benefits to the region, State, and nation will be delayed, resulting in short- to long-term economic disadvantages from loss of construction and operations jobs, income, and taxation revenue. Deferring the development until capacity is available in the approved Foundation Project Gas Treatment Plant would still require significant offshore infrastructure to be installed, including wells, manifolds, intrafield flowlines, and potentially an additional Feed Gas Pipeline System.

If the Fourth Train Proposal is delayed, it would not be able to capitalise on the availability of experienced workers created by the approved Foundation Project. A significant delay may result in experienced workers moving to other major projects, resulting in a skill shortage in the short to medium term. Delaying the Fourth Train Proposal could also result in the loss of potential industrial gas customers to other international competitors. The Fourth Train Proposal would ensure the realisation of economic benefits to the nation, State, and region, and will help Western Australia to maintain a high rate of economic growth and low rate of unemployment.

4.2.2.2 Not Develop

The primary adverse impact of not developing the additional gas resources in the Greater Gorgon Area includes the loss of economic benefits to the nation, State, and the Pilbara Region that would increase general economic growth and sustain regional development.

Not developing the gas resource will include a range of short-, medium-, and long-term disadvantages. Short-term disadvantages include the loss of job opportunities and business/service income to support the construction activities, and the loss of government revenue through the direct payment of taxes from workers and businesses. Economic modelling undertaken by ACIL Tasman (2012) for the Fourth Train Proposal and based on 2011 inputs (Section 14.8) indicates that the development is expected to create approximately 6300 direct and indirect jobs during the construction period and generate approximately AU$97 billion (for a Net Present Value of approximately AU$46 billion)[5] in total revenues. This has considerable beneficial effects to the Australian and Western Australian economies.

Medium- and long-term disadvantages include the loss of national, State, and regional revenue, in the form of decreased taxation payments, decreased national Gross Domestic Product, and decreased employment. This would deny Australians and Western Australians the associated economic and social benefits of that increased revenue.

The beneficial impact of not developing the resource is that it eliminates additional environmental impacts in the short, medium, or long term. However, the global energy demand for LNG would still remain and the benefits of using natural gas as a source of low-emissions thermal energy would not be realised (Figure 11-1), potentially resulting in future global energy demand being satisfied through other sources of energy with markedly higher greenhouse gas emissions.

4.2.3 Comparison of Alternatives in Relation to the Controlling Provisions

Consideration was given to whether the above-mentioned alternatives would impact on the matters of national environmental significance relevant to the Fourth Train Proposal (termed 'controlling provisions').

Table 4-1 shows that all alternatives, except the 'not develop' alternative, could directly potentially impact on the controlling provisions. This is primarily due to the potential offshore impacts associated with each alternative, particularly hydrocarbon spills. Hydrocarbon spill modelling completed for the Fourth Train Proposal (Section 5.7.2.1) indicates that the modelled scenarios have the potential to impact on the Fourth Train Proposal controlling provisions, which are similar for each alternative.

Table 4-1: Comparison of Alternatives to the Fourth Train Proposal that can Potentially Impact the Controlling Provisions

Controlling Provision	Existing Location	New Location	Defer	Not Develop
National Heritage Places	×	×	×	
Listed threatened species and communities	×	×	×	
Listed migratory species	×	×	×	
Commonwealth Marine Environment	×	×	×	

4.2.4 Preferred Alternative

An evaluation by the GJVs of the environmental, social, and economic advantages and disadvantages of the above alternatives concluded that the Fourth Train Proposal, which includes the construction of a new offshore Feed Gas Pipeline System and an additional LNG

[5] Includes LNG and condensate sales

processing train within the approved Foundation Project Gas Treatment Plant on Barrow Island, was the preferred alternative.

The existence of the approved Foundation Project is advantageous in understanding and mitigating impacts and reducing uncertainty, resulting in a well-informed and comprehensive environmental impact assessment of the Fourth Train Proposal. Incorporating the Fourth Train Proposal into the approved Foundation Project Footprint on Barrow Island has the added benefit of reducing the overall physical footprint and associated environmental impacts of the development compared to establishing a new gas processing facility at an alternative new location.

The Fourth Train Proposal has the potential to create considerable economic benefits for Australia. As a brownfield development, the Fourth Train Proposal has the ability to create synergies with the approved Foundation Project that could potentially result in a lower net environmental impact than the other development options presented above. The Fourth Train Proposal is also the most cost-competitive option of the development options discussed, and the commercial agreements are the most compatible for developing the gas fields shown in Figure 4-1.

4.3 Offshore Components

The offshore components of the Fourth Train Proposal will access the gas fields using subsea production wells fitted with subsea trees to control the gas flow, and which may also provide chemical injection capability. The subsea trees will be connected to cluster manifolds, which then route the production fluids (comprising gas, condensate, and produced water with production chemicals) via intrafield flowlines to the Feed Gas Pipeline System for transport to Barrow Island. Production fluids will be evacuated by either the new Fourth Train Proposal Feed Gas Pipeline or the Foundation Project Jansz–Io Feed Gas Pipeline. Offshore facilities will be placed on the seabed and the GJVs expect that the Fourth Train Proposal will not need surface production facilities such as an offshore processing platform.

The Fourth Train Proposal comprises a number of additions to the approved Foundation Project; Table 4-2 summarises the key offshore characteristics of the Fourth Train Proposal compared to those approved for the Foundation Project.

Table 4-2: Summary of the Key Offshore Characteristics of the Fourth Train Proposal Compared to the Approved Foundation Project

Element	Approved Foundation Project	Fourth Train Proposal
Number of gas fields	Two (Gorgon and Jansz–Io)	Additional four (Chandon, Geryon, Orthrus [including Orthrus Deep], and Maenad)
Number of production wells*	Approximately 35 subsea production wells	Additional 16 (approximately) subsea production wells
Subsea infrastructure*	Subsea trees, intrafield pipelines, and manifolds in the Gorgon and Jansz–Io gas fields	Additional subsea trees, intrafield pipelines, and manifolds in the Fourth Train Proposal gas fields
Offshore Feed Gas Pipeline System[#]	Two separate Feed Gas Pipeline Systems linking the Gorgon and Jansz–Io gas fields and Barrow Island	An additional Feed Gas Pipeline System to provide additional capacity for accessing gas fields within the Greater Gorgon Area
Marine component of the shore crossing^	Offshore from North Whites Beach	Additional shore crossings offshore from North Whites Beach, adjacent to the approved Foundation Project crossing

** infrastructure in Commonwealth jurisdiction*

 # infrastructure in both Commonwealth and State jurisdiction

^ infrastructure in State jurisdiction

A comprehensive summary of key characteristics for the Combined Gorgon Gas Development is included in Appendix A [Project Characteristics].

The sections below describe the offshore components of the Fourth Train Proposal in more detail.

4.3.1 Gas Fields

The Fourth Train Proposal is part of a phased development of the gas fields within the Greater Gorgon Area and Title Areas, as defined in the Gorgon Gas Processing and Infrastructure Project Agreement. In this PER/Draft EIS, approval is being sought for the development of hydrocarbons from Chandon, Geryon, Orthrus (including Orthrus Deep), and Maenad gas fields to be sent to Barrow Island for treatment in the Gas Treatment Plant.

Table 4-3 lists the petroleum titles and gas fields that are currently planned to be developed as part of the Combined Gorgon Gas Development, and future developments, subject to further technical evaluation of these gas fields.

Table 4-3: Gas Fields Proposed to be Developed as Part of the Phased Development of the Combined Gorgon Gas Development, and Future Developments

Gas Field	Approximate Distance from Barrow Island (km)	Licence Block(s)	Approximate Water Depth (metres below sea level)	Assessed as Part the Fourth Train Proposal
Gorgon	65	WA-37-L	200 – 215	No
Jansz–Io	130	WA-36-L, WA-39-L, WA-40-L	1200 – 1400	No
Chandon	190	WA-268-P	1160 – 1270	Yes
Geryon	110	WA-20-R, WA-22-R	1170 – 1320	Yes
Orthrus	100	WA-19-R, WA-24-R	1120 – 1220	Yes
Maenad	110	WA-24-R	1240	Yes
Chrysaor	75	WA-14-R, WA-15-R	300 – 1030	No
Dionysus	85	WA-15-R	990 – 1140	No
West Tryal Rocks	65	WA-5-R	120 – 160	No
Satyr and Achilles	105	WA-374-P	1010 – 1200	No
Yellowglen	190	WA-268-P	1010 – 1200	No

The gas fields listed in Table 4-3 are expected to be developed over the life of the Gorgon Project, which is predicted to be approximately 60 years.

The exact sequencing of the gas fields will be evaluated as part of the pre Front End Engineering and Design (FEED) technical studies. The final sequencing will depend on the expected production rates, feed gas composition, predicted well pressure, and a cost analysis of developing each field.

Although not all gas fields listed in Table 4-3 are part of this PER/Draft EIS, the GJVs anticipate that the gas from the fields listed in Table 4-3 would be processed within the requirements of the *Barrow Island Act 2003* (WA) and existing Foundation Project approvals required under Section 13 of the *Barrow Island Act 2003* (WA).

Each gas field included in the Fourth Train Proposal has a different composition, based on produced water, carbon dioxide (CO_2), nitrogen content, and hydrocarbons. Table 4-4 shows the predicted compositions of the gas fields expected to be developed in this phase of the

Gorgon Project, based on available data gathered during exploration drilling programs. The actual compositions produced will vary slightly over the life of the gas fields due to natural variations in the gas composition within each field and in response to the changing pressure in the reservoirs as a result of extracting the gas.

Table 4-4: Composition of the Gas Fields to be Developed as Part of the Fourth Train Proposal

Component	Geryon Mol %	Chandon Mol %	Orthrus Mol %	Maenad Mol %
Carbon dioxide (CO_2)	1.174	0.296	1.453	1.720
Nitrogen (N_2)	2.124	3.449	1.778	1.840
Hydrocarbons				
Methane (C_1)	88.936	85.3000	88.609	88.930
Ethane (C_2)	4.585	5.119	4.781	4.340
Propane (C_3)	1.617	2.637	1.695	1.610
Butane (C_4)	0.619	1.350	0.694	0.650
Pentane and larger (C_5+)	0.944	1.841	0.990	0.810

4.3.2 Wells and Subsea Facilities

The production wells will be in water depths ranging between approximately 1120 and 1320 m. The wells are expected to be deviated wells that can reach a number of subsurface targets from a single drill centre.

Future Management of Reservoir Pressure

In future, the pressure in the targeted reservoirs will become insufficient to sustain peak production rates. Compression may then be necessary to maintain hydrocarbon flow rates. Should compression be necessary, the GJVs envisage tying-in to compression facilities that are expected to be needed in future for the approved Foundation Project Gorgon and Jansz–Io gas fields. The GJVs will seek separate environmental approval for such compression, if required.

Initially, gas and gas condensate (condensate) will be produced from approximately 16 production wells. The location of each well will be determined prior to drilling.

Each well will be fitted with an arrangement of valves, controls, and instrumentation known as a subsea tree. The Fourth Train Proposal is expected to use vertical tree systems, which will be located on the seabed. The subsea tree will be installed onto the wellhead to control the flow of fluids from the well. In addition to the valves, a subsurface safety valve will be installed in each well below the seabed to provide a fail-safe system to seal the well in the event of a system failure or damage to the production control facilities. Together, these valves are designed to close automatically if mechanical failure or loss of system integrity occurs during production via the well. A choke valve will also be included in the subsea tree to control the flow and pressure of hydrocarbons from the well to the intrafield flowlines and the Feed Gas Pipeline.

Each group of wells will be connected to a cluster manifold using flowline jumpers. The wells and manifolds will be connected to the Gas Treatment Plant by a control umbilical, monoethylene glycol (MEG) pipeline, and a utility pipeline, which are included in the Feed Gas Pipeline System (Section 4.3.4). These services will provide the necessary electrical power, control signals, and chemical injection to allow the wells and cluster manifolds to be operated remotely from Barrow Island.

4.3.2.1 Alternatives Considered

The GJVs undertook a selection process to determine the appropriate subsea tree for use on the Fourth Train Proposal. Two subsea tree systems were investigated: horizontal tree systems and vertical monobore tree systems. Horizontal tree systems are those where the production and annulus tree valves are located on the horizontal plane (i.e. not within the main vertical tree bore). Vertical monobore tree systems are those where the production tree valves are located within the tree vertical bore.

The GJVs prefer vertical tree systems, due to the permanent barriers in the vertical bore of these systems (i.e. the production master and production swab valves). Vertical tree systems enable well intervention and kill operations without wireline operations.

4.3.3 Intrafield Flowlines

From the cluster manifolds, intrafield flowlines will transfer the production fluids (comprising gas, condensate, and produced formation water with production chemicals) to a tie-in structure, which connects to a Feed Gas Pipeline for transportation to the Gas Treatment Plant on Barrow Island.

The separation distances and routing of the intrafield flowlines compared to the MEG pipeline, utility pipeline, and control umbilical (Section 4.3.4) will vary to allow for subsea features, and to optimise the recovery of production fluids and use of materials. Due to the location of the various gas fields in the Fourth Train Proposal Area, the GJVs anticipate that a network of approximately 140 km of intrafield flowlines will be required to connect the wells to the Feed Gas Pipeline System, resulting in approximately 5.7 km^2 of seabed disturbance. Section 13.5 assesses the potential impacts of installing the intrafield flowlines.

4.3.4 Offshore Feed Gas Pipeline System

The Feed Gas Pipeline System will be designed for the safe and reliable supply of production fluids from the offshore gas fields to Barrow Island. The key components of the Feed Gas Pipeline System will include:

- a Feed Gas Pipeline to transport production fluids (comprising gas, condensate, and produced water with production chemicals) from the tie-in structures at the outlet of the intrafield flowlines to the Gas Treatment Plant on Barrow Island
- a MEG pipeline to provide continuous injection of MEG into the production system for hydrate management and for the delivery of corrosion and scale management chemicals
- a utility pipeline to support subsea maintenance and depressurisation of the production system in the remote event of a hydrate blockage
- a control umbilical providing hydraulic power, electrical power, and a fibre-optic control link allowing remote operation and management of the subsea wells and infrastructure from the Administrations and Operations Complex on Barrow Island.

It is anticipated that these components of the Fourth Train Proposal Feed Gas Pipeline System will be installed in separate lay corridors. In general, separation distances between each of the pipeline components along the offshore route will vary from a minimum of 15 m to a nominal distance of 50 m to avoid subsea features. In shallow waters (i.e. less than 70 m water depth), the separation distance might be decreased to 3 m to minimise the amount of secondary stabilisation required.

4.3.4.1 Pipeline Route Options

The GJVs are investigating two options for the Feed Gas Pipeline System route (Figure 4-3), including:

- Northern Pipeline Route
- Southern Pipeline Route.

The Northern Pipeline Route is approximately 140 km long and will require crossings with other pipelines, including the Gorgon, Jansz–Io, Wheatstone, and third-party pipelines. Third-party pipelines include the East Spar pipeline and Halyard umbilical. The Southern Pipeline Route is approximately 185 km long and will require a crossing with the Wheatstone pipeline.

No third-party pipeline crossings are required with this option. All third-party pipeline crossings will be designed and constructed in accordance with Australian standards (i.e. AS 2885.0 Pipelines – Gas and Liquid Petroleum – Part 0: General Requirements [Standards Australia 2008]).

Indicative lengths for both pipeline route options are listed in Table 4-5.

Table 4-5: Indicative Lengths for the Fourth Train Proposal Offshore Feed Gas Pipeline System

Offshore Feed Gas Pipeline System Location	Indicative Length	
	Northern Pipeline Route Option	Southern Pipeline Route Option
Commonwealth Marine Area	135 km	179 km
Montebello Commonwealth Marine Reserve	12 km	11 km
State Waters	5 km	6 km
Indicative length (total)*	**140 km**	**185 km**

* *Approximate length from horizontal directional drilling exit point*

The GJVs expect to select the final route during detailed design; this route will reflect technical, commercial, and environmental constraints. The final route will be outlined within an Offshore Feed Gas Pipeline Installation Management Plan to be submitted to the Commonwealth and Western Australian Ministers for Environment. An offshore geotechnical and geophysical survey will increase the understanding of the subsea and geotechnical conditions present along the route options. This offshore geotechnical and geophysical survey will provide the necessary inputs to the design of the Feed Gas Pipeline System.

Approval of the two options is sought by the GJVs under this PER/Draft EIS; however, only one will be constructed. The Northern and Southern Pipeline Routes are assessed in Sections 5, 10, and 13 of this PER/Draft EIS, for impacts within Western Australian and Commonwealth jurisdictions.

The Southern Pipeline Route was included and assessed in the Jansz Feed Gas Pipeline Environmental Impact Statement/Assessment on Referral Information and EPBC Referral assessment processes (Mobil Australia Resources 2005; Mobil Exploration and Producing Australia 2006). The Jansz Feed Gas Pipeline was approved by the Western Australian Minister for Environment on 28 May 2008 by way of Ministerial Implementation Statement No. 769 (Statement No. 769) and the Commonwealth Minister for Environment and Water Resources on 22 March 2006 (EPBC Reference: 2005/2184); however, this route was never constructed, due to another approved option being implemented. A summary of the conclusions from the previous assessment is included in Section 13.5.7.1.

The seabed substrate and size of the scarp crossing pose a number of engineering challenges. Along the Northern Pipeline Route, the natural profile of the scarp is considered too steep for a pipeline to be laid across without some pre-lay seabed preparation. The options for managing the scarp crossing include:

- re-profiling small sections of the scarp to reduce the severity of the natural gradient to allow the pipeline system to be laid (Northern Pipeline Route).
- routing the pipeline around the steep gradients of the scarp completely (i.e. using the Southern Pipeline Route).

Routing the pipeline around the steep section of the scarp would avoid the need to re-profile small sections of seabed in this area. However, approximately 45 km of additional pipeline would be required to avoid the steep scarp and construct the Southern Pipeline Route option. The GJVs are currently investigating scarp management options to determine the best practicable option, as described in Section 4.5.1.3.

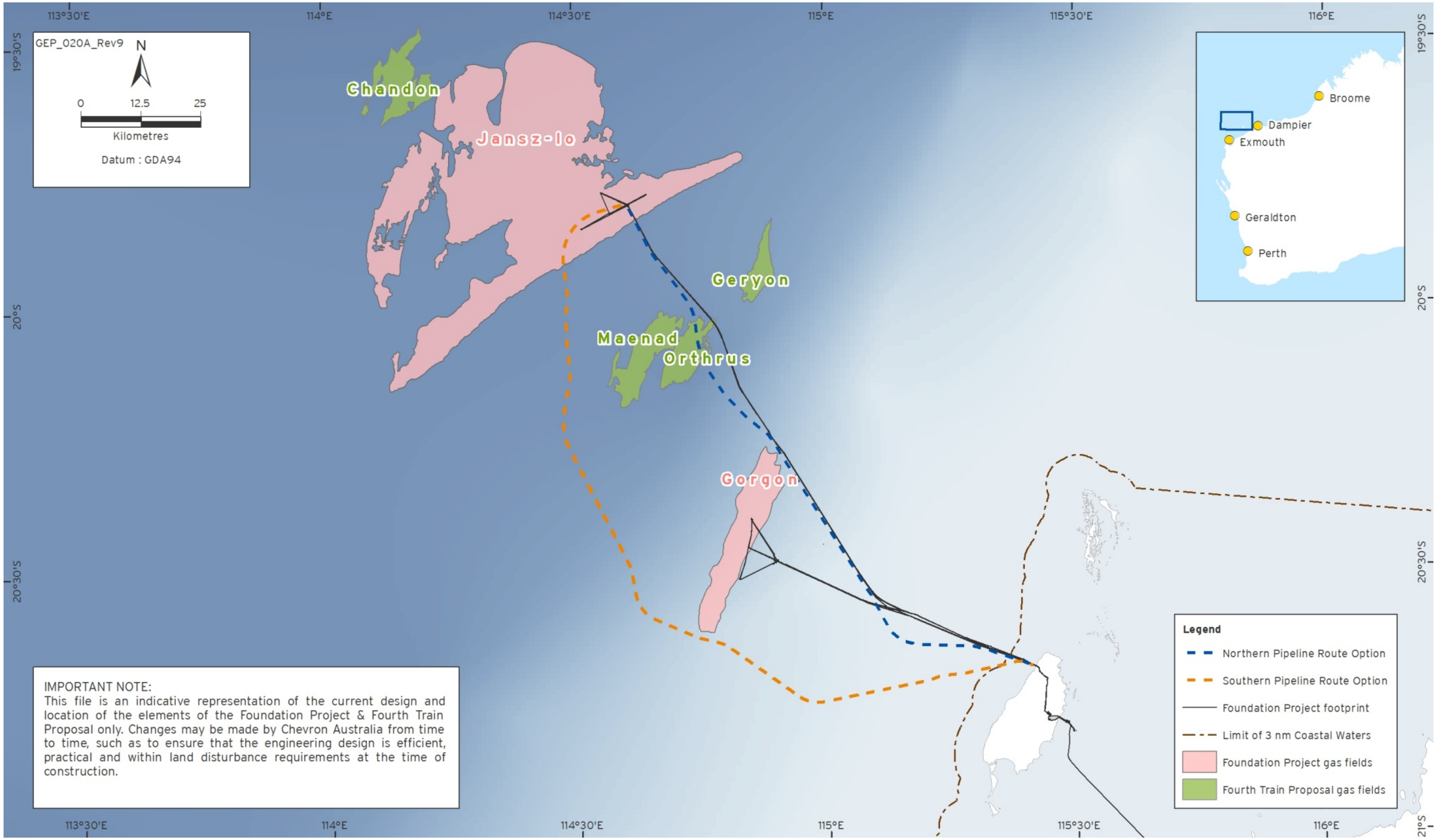

Figure 4-3: Proposed Feed Gas Pipeline System Route Options Included in the Fourth Train Proposal

Note: The Fourth Train Proposal gas fields shown are linked to the Feed Gas Pipeline System by intrafield flowlines, which are not shown on this figure.

4.3.4.2 Feed Gas Pipeline

The Feed Gas Pipeline will transport the production fluids from the outlet of the intrafield flowlines to the Gas Treatment Plant at Town Point on Barrow Island. The Feed Gas Pipeline will be mainly constructed from carbon steel or similar; it is expected to be approximately 26 to 30 inches in diameter, depending on the section of pipeline. The Feed Gas Pipeline will be designed, constructed, operated and maintained in accordance with Australian Standards (e.g. AS 2885.0 Pipelines – Gas and Liquid Petroleum – Part 0: General Requirements [Standards Australia 2008]) and international standards (e.g. DNV OS-F101 Submarine Pipeline Systems [Det Norske Veritas 2012]).

The Fourth Train Proposal Feed Gas Pipeline configuration may be connected with the Jansz Feed Gas Pipeline to allow switching between the production fluids of the respective fields as the fluids enter the pipeline.

During normal operation, pipeline flow and pressure will be controlled primarily by the choke valves at the wellheads to ensure that the normal operating pressure in the Feed Gas Pipeline is within the desired operating pressure envelope at the inlet to the Gas Treatment Plant.

Pipelines may require pigging to clean or inspect the pipeline, and/or to remove foreign objects from it. A pig is a device that is inserted into the pipeline and travels the length of the line, driven by the fluid pressure behind it. The intrafield flowlines and Feed Gas Pipeline may require pigging during their life to inspect for signs of internal corrosion. Although frequent pigging of the Feed Gas Pipeline for inspection is not expected to be required, the Feed Gas Pipeline will be designed for conventional utility pigs and inline inspection tools for pipeline integrity testing. The field inspection regime will be determined using risk-based inspection principles.

4.3.4.3 Monoethylene Glycol Pipeline

A dedicated pipeline within the Feed Gas Pipeline System will deliver MEG to the subsea wells to be used as a hydrate inhibitor. Natural gas hydrates (solid crystalline compounds consisting of water and natural gas components) have the potential to form in the flowlines and pipelines when there is high pressure and low temperature. The resulting hydrates can cause problems for the normal operation of equipment and so must be prevented from forming. The GJVs selected MEG as the preferred hydrate inhibitor as it is being used by the approved Foundation Project and thus provides synergies in its supply and use by the Fourth Train Proposal. MEG will be stored at the Gas Treatment Plant on Barrow Island and pumped to the gas fields through the MEG pipeline. It will flow back to the Gas Treatment Plant with the gas stream within the Feed Gas Pipeline. At the Gas Treatment Plant, it will be recovered for treatment and re-used. The MEG pipeline will follow the same path as the Feed Gas Pipeline, where practicable.

4.3.4.4 Utility Pipeline

A utility pipeline will be included in the Feed Gas Pipeline System. The utility pipeline will follow the same path as the Feed Gas Pipeline, where practicable. This multipurpose pipeline will be used to maintain operational flexibility, and to depressurise subsea components connected to the Gas Treatment Plant or Feed Gas Pipeline to allow for maintenance.

4.3.4.5 Control Umbilical

The control umbilical will follow the same path as the Feed Gas Pipeline, where practicable. The control umbilical will provide hydraulic power, electrical power, fibre-optic cables for communication, and a chemical injection line, and will be used to control the valves on the subsea trees, with control fluid powering valve movements. The control fluid system is expected to be an open-loop system with small quantities of the fluid being discharged to the ocean during the operation of the well and pipeline control valves. This open system is consistent with that used for the approved Foundation Project. The control fluid is expected to be water-based (with glycol), which has been designed and selected to be suitable for release to the marine environment. Alternative closed-loop systems that do not release fluids into the ocean were investigated and discounted by the GJVs. These closed-loop systems do not provide the same functionality as an open-loop system and are impracticable over the distance of umbilical required for the Fourth Train Proposal.

An electrical power line will supply the electrical power needed to operate and control the wells and flowline valves. Fibre-optic cables will be included in the control umbilical to provide communication between the production wells and the Administrations and Operations Complex on Barrow Island.

The chemical injection line will transport chemicals for use in the offshore operations; these chemicals may include corrosion and scale management chemicals, pH stabilisers, and acids for well maintenance. Corrosion inhibitors and other chemicals may also need to be injected into the wells and flowlines via the umbilical.

Depending on the final design of the Fourth Train Proposal, construction activities may be staged, with the control umbilical possibly constructed earlier than other components of the Feed Gas Pipeline System.

4.3.4.6 Offshore Feed Gas Pipeline System Stabilisation and Protection

The offshore section of the Feed Gas Pipeline System will be stabilised, where necessary, by a combination of primary and secondary stabilisation measures to protect against hydrodynamic forces (such as from waves and currents) and to protect against external impacts (such as from ship anchors). Potential primary stabilisation measures may include concrete coating of pipelines or sections of the pipelines, and optimising pipeline wall thickness. Concrete coating may be used where necessary to stabilise the pipelines, with the coating thickness varying based on the degree of stabilisation required.

Secondary stabilisation of the Fourth Train Proposal Feed Gas Pipeline System will be required where primary stabilisation alone is not sufficient. Several techniques may be used for secondary stabilisation, such as the use of stabilisation materials (e.g. quarry rock and concrete mattresses), trenching, rock bolting, and pipeline anchors.

Trenching may be required for elements of the Feed Gas Pipeline System. While trenching is expected in the Commonwealth Marine Area (at depths between approximately 70 and 200 m) it may also be required in shallower water depths including within State Waters, although this is not the base case. Trenches may be backfilled with rock to provide further stabilisation. Rock stabilisation (e.g. placing graded rocks on top of the pipelines) is likely to be used where appropriate to protect the Feed Gas Pipeline System from the increased hydrodynamic forces as the pipelines approach the shore. A similar approach is being undertaken for the approved Foundation Project Feed Gas Pipeline Systems. The rocks to be used for stabilisation are expected to be supplied from trenching activities and/or licensed third-party quarries on the mainland. Table 4-6 lists indicative areas of seabed in the Commonwealth Marine Area, Montebello Commonwealth Marine Reserve, and State Waters that may be disturbed by construction activities. The possibility of construction of the control umbilical ahead of the other components of the Feed Gas Pipeline System is included in Table 4-6.

Table 4-6: Indicative Areas of Seabed Disturbance for the Fourth Train Proposal Offshore Feed Gas Pipeline System

Offshore Feed Gas Pipeline System Location	Seabed Disturbance Areas	
	Northern Pipeline Route Option	**Southern Pipeline Route Option**
Commonwealth Marine Area	1.961 km^2	2.453 km^2
Montebello Commonwealth Marine Reserve	0.231 km^2	0.219 km^2
State Waters*	0.271 km^2	0.318 km^2
Indicative seabed disturbance area (total)	**2.463 km^2**	**3.052 km^2**

** Approximate distance from horizontal directional drilling exit point*

The final methods of stabilisation chosen by the GJVs will factor in life cycle costs and risks, equipment and material availability, as well as metocean and seabed/geotechnical conditions. The results of the Fourth Train Proposal offshore geotechnical and geophysical survey will provide additional detail on seabed relief and sediment properties in relation to the proposed locations for the Fourth Train Proposal subsea facilities. This information will assist the GJVs in determining the most suitable stabilisation methods for the Offshore Feed Gas Pipeline System, and will allow further definition of secondary stabilisation methods. It is anticipated that the results of the offshore geotechnical and geophysical survey will be analysed and the method of stabilisation will be confirmed prior to construction.

The potential environmental impact of the stabilisation options is discussed in Sections 10 and 13, for impacts within Western Australian and Commonwealth jurisdictions, respectively.

4.3.5 Marine Component of the Shore Crossing

The Feed Gas Pipeline System will cross the Barrow Island shore at North Whites Beach. At approximately 15 m water depth, the components of the Feed Gas Pipeline System are planned to be sunk into a series of approximately four to eight holes that will be created underneath North Whites Beach using a horizontal directional drilling technique. The offshore drilling exit point of the holes is expected to be approximately 400 to 500 m from the low water mark.

Figure 4-4 shows the location of the shore crossing on Barrow Island and an indicative layout of the shore crossing area.

Section 4.5.2 outlines the construction activities associated with the shore crossing.

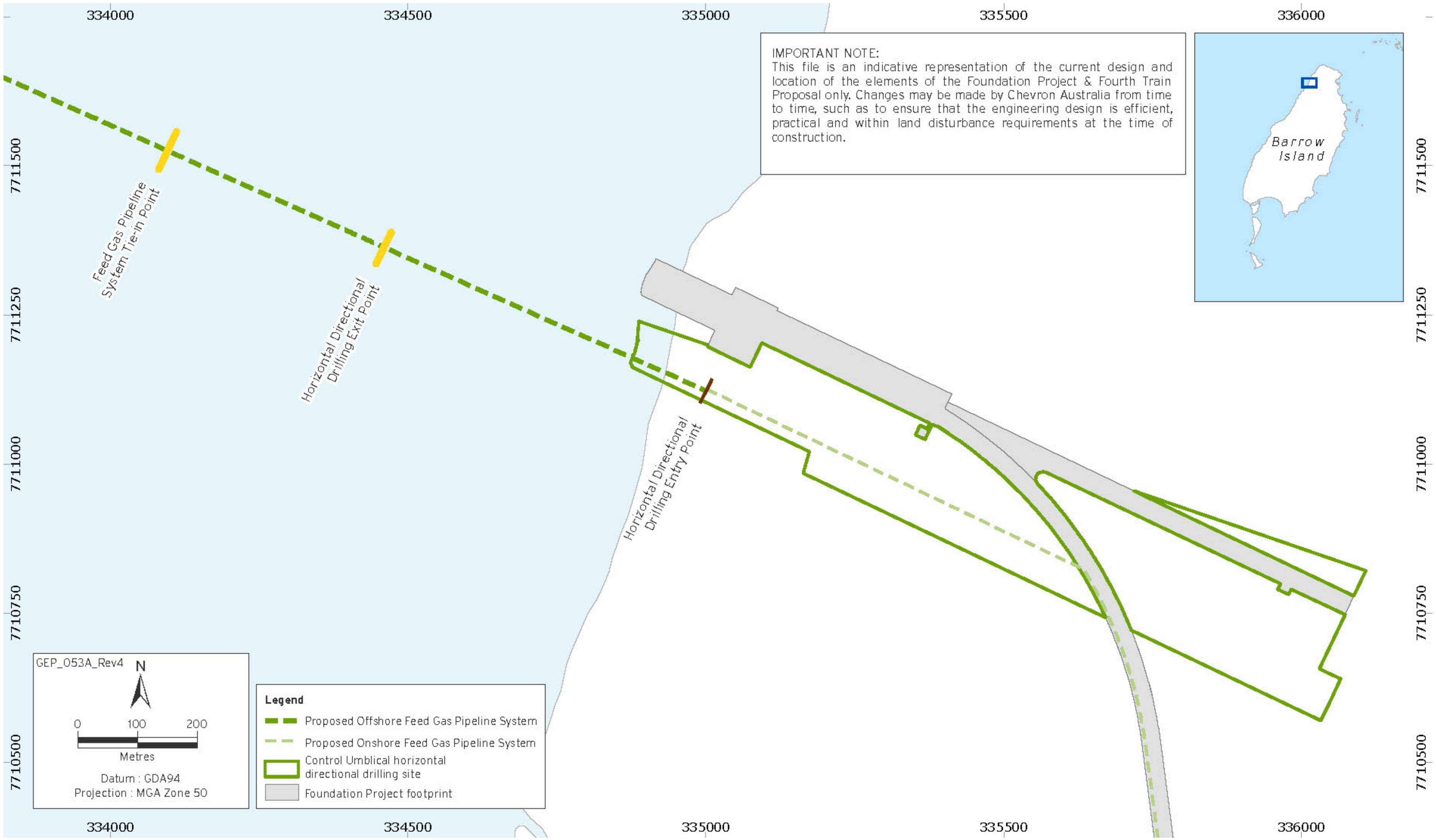

Figure 4-4: Location of the Shore Crossing at Barrow Island and an Indicative Layout of the Shore Crossing Area

4.4 Onshore Components

The increased gas supply to Barrow Island as a result of the Fourth Train Proposal will require additional onshore infrastructure to transport, process, and store the hydrocarbons before export to market. This infrastructure will include the terrestrial component of the shore crossing, a new onshore Feed Gas Pipeline System, Inlet Facilities, an additional LNG train, and supporting utilities on Barrow Island.

The Fourth Train Proposal comprises a number of additions to the approved Foundation Project; Table 4-7 summarises the key onshore characteristics of the Fourth Train Proposal compared to the approved Foundation Project.

Table 4-7: Summary of the Key Onshore Characteristics of the Fourth Train Proposal Compared to the Approved Foundation Project

Element	Approved Foundation Project	Fourth Train Proposal
Gas Treatment Plant		
Number of LNG trains	Three	Additional one
Size of LNG trains	5 MTPA nominal (each)	5 MTPA nominal
LNG tank size	2 × 180 000 m^3 nominal	An additional 1 × 180 000 m^3 nominal tank may be required
Gas Processing Drivers	6 × 80 MW (nominal) gas turbines fitted with dry low nitrogen oxide burners	Two additional 80 MW (nominal) gas turbines fitted with dry low nitrogen oxide burners
Power Generation	5 × 116 MW (nominal) conventional gas turbines fitted with dry low nitrogen oxide burners	One additional 116 MW (nominal) conventional gas turbine fitted with dry low nitrogen oxide burners
Condensate production rate	3600 m^3/day (nominal) hydrocarbon condensate	Additional condensate production of 2900 m^3/day (nominal)
Onshore Feed Gas Pipeline System		
Length onshore (Barrow Island)	Approximately 14 km	One additional Feed Gas Pipeline System approximately 14 km long
Terrestrial component of the shore crossing	North Whites Beach Area of disturbance (horizontal directional drilling onshore construction area) approximately 7 ha	North Whites Beach Area of disturbance (horizontal directional drilling onshore construction area) up to (approximately) 10 ha

Source of Foundation Project information: Ministerial Implementation Statement No. 800.

A comprehensive summary of key characteristics for the Combined Gorgon Gas Development is included in Appendix A [Project Characteristics].

4.4.1 Terrestrial Component of the Shore Crossing

The Feed Gas Pipeline System will traverse under the beach and surface at an onshore drilling entry point, which is planned to be approximately 60 m inland from the high water mark. The maximum depth of the horizontal directional drilled holes is approximately 10 m below ground level.

The planned location for the shore crossing for the Fourth Train Proposal is adjacent to, and south of, the approved Foundation Project shore crossing area (Figure 4-4)

Section 4.5.2 outlines the construction activities associated with the shore crossing, including land clearing.

4.4.2 Onshore Feed Gas Pipeline System

From the shore crossing, the Fourth Train Proposal Feed Gas Pipeline System will traverse Barrow Island to the inlet area of the Gas Treatment Plant. Figure 4-5 shows the route of the Feed Gas Pipeline System for the Fourth Train Proposal across Barrow Island.

The onshore Feed Gas Pipeline System will be installed in a below-ground trench within the approved Foundation Project Feed Gas Pipeline Systems footprint. Clearing of the Foundation Project Feed Gas Pipeline Systems footprint was approved as part of the Foundation Project, although not all has been cleared. Clearing to the boundaries of the Foundation Project Feed Gas Pipeline Systems footprint (pipeline easement) may take place as part of the Fourth Train Proposal. Approximately 15 ha of land within the Foundation Project Feed Gas Pipeline Systems footprint is expected to be occupied by the Fourth Train Proposal Feed Gas Pipeline System, which represents approximately one-third of the approved Foundation Project Feed Gas Pipeline Systems footprint. Figure 4-6 shows an indicative cross-section of the Fourth Train Proposal Feed Gas Pipeline System installed within the Foundation Project Feed Gas Pipeline Systems footprint.

If the Fourth Train Proposal is implemented as a staged development, the control umbilical (Section 4.3.4.5), including the shore crossing, may be installed ahead of the remaining components of the Feed Gas Pipeline System. The location of the pipelines within the trenches is not fixed and the pipelines may be installed in separate trenches. Section 4.5.3.1 outlines the construction aspects of the onshore Feed Gas Pipeline System for the Fourth Train Proposal.

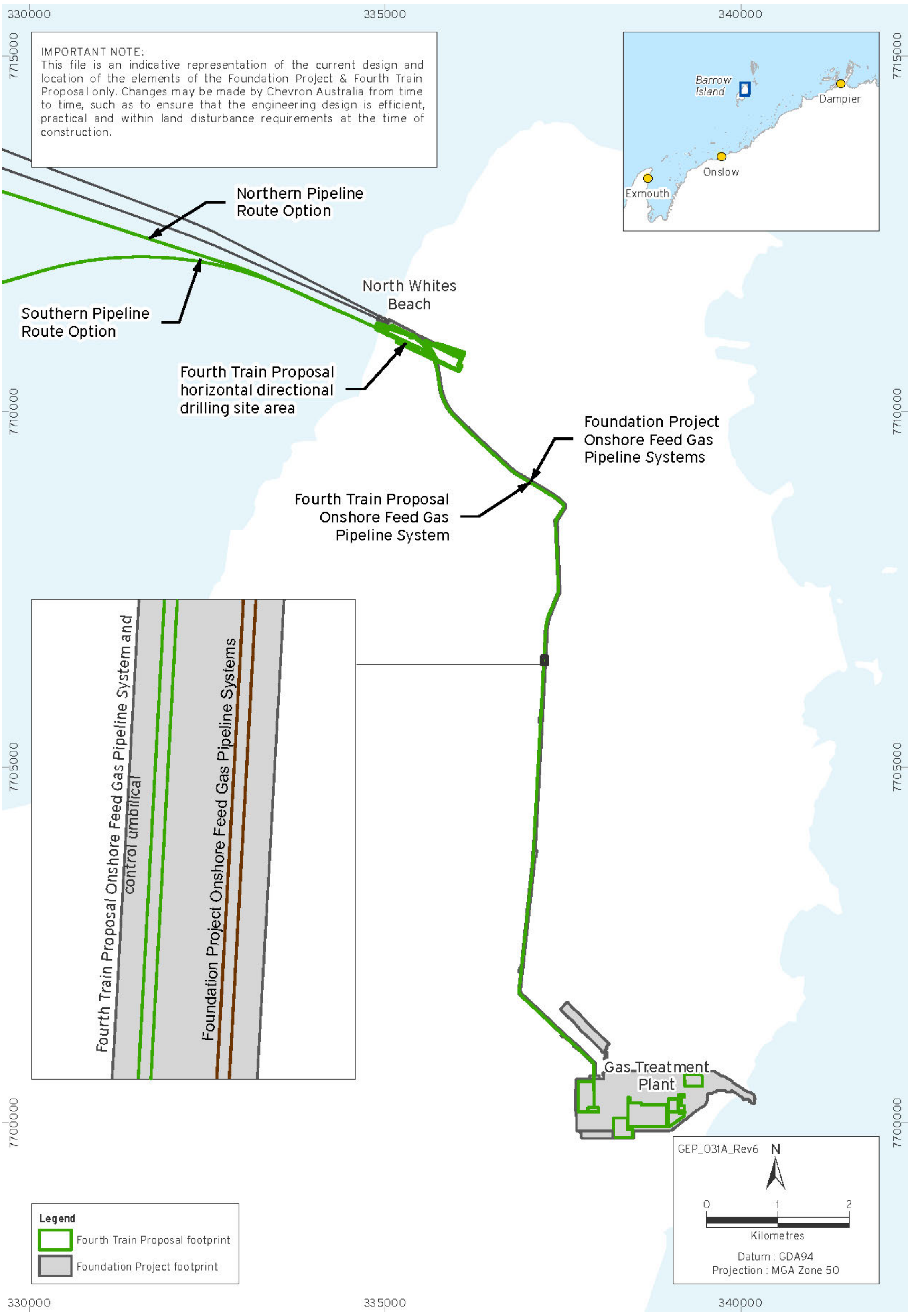

Figure 4-5: Onshore Route of the Feed Gas Pipeline System for the Fourth Train Proposal

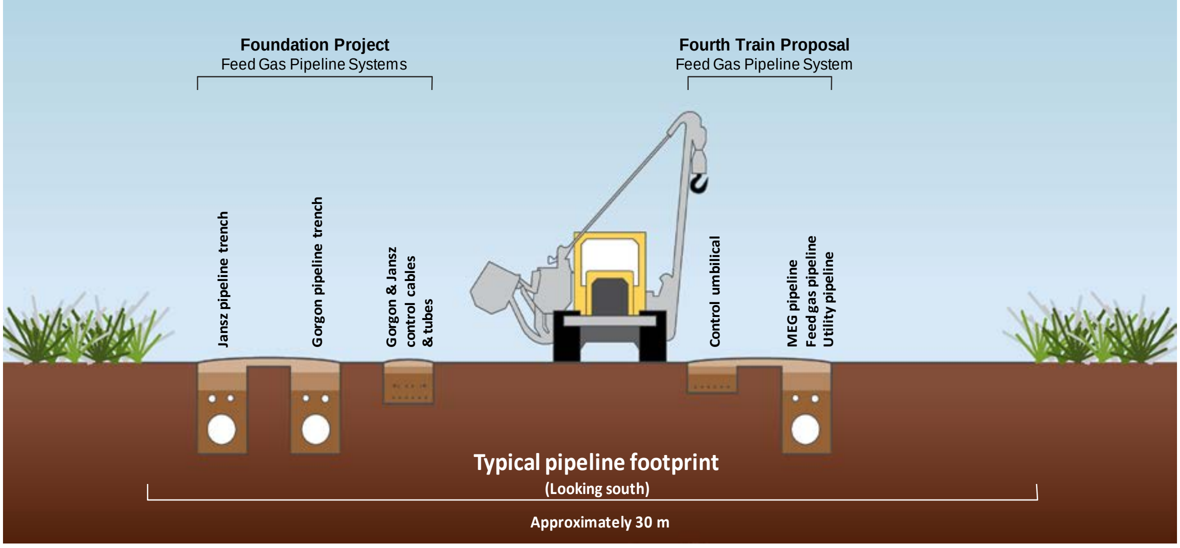

Figure 4-6: Indicative Cross-section of the Fourth Train Proposal Onshore Feed Gas Pipeline System Installed within the Approved Foundation Project Feed Gas Pipeline Systems Footprint

4.4.3 Gas Treatment Plant

The Fourth Train Proposal will increase the throughput capacity of the Gas Treatment Plant from the nominal LNG production capacity of 15 million tonnes per annum (MTPA) to 20 MTPA. An additional LNG train to cater for feed gas from the Fourth Train Proposal will be required; it will be located within the approved Foundation Project Gas Treatment Plant on Barrow Island. It is expected that the Fourth Train Proposal infrastructure within the Gas Treatment Plant will cover approximately 50 ha, occupying approximately one-third of the total area of the Foundation Project Gas Treatment Plant.

Where design and function permits, the infrastructure and utilities included in the Fourth Train Proposal will be similar to those of the Foundation Project. As Barrow Island is situated in a region that experiences frequent tropical cyclones, the Gas Treatment Plant facilities and infrastructure are to be designed and constructed in accordance with Australian Standards to withstand appropriate regional wind speeds.

Figure 4-7 shows an indicative layout of the onshore infrastructure components for the Fourth Train Proposal in relation to the Foundation Project.

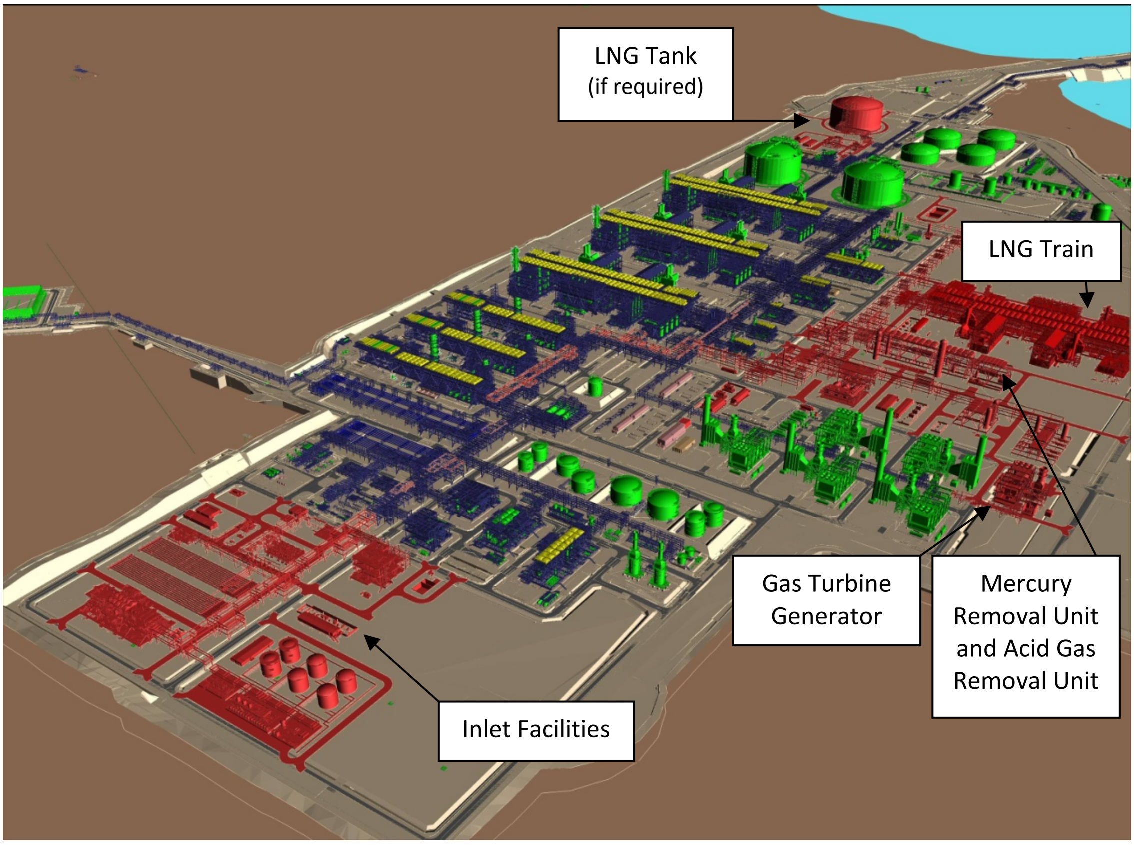

Figure 4-7: Indicative Layout of the Fourth Train Proposal Components of the Gas Treatment Plant

Note: The Fourth Train Proposal infrastructure is shown in red.

Figure 4-8 shows an indicative block flow diagram of the treatment process planned to be used in Fourth Train Proposal Gas Treatment Plant. Emissions, discharges, and waste associated with this process are described in Section 5.

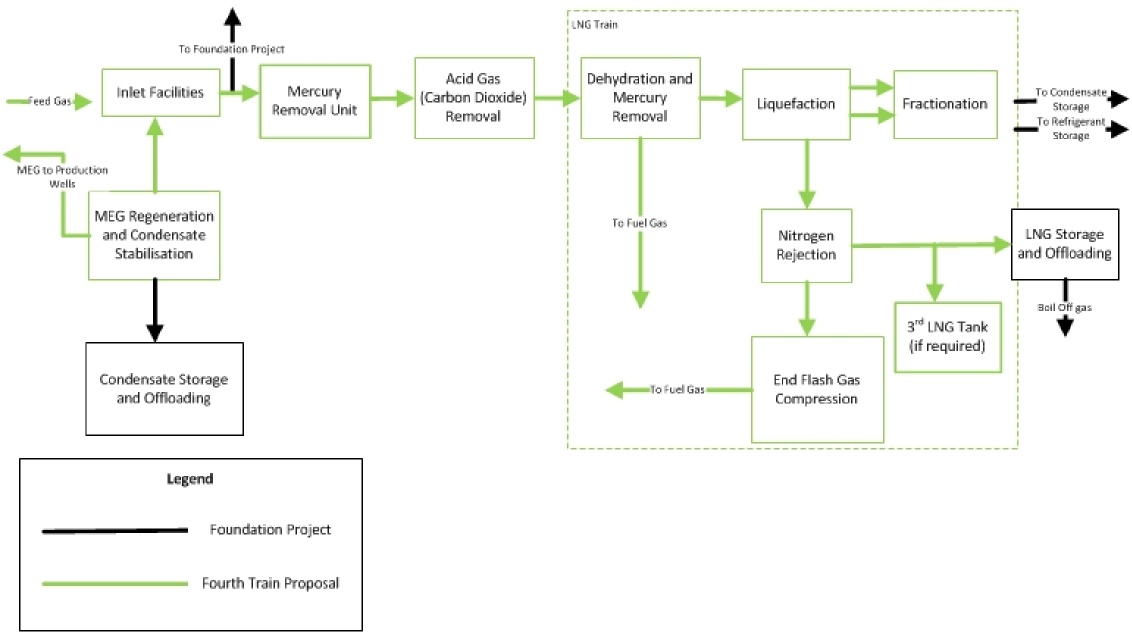

Figure 4-8: Indicative Block Flow Diagram of the Treatment Process Planned to be Used in the Fourth Train Proposal Gas Treatment Plant

The following sections outline the main systems of the Gas Treatment Plant to be installed for the Fourth Train Proposal.

4.4.3.1 Inlet Facilities

Inlet Facilities, similar to those installed for the Foundation Project, will be constructed where the Feed Gas Pipeline System enters the Gas Treatment Plant. The Inlet Facilities are expected to include a:

- Slug Catcher
- permanent pig receiver facility
- MEG Regeneration Unit
- Condensate Stabilisation Unit.

Minor amendments may also be made to the approved Foundation Project inlet facilities to facilitate increased volumes of feed gas following the introduction of new fields. These minor amendments may be before the construction of Fourth Train Proposal Inlet Facilities if the Fourth Train Proposal gas fields are developed to support the three-train Foundation Project prior to the construction of the fourth LNG train.

The feed gas arrives from the Feed Gas Pipeline System to the Slug Catcher and inlet separator, which segregates the incoming fluids into gas, condensate, and aqueous phases. The Slug Catcher also provides a steady flow rate to the downstream units. The gas phase is sent to the Mercury Removal Units (Section 4.4.3.2).

The aqueous phase, comprising MEG and produced formation water containing salts, is sent to the MEG Regeneration Unit, which removes the water and salts from the MEG. Section 5.5 outlines the management and disposal of produced formation water. The MEG Regeneration Unit provides storage for rich MEG (with water and salts) and lean MEG (with the water and salts removed). Regenerated MEG is then sent back to the offshore subsea wells via the MEG pipeline in the Feed Gas Pipeline System.

The condensate stream is sent to the Condensate Stabilisation Unit, where light hydrocarbon components are stripped out to stabilise the condensate stream. The condensate stream is then combined with the condensate from the LNG train's Fractionation Unit (Section 4.4.3.5) prior to storage and export. Production of condensate from the Gas Treatment Plant will increase from approximately 3600 m^3/day under the approved Foundation Project, to approximately 6500 m^3/day for the Combined Gorgon Gas Development.

The Fourth Train Proposal Gas Treatment Plant will also be designed so that the feed gas from the Fourth Train Proposal may be commingled with the Gorgon and/or Jansz–Io feed gas. Therefore, the feed gas from the approved Foundation Project or Fourth Train Proposal gas fields could be mixed and processed in any of the four LNG trains.

Approval is sought by the GJVs in this PER/Draft EIS for this 'mixing before processing' option in the Fourth Train Proposal Gas Treatment Plant, due to commingling the feed gas in the Gas Treatment Plant. The GJVs, through this PER/Draft EIS, are also seeking approval to alter the basis of the Foundation Project environmental approvals, to reflect that the Fourth Train Proposal feed gas may be mixed with the Foundation Project feed gas before being processed by the Foundation Project infrastructure. The final design will be determined by the GJVs during detailed design. The option of commingling the feed gas is discussed, where relevant, in Section 5 of this PER/ Draft EIS to ensure that it has been adequately considered.

4.4.3.2 Mercury Removal Unit

Mercury occurs naturally in gas fields in the Fourth Train Proposal Area, and will occur in low concentrations in the feed gas leaving the Slug Catcher. An additional Mercury Removal Unit will be installed as part of the Fourth Train Proposal; it will be located in the Acid Gas Removal Unit.

The Mercury Removal Unit is primarily an adsorber, where mercury contained within the gas stream is chemically trapped. The adsorbent containing mercury removed from the feed gas stream will be replaced periodically by clean adsorbent. Section 5.6.2.2 outlines the management and disposal of mercury and mercury-rich adsorbent.

4.4.3.3 Acid Gas Removal Unit

The gas leaving the Mercury Removal Unit will contain acid gas (CO_2, with traces of hydrogen sulfide [H_2S], and other contaminants). An additional Acid Gas Removal Unit will be required for the Fourth Train Proposal to remove the acid gas, which can freeze and block the pipelines in the Liquefaction Unit. Removing the acid gas also makes the feed gas compliant with LNG product specifications for CO_2 and sulfur content. The additional Acid Gas Removal Unit will be similar in design to the Acid Gas Removal Units included in the approved Foundation Project.

The Acid Gas Removal Unit will use activated methyldiethanolamine (a-MDEA), the same technology used by the approved Foundation Project. The a-MDEA technology works by passing a solution of a-MDEA and water in the opposite direction past the feed gas in a contactor vessel. During this process, the CO_2 and H_2S will be removed from the feed gas along with very small amounts of hydrocarbons.

The a-MDEA, rich in CO_2 (and H_2S), will be directed to a regeneration column to be heated. The heating process and low pressure will liberate the CO_2 with trace quantities of H_2S and hydrocarbon gases (including some benzene, toluene, ethylbenzene and xylene [collectively known as BTEX]). The regenerated a-MDEA will then be cooled and pumped back to the contactor vessel to start the cycle again.

The liberated CO_2 and trace quantities of H_2S and hydrocarbon gases will be piped from the Acid Gas Removal Unit to the approved Foundation Project CO_2 Compression Units via a new CO_2 Transfer Compression facilities, to be installed for the Fourth Train Proposal. The approved Foundation Project CO_2 Compression Units will compress the CO_2 stream from approximately atmospheric pressure to the required injection pressure.

Lean–rich heat exchangers in the Acid Gas Removal Unit will be provided to improve the overall energy efficiency of the process.

The Fourth Train Proposal is not expected to require any additional a-MDEA storage. When implemented, the Fourth Train Proposal is expected to share the a-MDEA storage areas with the approved Foundation Project.

4.4.3.4 Carbon Dioxide Compression

Following compression, the CO_2 will be fed into the approved Foundation Project CO_2 Injection Pipeline and then to the CO_2 injection wells. Section 11 outlines the approved Foundation Project Carbon Dioxide Injection System that the Fourth Train Proposal plans to use.

4.4.3.5 LNG Train

An additional LNG train is the key onshore component of the Fourth Train Proposal. The fourth LNG train will be similar in design to the three LNG trains included in the approved Foundation Project. The key processes that occur within an LNG train include:

- dehydration
- mercury removal
- liquefaction
- fractionation.

The Dehydration Unit removes water from the gas as it leaves the Acid Gas Removal Unit; water can freeze and block pipelines and equipment in the Liquefaction Unit.

A Mercury Removal Unit, if required, will remove trace quantities of mercury that may remain in the feed gas following initial mercury removal treatment (Section 4.4.3.2).. After the Mercury Removal Unit, the gas is sent to the Liquefaction and Fractionation Units.

Liquefaction and Fractionation Units are the main components of the LNG train. The liquefaction process operates by cooling the gas using large industrial gas turbine drivers and cryogenic heat exchangers. This process will use technology from Air Products and Chemicals Incorporated. The LNG train will include refrigeration compressors driven by two Frame 7 gas turbines fitted with dry low nitrogen oxides burners and a heat recovery system, as used by the approved Foundation Project.

Section 11 outlines the selection process of the gas turbine drivers for liquefaction.

Each constituent of the feed gas liquefies at a specific temperature; therefore, each component can be collected at a set point in the process. As the gas is progressively cooled, different chemical components or fractions of the gas are liquefied and collected. This process allows the heavy and aromatic hydrocarbons to be removed, as these may freeze and disrupt the heat exchange process; removing these hydrocarbons also allows the product to comply with the LNG product specification. The removed heavy and aromatic hydrocarbons will be processed through the Fractionation Units and then sent to the approved Foundation Project Condensate Tanks along with the stream from the Fourth Train Proposal Condensate Stabilisation Unit, ready for export. The liquefaction and fractionation processes also condense and remove ethane and propane from the gas; these by-products are collected and used as refrigerants in the liquefaction process.

4.4.3.6 Nitrogen Removal and End Flash Gas Compression

Liquefied natural gas is further cooled in the Nitrogen Column Reboiler and subsequently flashed off in the top of the Nitrogen Rejection Column. The LNG product separates as a liquid in the Nitrogen Rejection Column bottom and is pumped to the LNG Tanks. End flash gas, which is relatively rich in nitrogen, is routed to an End Flash Gas Compressor, which compresses it to the pressure required for the high-pressure fuel gas system in the Gas Treatment Plant.

4.4.3.7 LNG and Condensate Storage and Offloading

An additional LNG Tank may be required as part of the Fourth Train Proposal; if so, it will be constructed in the same vicinity as the two existing LNG Tanks at the Gas Treatment Plant, and it may require additional boil-off gas handling capability. If no third LNG Tank is required, additional boil-off gas handling capability may still be required and the LNG produced by the fourth LNG train will be stored in the approved Foundation Project LNG Tanks.

No additional Condensate Tanks are proposed by the GJVs. The additional condensate produced due to the Fourth Train Proposal will be stored in the approved Foundation Project Condensate Tanks.

Gas and condensate from the Fourth Train Proposal will be exported via the approved Foundation Project LNG Jetty infrastructure. The frequency of LNG and condensate loading at the LNG Jetty is expected to increase from approximately 220 to 250 shipments per year (for the approved Foundation Project) to approximately 310 to 330 shipments per year once the Fourth Train Proposal is operational, depending on fleet configuration. Alterations to the approved Foundation Project LNG Jetty may be required, particularly if an additional LNG Tank is not constructed. Changes involve topside alterations to the LNG Jetty so that loading of one LNG vessel can occur while cooling down another vessel located at the other berth.

Condensate loading is expected to be serviced by the single condensate berth installed for the approved Foundation Project. However, the second loading berth, which under the approved Foundation Project is capable of loading LNG only, may be altered to also support condensate loading with additional pipe work and loading mechanisms.

The option of the third LNG Tank has been considered, where relevant, in Sections 5, 9, 10, and 13 of this PER/Draft EIS. Similarly, Section 10 includes an assessment of the environmental impacts of the potential alterations to the approved Foundation Project loading infrastructure.

4.4.4 Utilities and Supporting Infrastructure

Where utilities and supporting infrastructure are required for the Fourth Train Proposal, synergies with the approved Foundation Project are being explored by the GJVs and will be implemented to the extent practicable, so that approved Foundation Project facilities may be shared by the Fourth Train Proposal. Minor changes may be made to shared facilities to ensure they are suitable for use by the Fourth Train Proposal. These modifications are not predicted to result in a substantial environmental impact; therefore, they have not been assessed in this PER/Draft EIS. Approval is being sought for major changes to Foundation Project utilities and supporting infrastructure, which are outlined in the sections below.

4.4.4.1 Domestic Gas Facilities

No additional domestic gas processing capability is proposed in the Fourth Train Proposal.

4.4.4.2 Heating Medium System

The Fourth Train Proposal will transfer heat within the Gas Treatment Plant via a Heating Medium System. The Heating Medium System will be a pressurised, closed-loop, hot demineralised water recirculating system. Heat will be recovered from mechanical drive gas turbine exhausts in the Waste Heat Recovery Units and sent to various heat consumers around the Gas Treatment Plant, including inlet gas heating, Acid Gas Removal Unit reboilers, Condensate Stabilisation reboilers, Fractionation reboilers, and the MEG Regeneration Unit.

An additional Heating Medium System is planned to be installed as part of the Fourth Train Proposal. To improve overall reliability of critical Fourth Train Proposal facilities, the approved Foundation Project Heating Medium System may provide backup heating, where practicable.

4.4.4.3 Fuel Gas and Recycle Gas

As part of the Fourth Train Proposal, the Foundation Project Fuel Gas System will be altered to ensure that adequate fuel gas is supplied to the Fourth Train Proposal:

- Refrigerant Gas Turbine Drivers
- Gas Turbine Generator
- Heating Medium Heaters
- pilot and purge gas for the flare systems.

An additional Mercury Removal Unit may be required, depending on the final design, to chemically trap mercury present in the gas stream before the gas is provided as fuel gas. An additional Recycle Gas Unit may be provided to return low-pressure gas, which is unsuitable for use as fuel, to the process for treatment. However, modifications to the approved Foundation Project Recycle Gas Unit may be sufficient to provide the recycle gas capability required by the Fourth Train Proposal and thus no additional Recycle Gas Unit would be required. As the same function will be provided by both Recycle Fuel Gas Unit options, with no differences in the resulting environmental impacts, no additional assessment of these options is provided in this PER/Draft EIS.

4.4.4.4 Power Generation

The estimated total power load for the operations phase of the four-train complex is expected to be approximately 515 MW, which is an increase of approximately 108 MW on the power needs for the approved Foundation Project. An additional Gas Turbine Generator is planned to be installed for the Fourth Train Proposal, which will be an industrial type, similar to those used in the approved Foundation Project. The GJVs are conducting studies to assess the power requirements in more detail and to determine if additional power is required. If additional power is required, additional power capacity such as a second additional Gas Turbine Generator or other power debottlenecking options may be implemented; however, this is not the base case and approval is only sought for one Gas Turbine Generator in this PER/Draft EIS.

Together, the Gas Turbine Generators for the approved Foundation Project and the Fourth Train Proposal will power the Gas Treatment Plant, utilities, and other electricity users (e.g. Administrations and Operations Complex, Butler Park [Construction Village]).

Backup power during non-routine operations, including a black start in the event of a full plant shutdown, will be provided by essential diesel generators. The Fourth Train Proposal will increase the capacity of the essential diesel generators at the Gas Treatment Plant.

Section 11 outlines the selection of industrial Gas Turbine Generators for the Fourth Train Proposal.

4.4.4.5 Flare Systems

Flaring from the Fourth Train Proposal will use the facilities and the two flare systems installed for the approved Foundation Project:

- Ground Flare, which safely burns off excess gas and avoids the build-up of gas within the processing system
- Boil-off Gas Flare, which safely disposes boil-off gas collected from the LNG Tanks and manages the return boil-off gas vapour from the LNG loading operations.

An additional Boil-off Gas Flare may be installed as part of the Fourth Train Proposal.

The design basis for the Fourth Train Proposal specifies no routine flaring. Routine flaring is defined as the continuous flaring of process hydrocarbon gas beyond that required for the safe operation of the flare system (i.e. flare pilots and purge gas) and plant (e.g. small flows from equipment purges, which are not practicable to collect) during normal production operations.

Two main types of flare events are expected:

- non-routine flaring (i.e. start-up, commissioning, shutdown, and minor emergency relief events) to prevent the build-up of gas within the Gas Treatment Plant
- emergency flaring (i.e. using full flaring capacity to evacuate the contents of an entire LNG train in an emergency situation) to prevent potential explosion from over-pressurising systems within the Gas Treatment Plant.

Section 4.7.2.1 describes these flare events and predicts their frequency.

4.4.4.6 Wastewater Disposal

Liquid wastes, including process and produced formation water, will be produced in the Fourth Train Proposal Gas Treatment Plant from sources that include:

- produced formation water from the gas fields
- condensation water
- water from the Dehydration Unit
- contaminated stormwater.

Depending on the source, these wastes will be collected by a variety of means including a Produced Water Header and the drainage system. Prior to disposal, the liquid wastes will be stored in Disposal Water Tanks within the Gas Treatment Plant. The approved Foundation Project is constructing two Disposal Water Tanks and the Fourth Train Proposal may require an additional Disposal Water Tank to allow for the increased flow. Section 5.5 outlines the management and disposal of wastewater.

Refer to Section 4.7.2.2 for a discussion on domestic wastewater and the reverse osmosis facility.

4.4.4.7 Firewater

The existing firewater capability required for the approved Foundation Project is planned to be expanded to support the Fourth Train Proposal. This capability is likely to comprise additional firewater distribution for the Fourth Train Proposal facilities.

4.4.4.8 Drainage Systems

The surface drainage systems established for the approved Foundation Project will be extended to include the areas of the Gas Treatment Plant included in the Fourth Train Proposal. The existing drainage system consists of a classed drainage network, which separates and segregates surface fluids based on their risk of contamination. The four classes of drainage are:

- Class One Contaminated Drainage System
- Class Two Potentially Contaminated Drainage System
- Class Three Onsite Uncontaminated Drainage System
- Class Four Offsite Uncontaminated Drainage System.

Refer to Section 5.5 for detail on drainage discharge and management.

4.4.4.9 Diesel Supply and Distribution

Additional diesel demand as a result of the Fourth Train Proposal is likely, due to the increased capacity or operating duration of diesel users within the Gas Treatment Plant. The Fourth Train Proposal will use shared facilities with the approved Foundation Project. Additional diesel storage will be provided to supply diesel to the emergency power and black start generators, freshwater fire pumps, seawater fire pumps, marine support vessels, and the vehicle refuelling bay.

The approved Foundation Project Diesel Storage Facility provides a bunded refuelling bay, which the Fourth Train Proposal will use to fill the light vehicles and trucks that fuel diesel users at locations remote from the Gas Treatment Plant.

The impacts from the option of additional diesel infrastructure are considered in Section 9.3.

4.4.4.10 Other Utilities

The Fourth Train Proposal is also expected to install other utilities (such as nitrogen and demineralised water production facilities), which will be operated on site. A new instrument air utility is expected to be installed to service the Fourth Train Proposal and the approved Foundation Project.

4.5 Construction Activities

Construction of the Fourth Train Proposal is expected to begin as the Foundation Project becomes operational. This may occur when the first approved Foundation Project LNG train becomes operational (i.e. operation of LNG Train 1 and construction of LNG Trains 2 and 3) or later.

The approved Foundation Project offshore and horizontal directional drilling construction activities are expected to be completed before commencement of offshore construction of the Fourth Train Proposal. Therefore, the Fourth Train Proposal will result in additional duration for construction activities, both offshore and at the horizontal directional drilling site.

When the Fourth Train Proposal starts construction at the Gas Treatment Plant site, construction activities associated with LNG Trains 2 and 3 may still be occurring. Therefore, the Fourth Train Proposal will extend the duration of construction activities for the Combined Gorgon Gas Development on Barrow Island. To support the extended construction period on Barrow Island, construction facilities and services (e.g. water supply, wastewater treatment) that were approved and installed for the Foundation Project may be retained and shared during the construction period of the Fourth Train Proposal, in combination with some approved Foundation Project construction and operational activities. This may provide synergies between the approved Foundation Project and the Fourth Train Proposal, and assist in reducing potential environmental impacts.

Additional environmental impacts reasonably expected to arise from the use or alteration of Foundation Project facilities over and above those approved under the Foundation Project are assessed in Sections 5, 9, 10, 13, and 15 of this PER/Draft EIS.

4.5.1 Offshore Facilities

4.5.1.1 Drilling and Well Completion

Well drilling campaigns are planned to optimise the efficiency of rig operations. Most wells will be drilled using deviated well technology as this will allow the clustering of wells and subsea facilities, thus reducing the footprint on the seabed. Wells are likely to be drilled using a semi-submersible drilling rig such as the Atwood Oceanics Pacific Pty Ltd (Atwood) *Atwood Osprey* (Figure 4-9) or a drilling ship. At the time of submission of this PER/Draft EIS, this rig is under contract to Chevron Australia to drill in the Gorgon gas field as part of the approved Foundation Project.

It is expected that the drilling rig will maintain its position either via dynamic positioning or by anchoring to the sea floor. Both techniques are considered in Section 13.

Figure 4-9: The *Atwood Osprey* Drilling Rig

The drilling process commences with drilling a surface hole (typically about 1 m diameter) in the seabed to a depth of approximately 60 m below the mud line. A steel casing is then placed inside the hole and cement is pumped through the casing and allowed to flow back up the annular section to fill the gap between the hole wall and the casing. When the cement has set, a smaller diameter hole is then drilled through the bottom of the cemented casing and continues to a depth of approximately 400 m below the mud line. At that point, another casing (slightly smaller than the new hole) is placed inside the hole and cemented in place in a manner similar to the first. This process of ever-decreasing sizes of hole and casing continues, until the reservoir section is reached.

The wells are drilled with rotating bits that chip off small pieces of rock (cuttings) as rock formations are penetrated. During the drilling process, the cuttings must be continuously removed from the hole. This is done using a specially formulated drilling fluid. The wells are expected to be drilled with a combination of non-aqueous drilling fluids (NADF) and water-based drilling fluids. Drilling fluid is used to lubricate and cool the drill bit, control bottom-hole pressures, and remove the cuttings. Equipment is provided on the drilling rig to pump the drilling fluid down through the drill pipe and drill bit. During riserless drilling (i.e. before the Blowout Preventer is fitted to the wellhead) seawater-based drilling fluids with high viscosity sweeps (i.e. bentonite) are expected to be used, with the drilling cuttings discharged at the seabed. As the well deepens, a Blowout Preventer is fitted and this is connected to the drilling rig via a marine riser that fully contains the drilling returns. At the surface, cuttings are treated to remove most of the drilling fluid, which is typically a low-toxicity synthetic-based fluid at this stage in the well. If NADF are used, a secondary cleaning technology, such as dryers or centrifuges, will be used prior to disposal overboard into the marine environment.

During drilling of the wells, a Blowout Preventer will be fitted to the wellhead prior to drilling in hydrocarbon zones. Blowout Preventers control subsurface pressures and consist of a series of rams to prevent uncontrolled flow from the well. The Blowout Preventers to be used in the Fourth Train Proposal will be designed to contain the expected reservoir pressures and will be tested regularly to verify system integrity and functionality, and manage the risk of loss of well control.

Vertical Seismic Profiling (VSP) may be used during drilling to evaluate formation characteristics. During VSP an acoustic source, generating short acoustic pulses, and a receiver are used to generate a picture of the subsurface formation.

Well completion is the process of making a well ready for production. During the well completion process, the well bores are cleaned, production tubing is installed, and the subsea trees are installed. A well testing program with flaring of all produced fluids for approximately 24 hours is expected to occur for each well, following on from the basic clean-up requirements. Rigorous safety and functional tests will be carried out during completions to ensure that pressure integrity is achieved and that the safety and control systems are working correctly.

4.5.1.2 Subsea Facilities

The cluster manifolds will be designed and built so that they can be installed by a suitable construction vessel or heavy lift vessel. The GJVs are investigating two options for the installation of the cluster manifolds—a suction anchor option and a skirt foundation option. The suction anchor option is where a construction vessel installs one or more piles on the seabed and sucks the water out from within or underneath the pile to embed it in the sea floor and secure it in place. The cluster manifold assembly is then lowered to the seabed and latched on to the top of the pile foundation at the seabed. The manifolds may also be installed on skirt foundations, which have a skirt with a large surface area to provide the foundation with stability. Further geotechnical work is required to confirm the suitability of the foundation option.

The assessment of environmental impacts reasonably expected from the two subsea foundation options is included in Section 13.

4.5.1.3 Intrafield Flowlines and Offshore Feed Gas Pipeline System

Pipe-lay barges will install the intrafield flowlines and Feed Gas Pipeline System. The pipe-lay barges used may be positioned using anchors or a dynamic positioning system, which uses computer-controlled propulsion units (thrusters). The positioning system used will depend on the work location, water depth, and operational requirements. Both techniques are assessed in Sections 10 and 13.

A crossing of the steep portion of the scarp will be required for the Northern Pipeline Route but not for the Southern Pipeline Route (Section 4.3.4.1). The scarp is approximately 150 m high extending from 570 m to 715 m water depth and is located approximately 80 km from Barrow Island in the Commonwealth Marine Area. Due to the steep incline of some sections of the scarp, cutting a trench is likely to be required to reduce the scarp's incline and to maintain the Feed Gas Pipeline System's strength, serviceability, and fatigue limits. The GJVs are investigating trenching techniques and it is likely that a combination of techniques will be used, including:

- jetting – using a pressurised water column to excavate the seabed
- cutting – using a cutting device to trench the seabed
- excavating – mechanical excavation using a grabber, similar to the approved Foundation Project.

The final selection of the trenching technique will depend on site-specific requirements (including sensitivity of the environment) and this selection is expected to be made by the GJVs during detailed design.

The scarp crossing may also require the installation of concrete mattresses or rock dumping to create a foundation for the pipeline to be installed on. The rock may either be sourced from the trenching activities and/or from licensed third-party quarries on the mainland. The decision on the use of concrete mattresses or rock dumping and the source of the rock is likely to be made by the GJVs during detailed design. All options are assessed in Section 13.

The pipe-lay barge will connect the Feed Gas Pipeline System to the pipe string installed for shore crossing and then lay the Feed Gas Pipeline System towards deeper water. It is likely that the pipe-lay barge will require increased anchoring in shallower water, compared to the anchoring required in deeper water. Anchors are also expected to be reset more often in shallower water to ensure that the Feed Gas Pipeline System is installed accurately. If the control umbilical is constructed before the other components of the Feed Gas Pipeline System, a smaller vessel is likely to be used. The pipe-lay barge will still be used for installing the remaining components.

The environmental impacts that may result from the different options associated with vessel positioning and trenching are included in Sections 10 and 13 for impacts within the State and Commonwealth jurisdictions, respectively.

4.5.2 Shore Crossing

Horizontally drilled holes will allow the Feed Gas Pipeline System to cross the shore on Barrow Island underneath North Whites Beach. Horizontal directional drilling involves drilling holes approximately 600 m long from a drilling site on the shore side of the shore crossing, underneath the beach, and exiting the ground offshore. The GJVs plan to use a single drilling pad for the horizontal directional drilling activities, with approximately four to eight holes drilled for the components of the Fourth Train Proposal Feed Gas Pipeline System. The horizontal directional drilling site, which includes an area for pipe stringing and installation, will be located adjacent to, and south of, the approved Foundation Project horizontal directional drilling site. If the Fourth Train Proposal is implemented as a staged development, holes for the control umbilical may be drilled ahead of the holes required for the remaining components of the Feed Gas Pipeline System. Alternatively a hole drilled for the Foundation Project may be re-used for the Fourth Train Proposal. Construction of the Fourth Train

Proposal horizontal directional drilling site may also require re-clearing of vegetation and earthworks at the Foundation Project horizontal directional drilling site.

The exact location, size, and dimensions of the horizontal directional drilling site will be finalised during detailed design. The horizontal directional drilling site is planned to be less than 10 ha in size, and located within the indicative area shown in Figure 4-4. Clearing will be within the allocated uncleared land available for tenure on Barrow Island for gas processing activities under the *Barrow Island Act 2003* (WA). Each hole is expected to first be drilled as a small-diameter pilot hole. To complete the holes for the Fourth Train Proposal, an assisted reaming technique may be used. This technique entails a larger-diameter hole being drilled as the drill bit is simultaneously pushed by the drill string and pulled by a cable attached to offshore support vessels. This technique improves the directional control of the reaming process, particularly when the drill encounters subsurface karst or cavern formations. At the commencement of each hole, if the ground is deemed unstable or requires additional support, a larger-diameter surface conductor will be installed. This may be done by reaming and insertion, or by conventional excavation during site works. This practice is commonly used to reduce the potential for frac-outs when drilling in unstable landforms.

Drilling fluids will be used during the drilling of the shore crossing to lubricate and cool the drill bit, transport the cuttings away from the drill bit, and provide hole stability along the length of the drilled profile. During drilling operations, the GJVs plan to use a closed-loop system for the drilling fluids, where the returns are collected in an excavated, lined collection sump. Where practicable, the drilling fluids are then processed through a recycling system where the cuttings are removed, prior to the fluid being recirculated through the hole, reducing the volume of fluids required.

When the drill breaks through at the exit points on the seabed, a small amount of drilling fluid and drilling cuttings will be discharged to sea. Therefore, low-toxicity water-based drilling fluids will be used, similar to those used by the approved Foundation Project. Section5.5 outlines the management of drilling fluids and drilling cuttings. The approved Foundation Project planned to use a delayed breakout method to complete the holes for the shore crossing. Delayed breakout involves the holes being drilled and reamed to the required size while leaving the last section of the hole undrilled, to prevent drilling fluids being discharged to sea. However, during construction of the approved Foundation Project shore crossing it was found that the ground conditions were unsuitable for this method, which created drilling issues such as drilling off course and not being able to confirm the exit hole reliably. The approved Foundation Project made the decision not to continue with the delayed breakout method, instead drilling the pilot hole to the exit point, resulting in a far greater success rate for subsequent holes.

The pipe sections need to be welded together into long strings so as to pass the Feed Gas Pipeline System through the holes drilled beneath the shore. Pipe welding will occur within the horizontal directional drilling stringing area, prior to installation.

Marine support vessels will be used to assist in the drilling operations and pipe string installation. A winch wire will be retrieved from the offshore vessels through the drilled hole. The winch wire will be attached to the pipe string, and the support vessels will apply tension to ensure the head is centred in the hole as the string is launched.

Once the pulling head emerges from the hole, pulling and/or thrusting operations will continue to install the pipeline through the hole and out a further 400 to 600 m (approximately) out to sea from the exit point. Span correction may be required to enable the pipeline to be supported on the seabed; this may consist of grout bags used to fill in depressions on the seabed. The pipeline will be flooded from onshore, with the offshore sections capped. Once flooded, the onshore pipeline ends are planned to be capped so that the pipeline can be left until the offshore Feed Gas Pipeline System is ready for connection with the shore crossing section. Marine support vessels are expected to be used to place temporary stabilisation, such as clump weights, along the pipeline. Placement of the clump weights is expected to be conducted using divers and cranes.

Marine vessels are expected to be used to assist with the launching of the pipeline sections and to carry out tail guidance and placement of temporary stabilisation blocks. A marine vessel is expected to be moored during these shallow water operations, and where practicable, floating lines will be used and connected to the vessel's winch wires and winches to reduce anchor chain drag on the sea floor. Dynamic positioned vessels may also be used, where required.

Figure 4-10 shows an indicative sequence of drilling and pipe-lay activities expected to be used during horizontal directional drilling.

The re-use of existing approved Foundation Project facilities at the horizontal directional drilling site, including bunded storage areas, water winning infrastructure, and communications infrastructure, is being investigated by the GJVs and may be implemented, where practicable. An additional temporary water supply system is expected to be required by the Fourth Train Proposal as a contingency to the main water winning infrastructure, which was installed by the approved Foundation Project. The installation of the temporary water supply system will require the installation of the intake pipeline and other infrastructure across the beach into the ocean. The pipeline is expected to be a flexible hose, approximately 150 mm in diameter.

Drilling and pipe thrusting operations are expected to occur 24 hours a day for the duration of works. On completion of the shore crossing, reinstatement of the horizontal directional drilling site will occur. Section 9 details the intended site reinstatement activities.

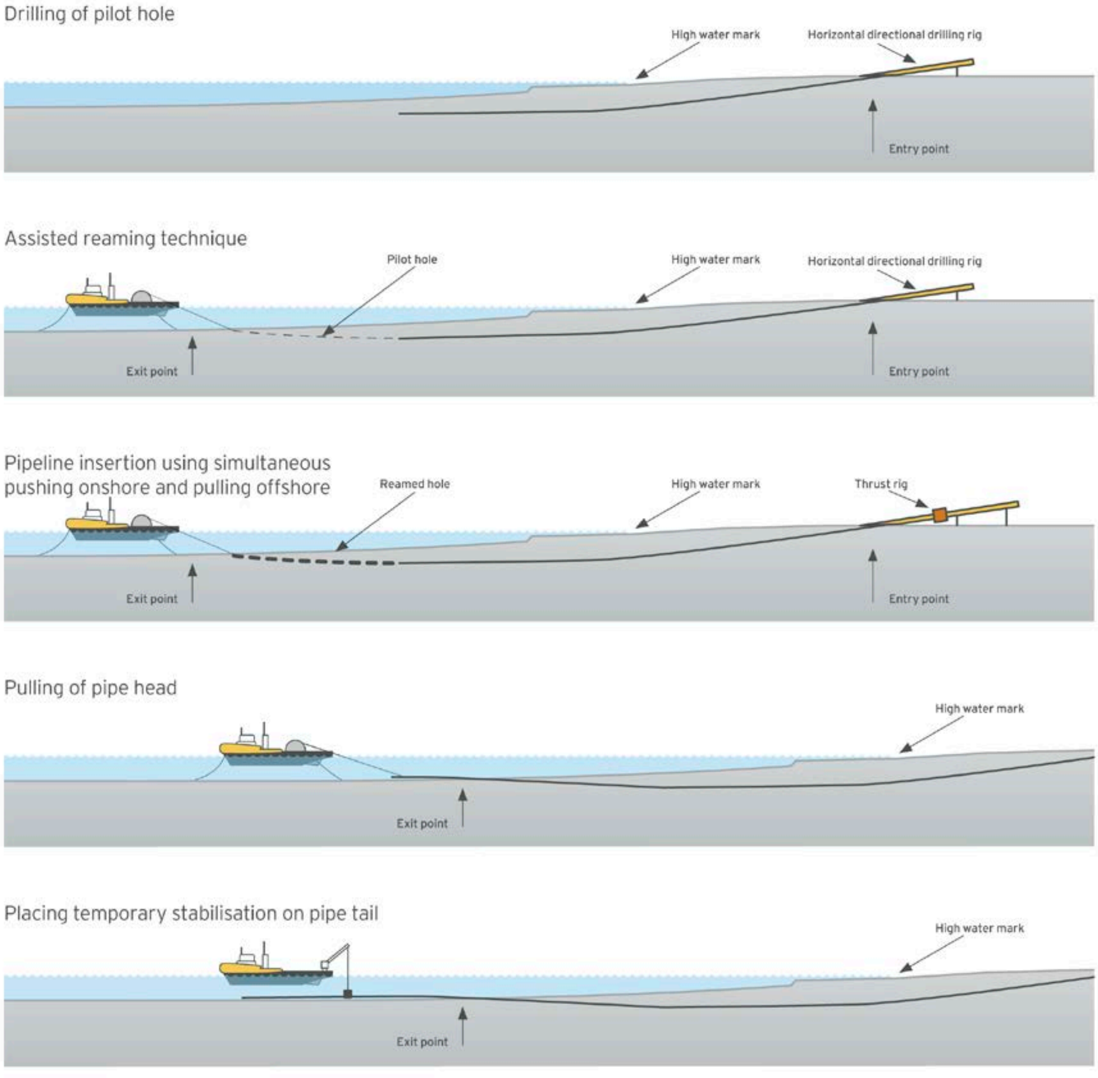

Figure 4-10: Outline of Horizontal Directional Drilling Procedure

4.5.3 Onshore Facilities

The Fourth Train Proposal onshore clearing and construction activities will be substantially less than those conducted for the approved Foundation Project, due to the Fourth Train Proposal intending to use infrastructure installed for the approved Foundation Project.

4.5.3.1 Onshore Feed Gas Pipeline System

The onshore Feed Gas Pipeline System will be installed in below-ground trenches within the Foundation Project Feed Gas Pipeline Systems footprint. Figure 4-6 shows an indicative cross-section of the Foundation Project Feed Gas Pipeline System footprint, and the Fourth Train Proposal Feed Gas Pipeline System located in the same corridor. Note that this design is indicative only and may be altered during detailed design.

Two trenches are likely to be required for the installation of the Fourth Train Proposal Feed Gas Pipeline System. The trenches will be excavated, and then the Feed Gas Pipeline, MEG pipeline, utility pipeline, and control umbilical will be installed prior to backfilling. The GJVs intend that construction activities, including trench spoil storage and welding, will occur within the Feed Gas Pipeline System footprint and/or on the horizontal directional drilling site. However, if additional space is required, existing cleared land, such as drilling pads or Foundation Project construction sites, may be used. If installation of the Feed Gas Pipeline System is done in stages (Section 4.4.2), trenching activities for the control umbilical may occur before the installation of other Feed Gas Pipeline System components.

Following pipeline installation, the trenches will be backfilled with appropriate bedding and padding material and then compacted. The minimum depth of the Feed Gas Pipeline System installation will conform to relevant Australian Standards. The depth of cover over the pipeline will be greater at road and river crossings, compared to other locations.

After backfilling the onshore Feed Gas Pipeline System trenches, excess spoil material is expected to remain as a result of the presence of the Feed Gas Pipeline System infrastructure within the trench. This excess material may be disposed of on Barrow Island, transported to the mainland for disposal, or disposed of in offshore disposal grounds. Topsoil will be reinstated on top of the trench to a depth that is approximately equal to its original depth. Section 9 outlines the site reinstatement activities.

4.5.3.2 Gas Treatment Plant

Earthworks will be required at the start of construction of the Fourth Train Proposal Gas Treatment Plant. An area of approximately 50 ha of existing cleared land will be subject to earthworks within the existing cleared approved Foundation Project Gas Treatment Plant site. Earthworks are required to install foundations, underground cables, drainage, and utilities.

The GJVs are investigating options for Fourth Train Proposal earthworks at the Gas Treatment Plant site. The options include excavating trenches to install foundations, pipes, drainage, utilities, etc. and then backfilling the trenches and building the site back up to final ground level, as well as the option of excavating the entire Fourth Train Proposal site to the level required to install the foundations, pipes, drainage, utilities, etc. and then building the site back up to final ground level. Earthworks may be required at the Additional Support Area, primarily to source aggregate suitable for use within the Gas Treatment Plant site during construction. These earthworks may take place over 32 ha, although the actual size of the area required to source aggregate in the Additional Support Area is expected to be less.

Some blasting during earthworks may be required. Note that the terrace levels of the Gas Treatment Plant, including the areas included within the Fourth Train Proposal, were established during construction of the Foundation Project. Drilling may also be required at the Gas Treatment Plant site to install earthing rods, rock anchors, and boreholes for the third LNG Tank, if this tank is required.

Preliminary assessment of the available geotechnical information for the approved Foundation Project suggests that expected soil conditions at the proposed third LNG Tank site will be similar to that encountered beneath the approved Foundation Project LNG Tanks. Therefore, ground preparation methods are expected to be similar to those carried out for the approved Foundation Project LNG Tanks, which included excavating, filling, and compacting. Detailed geotechnical investigations are planned for the proposed LNG Tank site, which will confirm the required ground preparation works. Ground preparation may include drilling to install piled foundations and/or ground improvement options that improve soil density (including high-pressure grouting, or dynamic compaction). Section 9 assesses the potential environmental impacts from ground preparation options for the third LNG tank.

Where practicable, offsite modularisation techniques will be used to construct many of the components of the Fourth Train Proposal Gas Treatment Plant. Pre-assembled units will be constructed and assembled in fabrication yards and transported to Barrow Island at a maximum level of completeness. The number of separate units will be reduced and each unit supplied will already be fitted with piping and auxiliaries to reduce installation time.

Modularisation is intended to:

- reduce the environmental impact
- reduce the workforce requirements on Barrow Island.

Where modularisation is not practicable, the Fourth Train Proposal infrastructure at the Gas Treatment Plant will be constructed onsite from non-modularised materials.

4.5.3.3 Laydown Areas

Laydown areas will be required on Barrow Island to support the construction of the Fourth Train Proposal. The approved Foundation Project uses cleared areas around Barrow Island for its laydown, and will use further land, e.g. land associated with the Additional Support Area, for laydown following clearing activities. The Fourth Train Proposal will use the same areas for laydown and spoil storage, where practicable. However, if these areas are unsuitable or insufficient, the GJVs will investigate using additional areas of cleared land on Barrow Island (such as disused WA Oil drilling pads). The Fourth Train Proposal horizontal directional drilling site will also be used for laydown, and the option of transporting excess spoil off Barrow Island may also be implemented to make additional laydown space available.

Barge laydown installed by controlled grounding adjacent to the Materials Offloading Facility or WAPET Landing may also be used to provide additional laydown areas to support construction. To enable safe controlled grounding to occur, seabed re-profiling may be required; this involves levelling the seabed (where required) to provide a flat surface profile for barge placement. No dredging or removal of seabed material will be required for this activity. The assessment of environmental impacts reasonably expected from the laydown area options on Barrow Island or in its surrounding waters is included in Sections 9 and 10, respectively. Laydown may also be undertaken at an existing mainland facility.

4.5.3.4 Utilities and Subsidiary Infrastructure

Various facilities will be required on Barrow Island to support construction activities for the Fourth Train Proposal. Facilities, including construction utilities and subsidiary infrastructure, were expected to be demobilised at the end of the Foundation Project construction phase or when no longer required. However, it is proposed that a number of these facilities are retained and their duration extended, where practicable, to support the construction of the Fourth Train Proposal. Therefore, these facilities may support the construction of the Fourth Train Proposal and approved Foundation Project and also support the operation of aspects of the approved Foundation Project. The use of these shared facilities by the Fourth Train Proposal is not expected to increase the maximum throughput or capacity approved under the Foundation Project, but may require some minor refurbishment of these facilities to maintain appropriate operating standards. If the same facilities are not able to be retained (e.g. due to contractual restrictions or lack of suitability for the Fourth Train Proposal), then new facilities with a similar or reduced throughput capacity may be required. In addition, the Fourth Train Proposal may use spare capacity available in the Foundation Project operations phase utilities to support construction.

Foundation Project facilities expected to be used by the Fourth Train Proposal as construction utilities include:

- reverse osmosis facilities
- sanitary wastewater systems
- power generation.

4.5.3.4.1 Reverse Osmosis Facilities

Fresh water required for the Fourth Train Proposal is expected to be supplied via Foundation Project facilities. The Foundation Project reverse osmosis facilities, including intake and outfall structures, will draw the source water from and discharge the reject brine into, the marine environment, adjacent to the Materials Offloading Facility (Figure 4-11). The Foundation Project temporary and permanent reverse osmosis facilities are expected to provide sufficient water to supply the Fourth Train Proposal during construction on Barrow Island, without breaching the maximum approved discharge limits. Note: The Fourth Train Proposal will require an extended duration of use of the Foundation Project's temporary reverse osmosis facilities. The Fourth Train Proposal may replace the Foundation Project's temporary reverse osmosis facilities with similar facilities if required, e.g. in the case of the Foundation Project temporary reverse osmosis facilities reaching their end of design life.

Technical studies were conducted to predict the volumes of freshwater and reject brine generated by the reserve osmosis facilities, and to determine the water demand from the approved Foundation Project and Fourth Train Proposal. The results of the technical studies are included below.

The approved Foundation Project temporary reverse osmosis facilities can produce approximately 3800 m^3/day of fresh water, with approximately 4600 m^3/day of reject brine generated. The permanent reverse osmosis facilities, which will be installed for the approved Foundation Project before commencement of Fourth Train Proposal construction activities, are expected to produce a maximum capacity of approximately 2100 m^3/day of fresh water and approximately 2600 m^3/day of reject brine. The Fourth Train Proposal is expected to use available spare capacity from these facilities to supplement the freshwater supply during construction activities.

Together, the temporary and permanent reverse osmosis facilities can produce approximately 5900 m^3/day of fresh water. The peak freshwater demand predicted for the Fourth Train Proposal during construction is approximately 4100 m^3/day and for the approved Foundation Project during turnaround operations (maintenance) is approximately 1100 m^3/day. Therefore, the approved Foundation Project temporary and permanent reverse osmosis facilities are expected to provide sufficient fresh water to meet the requirements of the Fourth Train Proposal and the approved Foundation Project.

The Fourth Train Proposal is seeking approval to extend the use of Foundation Project temporary reverse osmosis facilities beyond the approved time frame of approximately three years, to until the end of Fourth Train Proposal construction, or to replace the Foundation Project temporary reverse osmosis facilities with facilities that have similar production capabilities. This approval is sought through this PER/Draft EIS and by a subsequent update to the Reverse Osmosis Brine Disposal via Ocean Outfall Environmental Management and Monitoring Plan (Chevron Australia 2013). If this application is unsuccessful, the Fourth Train Proposal will seek other means to supply fresh water (i.e. barging water to supplement freshwater supplies, which was successfully used for the approved Foundation Project).

An outline of the discharges and the impacts that are reasonably expected from the temporary (or replacement) and permanent reverse osmosis facilities combined with the discharges from a possible Fourth Train Proposal accommodation vessel, are assessed in Sections 5 and 10 of this PER/Draft EIS, respectively.

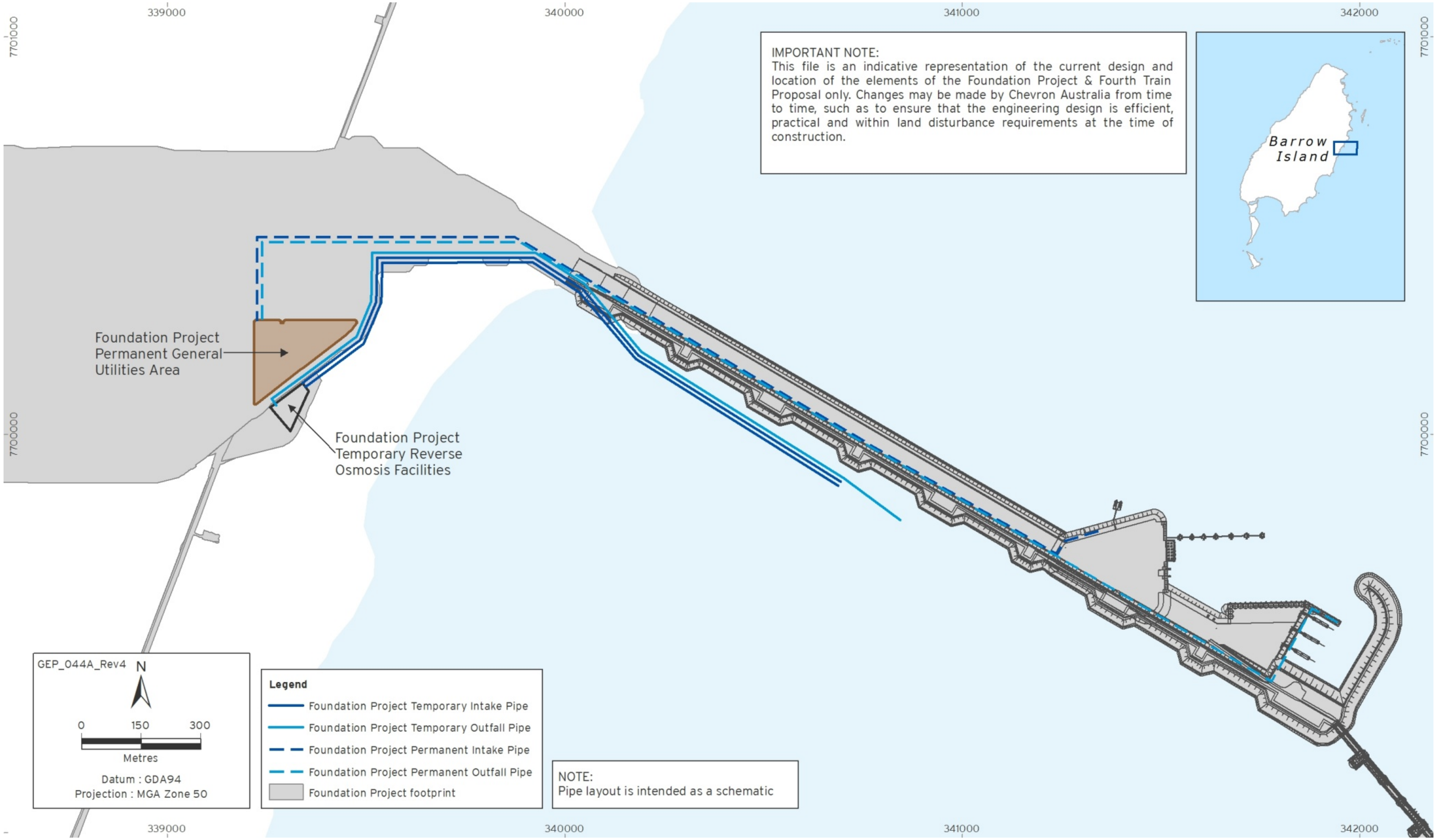

Figure 4-11: Location of Reverse Osmosis Facilities including Intake and Outfall Structures

4.5.3.4.2 Sanitary Wastewater Systems

Wastewater, including domestic black and greywater generated during the construction of the Fourth Train Proposal, will be treated together with the Foundation Project wastewater by the approved Foundation Project sanitary wastewater systems and/or temporary facilities located on offshore accommodation vessels (if required; Section 4.5.5). During peak construction, the approved Foundation Project intends to operate both the temporary construction phase and the permanent sanitary wastewater systems. The Fourth Train Proposal is expected to use temporary and permanent systems during its construction. The Fourth Train Proposal may also use shared sanitary wastewater systems with WA Oil.

Approved Foundation Project temporary sanitary wastewater systems were planned to be decommissioned and removed from Barrow Island, as they are not required during the operations phase. However, the Fourth Train Proposal will require these facilities during its construction, so they are planned to be retained until the Fourth Train Proposal construction is completed. The Fourth Train Proposal does not intend to increase the maximum approved treatment capacity of the Foundation Project sanitary wastewater systems or the method of discharge. Wastewater from offshore accommodation will be managed according to the hierarchy outlined in Section 5.5.3.1 and relevant regulatory approvals.

Approval is sought to extend the duration of use of these facilities by this PER/Draft EIS. Section 9 of this PER/Draft EIS assesses the impacts from the increased duration of use of the approved Foundation Project temporary sanitary wastewater systems. The use of the permanent sanitary wastewater systems by the Fourth Train Proposal activities will not alter those systems' approved capacity or duration of use; therefore, no additional assessment of the environmental impacts from the operation of the permanent sanitary wastewater systems is included in this PER/Draft EIS.

4.5.3.4.3 Power Generation

Power for the construction of the Fourth Train Proposal is expected to be sourced from approved Foundation Project facilities, with the power supply being provided by the existing approved Foundation Project temporary power stations and/or available capacity from the approved Foundation Project Gas Turbine Generators.

The Fourth Train Proposal is seeking approval to use the approved Foundation Project existing temporary power stations located on Barrow Island. These may be converted from diesel to gas in future, which is expected to reduce their emissions. The implementation of the Fourth Train Proposal is not expected to increase the maximum capacity of the approved Foundation Project existing temporary power stations.

The Fourth Train Proposal may use available spare electrical capacity from the Gas Turbine Generators, but further approval is not being sought to alter the Foundation Project Gas Turbine Generators' output or duration of use. Therefore, the environmental impacts reasonably expected from the operation of the approved Foundation Project Gas Turbine Generators is not assessed in this PER/Draft EIS.

Note that small mobile diesel generators may also be used where power supply from the existing temporary power station and/or Gas Turbine Generators is not available.

Table 4-8 summarises the Foundation Project facilities planned to be used by the Fourth Train Proposal as construction utilities, including the approximate maximum capacity, the Foundation Project approval mechanism, and aspect of the approval for which amendment is sought for the Fourth Train Proposal.

Table 4-8: Foundation Project Construction Utilities that are Planned to be Used by the Fourth Train Proposal and Approved Foundation Project

Construction Utility	Approximate Maximum Throughput or Capacity	Aspect of Approval to Amend
Reverse osmosis facilities	5900 m^3/day of fresh water	Duration of use
Sanitary wastewater systems	2000 m^3/day	Duration of use
Power generation	Approx. 24 MW (existing temporary power station) Approx. 80 MW each (Gas Turbine Generators, if practicable)	Use by the Fourth Train Proposal

4.5.3.4.4 Subsidiary Infrastructure

Subsidiary infrastructure on Barrow Island will be required to support the construction of the Fourth Train Proposal. Facilities installed by the approved Foundation Project may be retained and used to support the construction of the Fourth Train Proposal, as well as be used to support the approved Foundation Project. These facilities may include subsidiary infrastructure such as:

- offices, crib rooms, and toilets
- temporary diesel storage and distribution
- hazardous material storage areas
- concrete supply
- waste transfer station
- vehicle maintenance workshops
- abrasive blasting workshops
- powder coating workshops
- chemical storage areas
- scaffold yards.

Subsidiary infrastructure may be located on construction sites, including the horizontal directional drilling site, onshore Feed Gas Pipeline System footprint, the Gas Treatment Plant site, the Additional Support Area, or at other areas previously used by the approved Foundation Project or WA Oil such as the Old Airport, WAPET Landing, or disused drilling pads.

Hazardous material storage areas will be installed as required to house hazardous materials required for the Fourth Train Proposal construction. The hazardous material storage areas will have appropriate bunding and drainage systems in accordance with Australian Standards. Waste hazardous materials may be temporarily stored in the waste transfer station or transferred directly off Barrow Island from the source, for disposal on the mainland.

The assessment of the environmental impacts reasonably expected to occur from the extended duration of use of the Foundation Project subsidiary infrastructure is included in Section 9 of this PER/Draft EIS, where relevant. These assessments are based on retaining the Foundation Project facilities or installing new facilities with similar capacity.

4.5.4 Logistics

The Fourth Train Proposal will use the existing logistics infrastructure and supply chain established for the construction of the approved Foundation Project. This includes facilities on Barrow Island and on the Western Australian mainland such as:

- Materials Offloading Facility

- WAPET Landing (also known as the barge landing in the Foundation Project environmental approval documentation)
- Barrow Island road network
- Barrow Island Airport
- marine vessels, including tugs and barges
- mainland road network
- mainland supply bases (e.g. Dampier and Henderson).

Some changes may be required to the logistics infrastructure to ensure that it is suitable for use by the Fourth Train Proposal.

Anticipated logistics activities required for the Fourth Train Proposal includes fixed-wing and helicopter flights, tug and barge movements to and from the Australian mainland, and direct shipments from international ports and supply yards. Approximately 70 marine vessels may be used to support the construction of the Fourth Train Proposal.

4.5.5 Construction Workforce and Accommodation

The construction workforce required for the Fourth Train Proposal will be accommodated in the existing approved camps on Barrow Island, including Butler Park (Construction Village). No additional accommodation on Barrow Island is expected to be required to support the Fourth Train Proposal. The number of Fourth Train Proposal and Foundation Project construction personnel on Barrow Island is expected to be within the peak workforce requirement for the Foundation Project. However, an extension to the duration that this construction workforce is present on Barrow Island will be required.

The existing accommodation on Barrow Island may also house personnel involved in pre-commissioning, commissioning, and maintenance activities.

If the existing accommodation on Barrow Island is not sufficient to cater for the Fourth Train Proposal personnel, as well as the existing approved Foundation Project and WA Oil personnel, additional accommodation may be installed. Due to the shortage of available land on Barrow Island, offshore accommodation may be used. Two types of accommodation that may be considered include 'floatel' accommodation and barge accommodation. The barge accommodation is proposed to be installed by controlled grounding of the barge on the seabed. To enable safe controlled grounding to occur, seabed re-profiling may be required, which involves levelling the seabed (where required) to provide a flat surface for barge placement.

Both options comprise accommodation rooms and supporting facilities (e.g. offices, kitchens, utilities) installed on marine vessels, which may be self-propelled or non-propelled. If implemented, it is expected that floatel accommodation will be located within the Barrow Island Port, with the barge option located adjacent to the Materials Offloading Facility or WAPET Landing. Both accommodation options are expected to be limited to a maximum of 1000 people for the duration of the Fourth Train Proposal construction. Both Fourth Train Proposal and Foundation Project personnel may be accommodated on the offshore accommodation. The environmental impacts that may result from both options are included in Sections 5and 10 of this PER/Draft EIS.

4.5.6 Pre-commissioning

Prior to commencing commissioning, a range of infrastructure including tanks, vessels, pipelines and other equipment is expected to be pre-commissioned. Pre-commissioning will likely include a series of activities to verify that the infrastructure or equipment has been fabricated, constructed, and/or installed correctly. Pre-commissioning may occur on Barrow Island or at locations away from Barrow Island, including the fabrication yards. Activities conducted during pre-commissioning may include inspections, cleaning, hydrotesting, dewatering/drying, and inerting.

Hydrotesting is a key activity during pre-commissioning. Hydrotesting involves filling a tank, vessel, pipeline, or other equipment with water or similar fluid, then pressurising the fluid to test for leaks under the design specifications or maximum allowable operating pressure. The hydrotesting medium likely to be used for the Fourth Train Proposal Feed Gas Pipeline System, Gas Treatment Plant infrastructure, and the LNG Tank (if included) is expected to be sea water and/or fresh water.

Pre-commissioning of the Feed Gas Pipeline System is likely to require flooding with treated sea water and fresh water. Cleaning, gauging, and hydrotesting will use a series of pigs pushed along the pipeline. Following flooding, cleaning, and gauging, the Feed Gas Pipeline System will then be hydrotested to confirm structural integrity and to ensure there are no leaks. The hydrotest medium for the Feed Gas Pipeline System is expected to be treated sea water and/or fresh water depending on the individual pipeline selected. For the Feed Gas Pipeline, which is the largest component of the Feed Gas Pipeline System, approximately 150 000 m^3 of treated sea water or fresh water is expected to be required for the Northern Pipeline Route and approximately 200 000 m^3 is expected to be required for the Southern Pipeline Route, which is approximately 50 km longer. MEG may be used to dehydrate the Feed Gas Pipeline and intrafield flowlines following hydrotesting.

As required by pipeline legislation, third-party independent validation will be conducted to verify that the pipelines are installed in compliance with the relevant standards and design criteria.

Within the Fourth Train Proposal Gas Treatment Plant, it is predicted that the largest single component requiring hydrotesting will be the LNG Tank, if such a tank is needed. It is expected that approximately 120 000 m^3 of hydrotest water will be used. Hydrotest water is likely to be treated with additives. Commonly used additives include oxygen scavengers, biocides, and dyes.

Section 5.5 outlines the management of hydrotest water discharges. The environmental implications of the discharges of hydrotest sea water, fresh water, or MEG is assessed in Sections 10 and 13 of this PER/Draft EIS.

4.5.7 Commissioning and Start-up Activities

Once construction of the Fourth Train Proposal is complete, some infrastructure will need to be commissioned before start-up. Commissioning may involve processes such as quality assurance checks, cleaning, expelling air from the systems, introducing hydrocarbons into the system, and, finally, start-up. Where practicable, testing and systems checks will be conducted by manufacturers prior to shipment to Barrow Island. Manufacturers' checks are designed to ensure that rectification required as a result of the testing can be carried out in a cost-effective manner with minimal impact on the schedule.

The sections below summarise the preliminary plans for commissioning.

4.5.7.1 Offshore Facilities

Offshore components of the Fourth Train Proposal, including pipelines, umbilicals, wells, trees, and ancillary components will be divided into systems capable of being isolated and commissioned. System verification testing is required to ensure the complete installed system is performing adequately prior to the introduction of hydrocarbons. Some systems may require additional, more detailed, testing at a subsystem level; these may include several equipment packages and their interfaces.

Operational testing will be conducted to ensure operability and to ensure that data feedback from critical equipment is verified. Shutdown testing is also planned, which may consist of instigating potential shutdown scenarios, with the relevant valves and instrumentation proven to function as designed.

4.5.7.2 Onshore Facilities

Commissioning of onshore components of the Fourth Train Proposal will be conducted following the completion of construction. Commissioning is expected to follow a predefined sequence of activities. The commissioning phase will continue until the fourth LNG train and its associated infrastructure has reached steady state operations. The commissioning phase is expected to consist of three stages:

- commissioning
- start-up
- operational tests.

Systems and system boundaries will be defined so that each system can be isolated from other parts of the process. Such isolation minimises the interdependence of systems and allows for smaller, more manageable, sections of the process to be commissioned and started.

Commissioning activities include the preparation for operation of the Fourth Train Proposal Gas Treatment Plant prior to start-up; for example:

- software checks
- final electrical checks
- air freeing
- introduction of hydrocarbons
- equipment operational tests (e.g. nitrogen runs).

During the commissioning phase, fuel gas may be used for gas turbine testing, compressor testing, and power generation. Temporary construction utilities may also be required during this phase.

When these checks are complete, the systems are considered ready for start-up. Start-up involves activities that are required to achieve commercial operation of an area; these activities may include:

- introducing process fluids
- cooling down
- introducing feedstock for commercial production of LNG
- stabilising process circulation
- fine tuning process variables
- establishing normal operation
- transferring hydrocarbon product to storage
- first ship loading.

Following start-up, operational tests are likely. Operational tests demonstrate that systems operate according to their performance requirements.

4.6 Simultaneous Operations

Simultaneous operations (SIMOPS) are where separate construction or operations activities occur alongside each other. SIMOPS are expected to occur during construction of the Fourth Train Proposal with other operating projects, including the approved Foundation Project. Examples of SIMOPS are:

- Construction of Fourth Train infrastructure in the Gas Treatment Plant site near approved Foundation Project LNG trains during commissioning activities
- Fourth Train Proposal Feed Gas Pipeline System crossing other operational pipelines
- Fourth Train Proposal horizontal directional drilling occurring adjacent to the approved Foundation Project operating Feed Gas Pipeline Systems
- constructing the Fourth Train Proposal Feed Gas Pipeline near the operating Foundation Project Feed Gas Pipeline Systems
- installing the Fourth Train Proposal Feed Gas Pipeline System near the operating Foundation Project Ground Flare
- tying-in the Fourth Train Proposal Feed Gas Pipeline System to the operating Gas Treatment Plant
- unloading the Fourth Train Proposal modules, pre-assembled pipe racks, pre-cast foundations, stick-built materials, construction materials, and equipment at the Materials Offloading Facility while the approved Foundation Project is operating, including LNG and condensate load out
- constructing the fourth LNG train and its associated infrastructure near the three operating LNG trains
- undertaking major Gas Treatment Plant maintenance or shutdown while the remaining Gas Treatment Plant is operational.

During SIMOPS there may be an increased risk of incidents and accidents. Accordingly, SIMOPS will be managed in a way that manages or mitigates the associated risks. The SIMOPS management process is designed to identify, plan, and prioritise SIMOPS activities, and to provide a proactive approach to SIMOPS management in order to manage SIMOPS situations.

4.7 Operational Activities

The Combined Gorgon Gas Development, which includes both the approved Foundation Project and the Fourth Train Proposal, will be operated as an integrated development by Chevron Australia. Like the Foundation Project, the Fourth Train Proposal is expected to operate continuously 24 hours a day, 365 days a year. The offshore and onshore components of the Fourth Train Proposal are expected to be able to operate independently of each other (e.g. when the Fourth Train Proposal Gas Treatment Plant is shut down for maintenance, the offshore infrastructure may still operate to supply feed gas to the Foundation Project Gas Treatment Plant).

Suitably qualified personnel will be employed to operate the Combined Gorgon Gas Development. Supplementary contractors will be brought in during major maintenance periods or when required to supplement the core Chevron Australia workforce.

4.7.1 Offshore Facilities

The key offshore activities for the operation of the Fourth Train Proposal are extracting and transporting gas and condensate to Barrow Island. Supplementary activities include:

- start-up, ramp-up, and shutdown of individual wells
- flowline and pipeline flow assurance operations, which may include pigging
- hydrate mitigation with MEG injection into the Feed Gas Pipeline.

The offshore production wells will be controlled remotely from the Administrations and Operations Complex on Barrow Island using the control umbilical. Remotely operated vehicles deployed from offshore work vessels and/or drilling rigs will be used to inspect and maintain wells and subsea facilities. Such inspections are planned to occur periodically to monitor and assess the condition of the equipment and the seabed, and to identify if intervention is required to replace faulty equipment.

4.7.2 Onshore Facilities

The onshore operation of the Fourth Train Proposal will principally involve receiving and treating the gas and condensate for export.

To facilitate synergies between the approved Foundation Project and the Fourth Train Proposal, utilities and services included in the Fourth Train Proposal may be linked, combined, or connected with existing Foundation Project utilities and services. An example of this is power generation; the Fourth Train Proposal includes the provision for an additional Gas Turbine Generator, which will supply power to the Fourth Train Proposal and will increase the total power generated by the Combined Gorgon Gas Development.

Operation of the Fourth Train Proposal will commence after the approved Foundation Project has been operating for a number of years. Therefore, it is expected that the operation of the Fourth Train Proposal will be able to take advantage of the increased operational knowledge and lessons learnt from the approved Foundation Project, potentially streamlining the operation.

4.7.2.1 Gas Treatment Plant

The Fourth Train Proposal Gas Treatment Plant will use well-proven technology. The Gas Treatment Plant is expected to operate for more than 90% of the year, including during the cyclones that frequent Barrow Island. In the event of a cyclone, ships will depart the loading terminals and standby at sea until favourable docking and loading conditions return.

The increased production capability of LNG and condensate resulting from the Fourth Train Proposal will require additional export shipments. The Fourth Train Proposal is expected to increase the number of ship loadings from the LNG Jetty at Town Point from approximately 220 to 250 shipments per year (for the approved Foundation Project) to approximately 310 to 330 shipments per year for the Combined Gorgon Gas Development once the Fourth Train Proposal is operational, depending on fleet configuration. Vessel loading may occur 24 hours a day and two vessels may be berthed at the LNG Jetty at the same time, either loading, purging, cooling down, or being prepared for loading.

Prior to reaching Barrow Island, condensate marine vessels may standby in an anchorage area approximately 10 nm east of the Barrow Island Port limits, waiting for their berthing allocation. Typically, LNG marine vessels will not use the anchorage area as they are expected to time their journey to Barrow Island based on their allocated berthing time. The LNG and condensate marine vessels are expected to be piloted by pilots based at Barrow Island and escorted within the Barrow Island Port by a fleet of dedicated tugs based at Barrow Island. Approximately four tugs and one pilot vessel are planned to be based at Barrow Island to assist in escorting, mooring, unmooring, and emergency response duties. This represents no change from the approved Foundation Project.

The Fourth Train Proposal facilities will be controlled and monitored by a computer-based Integrated Control System, which includes a Process Control System, a Safety Instrumented System, a Subsea Control System, and a Fire and Gas System. The Gas Treatment Plant will have a comprehensive computerised maintenance database of equipment items. This system will ensure that inspection requirements are fulfilled, that appropriate preventive maintenance of equipment items is conducted, and that planned and unplanned downtime is monitored.

Major planned shutdowns of the fourth LNG train and associated equipment will be conducted regularly and will involve significant planning. Appropriate maintenance of facilities will ensure the integrity of those facilities. The fourth LNG train or equipment within the fourth LNG train will be shut down for routine scheduled maintenance or unscheduled repair work. During these periods, approved Foundation Project and other infrastructure within the Fourth Train Proposal may continue to operate.

The number of unplanned shutdowns of the facilities is difficult to predict. Unplanned shutdowns may be initiated by the operators, may occur as a result of equipment failure, or may occur if the Gas Treatment Plant is operating outside its design limits. The automatic Safety Instrumented System could also initiate a shutdown. Depending on the cause of the shutdown, the Gas Treatment Plant could either be shut down with no depressurisation to flare, or undergo partial or complete depressurisation. The Fourth Train Proposal, like the approved Foundation Project, is designed to operate with no routine flaring beyond that required for the safe operation of the flare system (i.e. flare pilots and purge gas) and plant (e.g. small flows from equipment purges, which are not practicable to collect) during normal production operations.

Section 5.2 outlines the predicted frequency of unplanned events and their proposed management.

4.7.2.2 Utilities and Subsidiary Infrastructure

Various facilities will be required on Barrow Island to support the operations phase of the Fourth Train Proposal. Facilities, including utilities and subsidiary infrastructure installed by the approved Foundation Project, are expected to be used by the Fourth Train Proposal. The use of these facilities by the Fourth Train Proposal is not expected to require any increase in the maximum capacity or any alteration of the discharge methods approved under the Foundation Project.

Approved Foundation Project facilities expected to be used by the Fourth Train Proposal during the operations phase include:

- reverse osmosis facilities
- sanitary wastewater systems.

4.7.2.2.1 Reverse Osmosis Facilities

Fresh water required for the Fourth Train Proposal will be supplied via the Foundation Project temporary and permanent reverse osmosis facilities. These reverse osmosis facilities, including intake and outfall structures, will draw source water and discharge reject brine into the marine environment adjacent to the Materials Offloading Facility (Figure 4-11). The Fourth Train Proposal seeks to amend the Foundation Project approval for ocean discharge and the use of these facilities (or replacement similar facilities [Section 4.5.3.4.1]) by the Fourth Train Proposal. Note: The Fourth Train Proposal will require an extended duration of use of the Foundation Project's temporary reverse osmosis facilities (or replacement facilities, if required). If this application is unsuccessful, the Fourth Train Proposal will seek other means to supply fresh water.

These permanent reverse osmosis facilities have a maximum design capacity of approximately 2100 m^3/day of fresh water producing approximately 2600 m^3/day of reject brine, which requires disposal. This is within the 5150 m^3/day (nominal) raw water supply for normal operations approved for the Foundation Project in Ministerial Implementation Statement No. 800. The Fourth Train Proposal in addition to the approved Foundation Project is approximately 1100 m^3/day. Therefore, the Foundation Project permanent reverse osmosis facilities are expected to provide sufficient water to supply both the Foundation Project and the Fourth Train Proposal during the operations phase, without increasing the maximum throughput. Fresh water may either be conditioned for use as potable water, service water within the plant, or demineralised further for use in the Heating Medium System.

Ministerial approval for the discharge of the reject reverse osmosis brine from the permanent reverse osmosis facilities to the marine environment has been granted, as required under Ministerial Conditions. As the Foundation Project has obtained approval for this discharge and associated potential environmental impacts from the operation of these permanent reverse osmosis facilities, no further assessment is provided in this PER/Draft EIS.

4.7.2.2.2 Sanitary Wastewater Systems

The existing sanitary wastewater systems, including wastewater treatment plants, on Barrow Island will be shared during the operation of the Fourth Train Proposal to treat sewage and other domestic wastewater, including black and greywater. The approved Foundation Project wastewater treatment systems are predicted to have sufficient capacity to process the increase in sanitary wastewater due to the increase in operational personnel as a result of the Fourth Train Proposal. For example, the Permanent Wastewater Treatment Plant can treat approximately 350 m^3/day of sewage and other domestic wastewater, which is expected to be sufficient to support the operations phase of the approved Foundation Project and the Fourth Train Proposal.

As the use of the permanent sanitary wastewater systems by the Fourth Train Proposal activities will not alter the systems' approved capacity, discharge volumes, or discharge locations, no additional assessment of the environmental impacts from their use by the Fourth Train Proposal is included in this PER/Draft EIS.

4.7.2.2.3 Subsidiary Infrastructure

Shared facilities installed by the approved Foundation Project and used to support the operation of the Fourth Train Proposal may include subsidiary infrastructure such as:

- waste transfer station
- vehicle maintenance workshops
- Administrations and Operations Complex
- offices, crib rooms, toilets, etc.

4.7.2.3 Operational Workforce Accommodation

The operational workforce for the Fourth Train Proposal will be accommodated at existing accommodation on Barrow Island. Operational personnel will rotate on and off Barrow Island and will not permanently reside on the Island. Various operational support personnel for the Fourth Train Proposal will also be required in Perth.

4.7.3 Logistics

Operation of the Fourth Train Proposal will increase the logistics requirement to and from Barrow Island. This requirement will be dictated by two key drivers:

- increase in the requirement for personnel, equipment, infrastructure, and materials
- increase in the generation of waste.

The Fourth Train Proposal will increase the amount of resources required on Barrow Island, including production chemicals (antifoam, corrosion inhibitor, a-MDEA, MEG, etc.), maintenance equipment, and infrastructure, as well as supplies to support the operational workforce. The increase in resources will need additional logistics support to transport this freight to Barrow Island, resulting in more marine vessel and aircraft transport activities to and from Barrow Island.

The operation of the Fourth Train Proposal will also generate additional waste on Barrow Island; some waste streams will need to be transported to the mainland. This reverse logistics requirement may necessitate additional marine vessel voyages from Barrow Island to the mainland. For additional detail on the waste management proposed for the Fourth Train Proposal, refer to Section 5.6.3.

Most of the required equipment, infrastructure, and materials will be transported to Barrow Island using the existing supply base network. On Barrow Island, the Materials Offloading

Facility, WAPET Landing, and the Barrow Island Airport will be the entrance points for shipments to Barrow Island during operation of the Fourth Train Proposal. These logistics entrance points will be serviced by supply bases on the mainland, including Perth and Dampier, as well as international locations for direct shipments.

4.8 Decommissioning Activities

The operational life of the Fourth Train Proposal is expected to be approximately 55 years. The Fourth Train Proposal will be decommissioned when it is no longer economically viable. However, individual equipment may be decommissioned when it is no longer required. Before decommissioning occurs, re-use and recycling alternatives will be considered.

The aim of decommissioning is to leave development areas in an appropriate condition to be returned to Commonwealth or State agencies. It is expected that there will be changes to decommissioning procedures and regulatory requirements that will incorporate advances in technology and information. Therefore, the actual methodology for decommissioning will be determined at the time of decommissioning, taking into account all regulatory requirements and industry standards, relevant safety and environmental issues, economic analysis, and practicability considerations available at that time.

Offshore facilities and infrastructure are to be designed and constructed to allow for complete removal of all structures and components (except flowlines and pipelines) above the sea floor. The decommissioning of offshore facilities is covered under International Maritime Organization resolutions; the *Environment Protection (Sea Dumping) Act 1981* (Cth), which implements the International Maritime Organization's London Convention 1972; and the *Petroleum (Submerged Lands) Act 1973* (Cth). Relevant pipelines will also be covered by the *Petroleum Pipelines Act 1969* (WA) and the *Petroleum (Submerged Lands) Act 1982* (WA), as amended from time to time. The main considerations of these Acts, resolutions, and regulations are that safety of navigation will be ensured; that pollution will be prevented or controlled; and that the environment will continue to be protected.

For activities in Commonwealth jurisdiction, the GJVs are required by Condition 21 of EPBC Reference: 2003/1294 and 2008/4178 to develop a Decommissioning and Closure Plan, and by EPBC Reference: 2005/2184 to develop a Decommissioning Plan. For activities in State jurisdiction, the GJVs are required by the Western Australian Ministerial Conditions to develop a Decommissioning and Closure Plan for the approved Foundation Project prior to decommissioning. It is anticipated that the decommissioning of the Fourth Train Proposal will be managed in accordance with these future plans. The objectives of these decommissioning plans are listed in Table 4-9.

Table 4-9: Objectives of Approved Foundation Project Environmental Management Plans Relevant to Decommissioning

Approval	Environmental Management Plan	Jurisdiction	Objectives of Environmental Management Plan
Condition 21 of EPBC Reference: 2003/1294 and 2008/4178	Decommissioning and Closure Plan	Commonwealth	• No stated objectives
Condition 3, Annexure 1 of EPBC Reference: 2005/2184	Decommissioning Plan	Commonwealth	• Addresses the removal of all structure and components (except flowlines) above the sea floor

Approval	Environmental Management Plan	Jurisdiction	Objectives of Environmental Management Plan
Condition 34 of Ministerial Implementation Statement No. 800	Decommissioning and Closure Plan	State	• Unless otherwise agreed with the Minister, the area occupied by the terrestrial and marine infrastructure facilities is returned to its undisturbed state • Unless otherwise agreed with the Minister, the site does not pose a risk to wildlife or personnel greater than the surrounding undisturbed areas

Refer to Table 16-2 for additional detail on the Foundation Project Environmental Management Plans. The GJVs propose to include areas affected by decommissioning the Fourth Train Proposal in these Plans when they are prepared.

4.9 Design for Predicted Climate Change

The Fourth Train Proposal infrastructure has been designed to suit the current and forecast climatic conditions on Barrow Island and in the surrounding waters, which are expected to occur during the design life of the Fourth Train Proposal, including predicted temperatures, rainfall, and waves. For additional detail on the current and forecast climatic conditions, refer to Section 6.4.10.

A range of design measures are to be implemented to account for the current climate and forecast climate change projections, as outlined below.

4.9.1 Sea Level Rise

In 2013, the Western Australian Planning Commission (WAPC) released the State Planning Policy 2.6: State Coastal Planning Policy (WAPC 2013), which provides guidance for coastal hazard risk management and adaptation. The Policy recognises that climate change will cause a variation in mean sea level, recommending that coastal developments should allow a vertical sea level rise of 0.9 m to 2110.

The Fourth Train Proposal is a brownfield development that has been designed to integrate with the approved Foundation Project, sharing infrastructure and facilities, where practicable. The key onshore components of the Fourth Train Proposal are within the footprint of the approved Foundation Project, except for the Fourth Train Proposal horizontal directional drilling site, which is adjacent to the Foundation Project horizontal directional drilling site (Section 4.4.1). Approved Foundation Project facilities and infrastructure, including the Gas Treatment Plant site, onshore Feed Gas Pipeline System, Materials Offloading Facility, and LNG Jetty, are not predicted to be adversely impacted by the predicted climate change, including sea level rise and storm surge.

The Fourth Train Proposal Gas Treatment Plant is set above 12 m Australian Height Datum (AHD) and is not expected to be affected by a projected sea level rise of 0.9 m. Areas within the onshore component of the Fourth Train Proposal Feed Gas Pipeline System Footprint may be inundated during a high tide if sea levels rose by 0.9 m. However, the onshore Feed Gas Pipeline System will be trenched and stabilised, and is not expected to be affected by inundation.

4.9.2 Extreme Weather Events

Research indicates that Australia is likely to experience more intense cyclones, which may result in an increase of precipitation rates by 20 to 30%, although there is a need for considerable work in this area to provide robust predictions (Commonwealth Scientific and

Industrial Research Organisation [CSIRO] and Bureau of Meteorology [BOM] 2007). More recently, the Indian Ocean Climate Initiative (2012) has undertaken climate modelling for the north-west of Western Australia. This modelling projects a decrease in extreme rainfall events for the Pilbara Region, although these projections should be regarded as initial estimates and not used as part of impact, vulnerability, and risk assessments (Indian Ocean Climate Initiative 2012).

Heavy rainfall associated with more intense extreme weather events may impact on the capacity of the stormwater drainage system at the Fourth Train Proposal Gas Treatment Plant site. The Fourth Train Proposal will use a classed stormwater drainage design system to manage stormwater run-off, consistent with the design used for the approved Foundation Project (Section 5.5.3.7). This drainage system has sufficient capacity to manage potentially contaminated stormwater for a 1-in-100 year Average Recurrence Interval event (384 mm).

Research by the Indian Ocean Climate Initiative (2012) also projects an increase in the proportion of tropical cyclones with a higher wind speed and intensity. Stronger winds from these more intense cyclones could increase wind shear stress on Fourth Train Proposal infrastructure. The Fourth Train Proposal Gas Treatment Plant facilities and infrastructure are to be designed and constructed in accordance with the most current Australian Standards to ensure they withstand appropriate regional wind speeds.

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5. Emissions, Discharges, and Wastes

5.1 Introduction

The construction, commissioning, operation, and decommissioning of the Fourth Train Proposal is expected to generate atmospheric emissions, artificial light, noise and vibration, discharges to land and water, and solid and liquid wastes. Accidental releases—such as spills or leaks of hydrocarbons or chemicals—may also occur. This section outlines the sources, nature, predicted volume, and fate of the emissions, discharges, wastes, and accidental releases from the Fourth Train Proposal.

This section is structured as follows:

- Assessment framework or policy: Outlines the management objective, which is used to assess the environmental acceptability of the Fourth Train Proposal.
- Baseline: Presents the baseline emissions to allow the identification of the incremental emissions that may result from the Fourth Train Proposal only. Where the baseline may vary due to the status of the Foundation Project (e.g. under construction or in the operations phase), the worst-case emissions, discharges, wastes are assumed.
- Assessment of potential impacts: Outlines the predicted emissions, discharges, and wastes from the Fourth Train Proposal and how these compare to the relevant statutory requirements and applicable standards. Note: The impact of these emissions and discharges on environmental factors (e.g. flora, fauna) is not presented in this section. Refer to Sections 9, 10, 13, and 15 for an assessment of emissions, discharges, and wastes on environmental factors.
- Proposed management actions: Discusses how the relevant emissions, discharges, or wastes will be managed.
- Predicted environmental outcome: Determines the predicted environmental outcome for each emission, discharge, or waste.

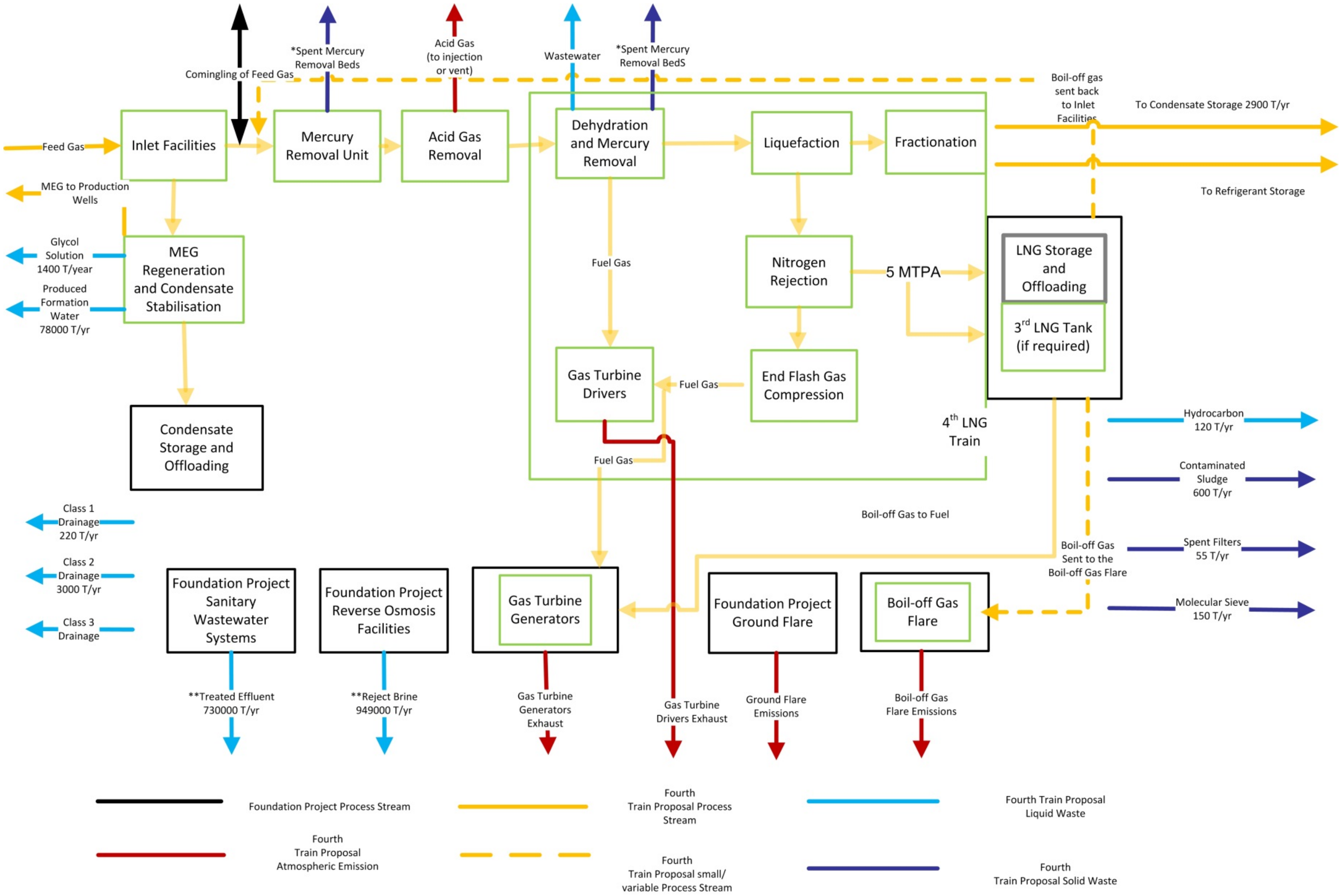
A number of technical studies were conducted to determine the volume of emissions or discharges predicted to result from the implementation of the Fourth Train Proposal, and, where relevant, how those emissions or discharges are predicted to disperse once released. Conservative emission production rates and equipment specifications were used where there was uncertainty in the planning and set-up of the technical studies. This produced reliable and conservative results, which are predicted to be the worst-case scenarios within the range of development concepts being proposed for the Fourth Train Proposal. Where multiple design concepts are included in this PER/Draft EIS, the predicted worst-case emissions, discharges, and wastes are used, or the emissions, discharges, and wastes from each concept are outlined. The technical studies include an outline of the scientific reliability of the studies conducted and conclusions drawn, including the degree of certainty, statistical confidence, assumptions, and limitations of the technical data, and, where appropriate, sources of authority and other information used or needed to make an assessment of the relevant impacts. No peer reviews of the technical studies have been included. Refer to Appendix D [Technical Studies] for copies of the technical studies.

Third-party consultants, who have expertise in the area of investigation, were contracted to conduct the technical studies. Results from the technical studies were compared to relevant legislative and regulatory guidelines, where available. The comparison with the relevant legislation and regulatory guidelines was used to assess if the proposed design measures to manage each emission, discharge, or waste is appropriate. The emissions, discharges, and wastes from the Fourth Train Proposal are included in this section to allow the assessment of the incremental emissions due to the Fourth Train Proposal in addition to the Foundation Project. Note: The management of emissions, discharges, and wastes from the Foundation

Project have not been included in this PER/Draft EIS document, except to assess if the mitigation and management measures approved for the Foundation Project were applicable to the Fourth Train Proposal. The results of the technical studies were also used to identify and assess the potential impacts from the Fourth Train Proposal emissions and spills and leaks, as detailed in Sections 9, 10, 13, 14, and 15 of this PER/Draft EIS, respectively.

Greenhouse gas emissions associated with the Fourth Train Proposal are covered in Section 11.

Most emissions, discharges, and wastes that the GJVs predict to be produced by the Fourth Train Proposal will originate from the Gas Treatment Plant. Figure 5-1 shows the key waste and discharge streams predicted to be produced, including the mass balance of these streams, where practicable to do so. Refer to Section 5.2.3.2 for a quantitative description of the atmospheric emissions.



* The Treated Effluent and Reject Brine discharge volumes are based on the maximum capacity of the respective approved Foundation Project plants
** Approximately 500 tonnes of spent mercury removal beds are predicted to require disposal during a full mercury removal bed change-out, with mercury bed change-outs expected to be required approximately every 4 years.

Figure 5-1: Indicative Process Flow Diagram and Approximate Volumes of Key Waste Streams Produced by the Fourth Train Proposal Gas Treatment Plant Operations

Note: Diffuse emissions, minor discharge and waste streams are not included in Figure 5-1. Refer to Section 5.2.3.2 for a quantitative description of the atmospheric emissions.

5.2 Atmospheric Emissions

5.2.1 Assessment Framework or Policy

5.2.1.1 Environmental Objective

The environmental objective established for atmospheric emissions in this PER/Draft EIS is:

> *To meet statutory requirements and acceptable standards, and thereby avoid or mitigate any adverse effects of atmospheric emissions on environmental values or the health, welfare, and amenity of people and land uses.*

While this section predicts the atmospheric emissions to enable comparison with the relevant statutory requirements and acceptable standards, it does not assess the impact of atmospheric emissions on environmental factors other than air quality. Refer to Sections 9, 10, 13, 14, and 15 for an assessment of atmospheric emissions on other environmental factors (e.g. flora, fauna).

5.2.1.2 Commonwealth Policy

The National Environment Protection Council (NEPC) has determined a number of measures relevant to air quality including:

- National Environment Protection (Ambient Air Quality) Measure (NEPM) (Ambient Air NEPM; NEPC 2003)
- National Environment Protection (Air Toxics) Measure (NEPC 2004).

The measures provide guidelines for levels of target species (including carbon monoxide [CO], nitrogen dioxide [NO_2], sulfur dioxide [SO_2], ozone [O_3] and particulate matter (PM) under 10 µm [PM_{10}] and 2.5 µm [$PM_{2.5}$]), below which air quality is deemed to be acceptable. The Western Australian DER has adopted the NEPM guidelines for application in air quality management. The GJVs have used the Ambient Air NEPM to assess the acceptability of the Fourth Train Proposal atmospheric emissions.

As the Fourth Train Proposal workforce will be accommodated on Barrow Island, relatively close (approximately 3 km) to the Gas Treatment Plant, residential-based impact assessment criteria for the air toxics emitted from the Gas Treatment Plant have been applied to air quality at Butler Park (Construction Village). These criteria are sourced from the New South Wales (NSW) DEC's Approved Methods for Modelling and Assessment of Air Pollutants in New South Wales (NSW DEC 2005).

The Fourth Train Proposal workforce will operate close to the Gas Treatment Plant, including within the Gas Treatment Plant, the Administration and Operations Complex, and the Materials Offloading Facility. Therefore, the occupational exposure air quality measures/guidelines documented in the National Exposure Standards (National Occupational Health and Safety Commission [NOHSC]: 1003–1995; as amended – Safe Work Australia [SWA] 1995) are also relevant to the assessment of the Fourth Train Proposal.

5.2.1.3 Western Australian State Policy

5.2.1.3.1 Department of Environment Guidelines – Ambient Air Quality Guidelines

The Ambient Air Quality Guidelines (Department of Environment [DoE] 2004) outline the relevant standards used by DER for the assessment of the impacts of atmospheric emissions. Under these Guidelines, proposals are required to demonstrate compliance with:

- the NEPM for Ambient Air Quality (NEPC 2003, 2004)
- in the absence of an NEPM standard, the World Health Organization (WHO) Guidelines for Air Quality (WHO 2000), with appropriate amendments to suit the Western Australian context

- in the absence of an NEPM standard or WHO guideline, criteria from another jurisdiction (once they have been assessed by DER and found to be applicable to the Western Australian context).

The WHO Guidelines (WHO 2000) were used to assess the acceptability and environmental impacts due to acid deposition from the Fourth Train Proposal, as there are no relevant NEPM standards for acid deposition.

5.2.1.3.2 Department of Environment Guidelines – Air Quality Modelling Guidance Notes

The Air Quality Modelling Guidance Notes (DoE 2006) clearly state the expectations with respect to air quality modelling and associated meteorological monitoring and/or modelling. Specifically, these Guidance Notes require:

- ‘identification and quantification of emissions to the atmosphere that have the potential for non-trivial impact on the environment
- for those primary and secondary target species that cannot be dismissed as being of no significance, the proponent must provide model predictions of the impact of emissions on the various elements of the environment, in the form of concentrations and/or rates of deposition over the range of averaging periods normally associated with relevant standards for each target species, and assess the magnitude of this impact against the relevant standards
- inputs into the model (emissions estimates, background concentrations etc.) and model capability should contain sufficient detail to render the model accurate, incorporating considerations outlined in this Guideline
- presentation of modelling results in the prescribed form and with reference to appropriate standards as outlined in this Guideline.’

The air quality modelling study—Appendix D1 [Gorgon Gas Development Fourth Train Proposal Air Quality Assessment]—has been prepared in compliance with the above Air Quality Modelling Guidance Notes.

5.2.2 Baseline Ambient Air Quality

The baseline air quality is the air quality that will exist on or near Barrow Island when activities of the Fourth Train Proposal commence, and is a result of a combination of natural and artificial atmospheric emissions sources. Natural emissions sources are predicted to have a minor impact on the local ambient air quality, but may affect the regional air quality more substantially (e.g. as a result of bushfires in the Pilbara Region). Natural emissions sources include:

- bushfires
- vegetation, producing terpenes
- soils, producing oxides of nitrogen (NO_X) and mercury (Hg).

For a more comprehensive account of the natural emissions sources, refer to Appendix D1 [Gorgon Gas Development Fourth Train Proposal Air Quality Assessment].

Artificial emissions sources also impact the ambient air quality on Barrow Island. These artificial sources are predicted to dominate the baseline ambient air quality for the Fourth Train Proposal. The baseline ambient air quality on Barrow Island is expected to be influenced by:

- WA Oil operations
- Foundation Project construction and/or operations.

The Foundation Project may still be under construction when the Fourth Train Proposal construction commences. To assess the worst-case atmospheric emissions, it has been assumed for the modelling that the entire approved Foundation Project is operational.

In addition, the regional baseline ambient air quality is expected to be influenced by additional emissions sources, including:

- North West Shelf Venture Karratha Gas Plant
- Pluto Gas Plant
- Hamersley Iron Power Station at Parker Point near Dampier
- Yara Pilbara Fertiliser Ammonia Plant (previously known as the Burrup Fertiliser Plant)
- regional shipping emissions
- power stations in the Pilbara Region such as at Dampier and Karratha
- emissions from residential sources (e.g. service stations, dry cleaning).

For a more comprehensive account of the regional baseline atmospheric emissions sources, refer to Appendix D1 Section 2.3 [Gorgon Gas Development Fourth Train Proposal Air Quality Assessment].

Quantification of the baseline ambient air quality at Barrow Island and within the wider Pilbara Region is detailed in the atmospheric pollutant air quality modelling study (Section 5.2.3.4.1).

In addition to the above, baseline Hg concentrations are expected to be influenced by the operational Foundation Project, primarily from the monoethylene glycol (MEG) system. Influence from other anthropogenic sources of Hg are predicted to be minimal due to the isolated location of Barrow Island. Worst-case baseline Hg concentrations on Barrow Island are predicted to be very low, estimated at less than 0.0023 $\mu g/m^3$ (annual average) at the Gas Treatment Plant site, and decreasing with distance away from the source. These concentrations represent less than 1.2% of the WHO Guideline (2003) for atmospheric Hg concentration, which is 0.2 $\mu g/m^3$. The Hg in ambient air quality is predicted to produce levels of Hg deposition that are comparable to levels commonly found on continental land masses around the world.

5.2.3 Assessment of Potential Impacts

Atmospheric emissions have the potential to alter ambient air quality and potentially impact environmental values or the health, welfare, and amenity of people and land uses. A qualitative and quantitative assessment of the predicted emissions from the Fourth Train Proposal was conducted and is included below.

5.2.3.1 Atmospheric Emissions from Construction Activities

Atmospheric emissions—consisting of key pollutants such as oxides of nitrogen (NO_X), oxides of sulfur (SO_X), CO, PM_{10}, and $PM_{2.5}$—will be produced during the construction of the Fourth Train Proposal.

Offshore construction activities associated with the Fourth Train Proposal are expected to generate atmospheric emissions including:

- engine exhaust, from sources such as:
  - drilling rigs
  - pipe-lay barges
  - heavy lift vessels
  - supply and support vessels

  - tugs
  - accommodation vessels
  - helicopters
- flaring from drilling rigs
- leaks of ozone depleting substances.

Ozone depleting substances (ODSs) are synthetic gases including halons, chlorofluorocarbons (CFCs), and hydrochlorofluorocarbons (HCFCs). Any emission of ODSs has the potential to contribute to the degradation of the Earth's stratospheric ozone layer.

Although not specifically generated by the Fourth Train Proposal, ODSs may already be integrated into older marine vessel systems. No routine emission of ODSs is expected.

Atmospheric emissions in the Commonwealth Marine Area are expected to result from a number of Fourth Train Proposal activities; the key activities are expected to be marine vessel and helicopter engine exhausts, and flaring. Emissions from marine vessel and helicopter engine exhausts will also be generated over State Waters, adjacent to the Commonwealth Marine Area. The emissions from vessel engine exhausts are transitory and expected to be minor. Flaring during well clean-up is expected to be short term. Emissions factors for SO_2 and NO_2 were derived from published sources (Institute of Petroleum 2000). Table 5-1 lists the predicted atmospheric emissions in the Commonwealth Marine Area.

Table 5-1: Approximate Atmospheric Pollutant Emissions Predicted to Occur in the Commonwealth Marine Area due to Construction of the Fourth Train Proposal

Activity	SO_2 (tonnes)	NO_X (tonnes)
Feed Gas Pipeline System construction (State Waters)	100	493
Feed Gas Pipeline System construction (Commonwealth Marine Area)*	830	4078
Drilling and completions**	700	3400
Well clean-up**	1	40

** SO_2 and NO_X produced during offshore construction*

*** SO_2 and NO_X produced during drilling, completions, and well clean-up for approximately 16 wells*

A well testing program with flaring of all produced fluids of approximately 24 hours is expected to occur for each well, following on from the basic clean-up requirements.

Onshore construction activities for the Fourth Train Proposal will also generate atmospheric emissions, including those from sources such as:

- power generation, either from the Foundation Project Gas Turbine Generators or temporary diesel power generators
- vehicle, equipment, and plant exhaust
- tank and storage vessel fugitive emissions
- aircraft movements.

There will be an increase in emissions from the increased number of aircraft flights to and from Barrow Island, and from vehicles and equipment required to support the extended construction period on Barrow Island for the Fourth Train Proposal, over and above the approved Foundation Project.

The volume and duration of the emissions from the marine vessels used during construction, the additional air traffic to Barrow Island, and the increased number of construction vehicles and equipment will not be significant compared to emissions levels expected during the operations phase. Furthermore, the construction emissions will not be concentrated in a single location for an extended period.

5.2.3.2 Atmospheric Emissions from Operational Activities

No significant atmospheric emissions are predicted to occur offshore during routine operations of the Fourth Train Proposal. This is the result of using subsea infrastructure instead of a gas processing platform. Atmospheric emissions will be produced during the operations phase as a result of marine activities such as the maintenance of subsea infrastructure (e.g. well workovers), with emissions generated from sources such as marine vessel and helicopter exhausts. The atmospheric emissions produced offshore are expected to be from similar sources to those produced during construction, but in smaller quantities.

Atmospheric emissions will also be produced during the operations phase of the Fourth Train Proposal Gas Treatment Plant. The major emissions sources can be divided into two broad categories:

- combustion equipment
- process waste emission sources.

Combustion equipment generally burns homogenous fuel sources and results in predictable atmospheric emissions. Combustion equipment that will produce significant emissions includes:

- Gas Turbine Generators
- Gas Turbine Drivers.

Process waste emissions occur where gas and other hydrocarbons are disposed of either by burning in a flare or venting to the atmosphere. Process waste emissions may occur due to upset situations where the gas may need to be disposed of to prevent over pressurising equipment, or due to other operational requirements. Key facilities that will produce process waste emissions during the operation of the Fourth Train Proposal include:

- Foundation Project Ground Flares (which will be used to flare hydrocarbons from the Fourth Train Proposal)
- Boil-off Gas Flares (including Foundation Project flares and an additional Fourth Train Proposal flare, if required)
- Acid Gas Vents of the Fourth Train Proposal.

5.2.3.2.1 Atmospheric Emission Types

The key atmospheric pollutants and air toxics considered in this PER/Draft EIS include:

- nitrogen dioxide, as the representative pollutant for nitrogen oxides (NO_X), which is a generic term for the mono-nitrogen oxides, i.e. nitric oxide (NO) and NO_2
- PM_{10}, a fraction of particulate matter with an aerodynamic diameter of less than 10 microns
- $PM_{2.5}$, a fraction of particulate matter with an aerodynamic diameter of less than 2.5 microns
- SO_2, as the representative pollutant for sulfur oxides (SO_x), which include also sulfur monoxide (SO), sulfur trioxide (SO_3), and other combinations of sulfur and oxygen
- non-methane Volatile Organic Compounds (NMVOCs), including aliphatic hydrocarbons (propane and longer straight chain hydrocarbons) and aromatic hydrocarbons such as benzene, toluene, ethylbenzene and xylene—collectively known as BTEX—as well as polyaromatic hydrocarbons (PAH) and formaldehyde
- carbon monoxide

- hydrogen sulfide (H_2S)
- ozone, as a secondary pollutant, resulting from the interaction between NOX, volatile organic compounds (VOCs), and naturally occurring oxygen.

Other atmospheric pollutant and air toxics emissions were considered on a review of the equipment emission factors included in the National Pollutant Inventory (NPI) Emissions Estimation Technique Manual (NPI 2002). Additional justification was taken from emissions reporting by other LNG Plant Operators (e.g. Woodside) on the NPI website. These reported emissions were used as an example of typical gas treatment plant emissions to determine the atmospheric pollutant and air toxic emissions rates. These typical but minor atmospheric pollutants and air toxics are listed in Table 5-2. The chemicals listed in Table 5-2 were excluded from the scope of this PER/Draft EIS as they are considered to be trivial emissions during the start-up, commissioning, and operation of the Gas Treatment Plant.

Table 5-2: Out of Scope Atmospheric Pollutants and Air Toxics

Atmospheric Pollutants and Air Toxics	Typical Emission Sources	Justification for Exclusion
Acetaldehyde	Natural gas-fired stationary gas turbines and diesel engines	Released in very low quantities and below the NPI Category 1 reporting threshold of 10 tonnes per year (SEWPaC 2012; DoE 2010). For example, Woodside Energy's NPI report 2011–12 for the Karratha Gas Plant did not include any emissions of acetaldehyde (NPI 2013).
Fluoride	Natural gas-fired stationary gas turbines and diesel engines	Released in very low quantities and below the NPI Category 1 reporting threshold of 10 tonnes per year (SEWPaC 2012; DoE 2010). For example, Woodside Energy's NPI report 2011–2012 for the Karratha Gas Plant did not include any emissions of fluoride (NPI 2013).
Formaldehyde	Natural gas-fired stationary gas turbines and diesel engines	Released in low quantities and below the NPI Category 1 reporting threshold of 10 tonnes per year (SEWPaC 2012; DoE 2010). For example, Woodside Energy's NPI report 2011–2012 for the Karratha Gas Plant did not include any emissions of formaldehyde (NPI 2013).
Heavy metals (except mercury)	Natural gas-fired stationary gas turbines, flares and diesel engines	Released in very low quantities and below the NPI Category 1 reporting threshold of 10 tonnes per year for most heavy metals (SEWPaC 2012; DoE 2010). For example, Woodside Energy's NPI report 2011–2012 for the Karratha Gas Plant indicates the total amount of heavy metals (including arsenic, beryllium, cadmium, chromium, copper, lead, mercury and nickel) released was 164 kg per year (NPI 2013).
Polyaromatic hydrocarbons (PAHs)	Natural gas-fired stationary gas turbines, flares, and diesel engines	Requires reporting based on NPI Category 2a and 2b reporting thresholds (SEWPaC 2012; DoE 2010). However, PAHs are expected to be released in very low quantities. For example, Woodside Energy's NPI report 2011–2012 for the Karratha Gas Plant indicates the release of 0.2 kg of PAHs (NPI 2013).
Polychlorinated dioxins and furans	Natural gas-fired stationary gas	Requires reporting based on NPI Category 2b reporting thresholds (SEWPaC 2012; DoE 2010).

Atmospheric Pollutants and Air Toxics	Typical Emission Sources	Justification for Exclusion
	turbines and diesel engines	However, these are expected to be released in very low quantities. Woodside Energy's NPI report 2011–2012 for the Karratha Gas Plant indicates the release of 0.00000038 kg of dioxins and furans (NPI 2013).

Table 5-3 lists the key atmospheric emissions that are predicted to result from the operation of the Fourth Train Proposal Gas Treatment Plant.

Table 5-3: Key Atmospheric Emissions Expected to be Generated from the Fourth Train Proposal Gas Treatment Plant

Gas Treatment Plant Emissions Sources	Associated Atmospheric Emissions
Gas Turbine Generators	NO_X, SO_2, NMVOCs, CO
Gas Turbine Drivers	NO_X, SO_2, NMVOCs, CO
Heating Medium Heaters	NO_X, SO_2, NMVOCs, CO
Diesel Power Generators	NO_X, SO_2, NMVOCs, CO
Ground Flares	NO_X, SO_2, NMVOCs, CO
Boil-off Gas Flares	NO_X, SO_2, NMVOCs, CO
Acid Gas Vents	NMVOCs, H_2S

Note: The GJVs predict that fugitive emissions will account for only a small portion (approximately 0.7%) of the total emissions generated by the Fourth Train Proposal Gas Treatment Plant. Therefore, the GJVs do not consider that fugitive emissions will be a significant emissions source.

5.2.3.2.2 Routine Operations

The atmospheric emissions will alter during different operational states of the Fourth Train Proposal. Routine operation of the Fourth Train Proposal occurs when the operating process is in a steady state, with stable operation of the Feed Gas Pipeline System, fourth LNG train, and associated utilities. During routine operations, atmospheric emissions from combustion equipment are expected to be the dominant emissions source.

Atmospheric emissions from process waste emission sources are expected to be limited during routine operations, due to the Fourth Train Proposal Gas Treatment Plant design incorporating 'no routine flaring' or venting of hydrocarbons, and reduced acid gas venting due to carbon dioxide (CO_2) injection.

'No routine flaring' will limit the continuous flaring of process hydrocarbon gas to only the amount required for the safe operation of the flare system (i.e. flare pilots and purge gas) and plant equipment (e.g. small flows from equipment purges, which are not practicable to collect) during routine operations. Table 5-4 lists the emissions predicted to occur during routine operations.

Table 5-4: Inventory of Atmospheric Emissions from Routine Operations of the Fourth Train Proposal (tonnes/year) per Emission Source

	PM	SO_X	NO_X	CO	H_2S	NMVOC	Total
Heating Medium Heaters	4	<1	66	40	<1	2	**112**
Routine Flaring	0	0	7	39	0	6	**52**

	PM	SO_X	NO_X	CO	H_2S	NMVOC	Total
Non-routine Flaring	0	0	2	13	0	<1	**15**
Gas Turbine Drivers	46	<1	690	105	<1	49	**890**
Gas Turbine Generators	37	<1	558	84	<1	21	**700**
Acid Gas Venting	0	0	0	0	34	450	**484**
Condensate Tanks	0	0	0	0	0	<1	**<1**
Condensate Loading	0	0	0	0	<1	966	**966**
Diesel Tanks	0	0	0	0	0	<1	**<1**
Diesel Consumption	2	<1	76	19	<1	2	**99**
Fugitive Emissions	0	0	0	0	0	24	**24**
Total	**89**	**<1**	**1399**	**300**	**34**	**1520**	**3342**

Note: Acid gas venting is based on venting 20% of the maximum annual average reservoir CO_2 and 80% being injected (over a five-year rolling average). The calculations are based on the Fourth Train Proposal known gas resources at the time of submission of the PER/Draft EIS.

5.2.3.2.3 Non-routine Operations

During non-routine operations, atmospheric emissions are expected to be greater than during routine operations. This increase is a result of additional emissions sources including flaring and reservoir CO_2 venting.

Flaring

Flaring will occur through the Ground Flares and Boil-off Gas Flare installed as part of the Foundation Project; an additional Boil-off Gas Flare may be installed as part of the Fourth Train Proposal. It is expected that the fourth LNG train will require an incremental increase in the frequency or duration of flaring events over the Foundation Project events. The incremental flaring required for the Fourth Train Proposal is expected to be approximately 30% of the flaring required for the Foundation Project. This incremental increase in flaring is due to planned maintenance and unplanned equipment failure of the additional infrastructure installed for the Fourth Train Proposal. The rates of flaring are conservatively predicted to be approximately proportional to the increase in infrastructure associated with the Fourth Train Proposal compared to the Foundation Project. However, the flaring due to the Fourth Train Proposal is expected to be less than proportional due to the operational lessons learnt from the approved Foundation Project.

The approved Foundation Project Ground Flares are designed for smokeless operation. It is predicted that the Ground Flares will operate smokeless almost 100% of the time, except when both the wet and dry components of the Ground Flares are operating at 100% of its capacity. This could lead to smoke emissions due to insufficient air flow and mixing with the flare boxes. However, this scenario is expected to occur at a frequency of 9.04×10^{-6}/ year, which makes it a very rare event.

Flaring may occur due to failure of certain equipment, without any impact on LNG production. During a typical operating year for the Fourth Train Proposal, non-routine flaring resulting from failure of these non-critical items has been estimated to occur for approximately 50 hours for the Ground Flares. It is also expected that the frequency and duration of non-routine flaring events would reduce over time as plant operating knowledge builds up and plant performance and efficiency improve. Boil-off Gas flaring is predicted to occur for approximately 390 hours per year for the Fourth Train Proposal and approved Foundation Project. Of this flaring, approximately 100 hours per year is predicted to be due to the Fourth Train Proposal.

Unplanned emergency shutdowns of the Fourth Train Proposal Gas Treatment Plant are anticipated to occur fewer than four times in the first year of operation and involve less than one hour of non-routine flaring, reducing to two events per year over the subsequent years. In addition to these events, there are other process upset events that could result in non-routine flaring, but not necessarily in shutdowns.

The construction of the Fourth Train Proposal may require portions of the Foundation Project to be shut down to allow construction work to occur. This may result in a temporary increase to the flaring from the Foundation Project as its equipment is depressurised to allow for safe construction of the Fourth Train Proposal.

A black start is expected to occur when the Gas Treatment Plant, including both the Fourth Train Proposal and approved Foundation Project, have been offline and require a full restart. This may occur if an unusually strong cyclone, or earthquake, tsunami, or any other unplanned event disrupts the gas supply to the Gas Turbine Generators and as a result the Gas Treatment Plant is shut down for an extended duration. During a black start, the Gas Treatment Plant is started up sequentially, with the entire process expected to take approximately eight days to complete. For additional detail on the black start scenario, refer to Appendix D1, Section 2.2.4 [Gorgon Gas Development Fourth Train Proposal Air Quality Assessment]. Cyclone preparedness may also result in reduction of Fourth Train Proposal Gas Treatment Plant throughput, or in a partial or complete shutdown and some or full plant inventory evacuation to the flare, depending on the expected severity of the cyclone. Note: The Gas Treatment Plant is designed to operate during a cyclone so a black start should only be a one in a five- to ten-year event.

Venting

Reservoir carbon dioxide injection is expected to reduce acid gas venting to non-routine situations, resulting in less frequent emissions of air toxics including Hg, H_2S and NMVOCs.

These air toxics will be removed in the Acid Gas Removal Unit and injected with the reservoir CO_2, which is predicted to be approximately 99.7 mol % of the acid gas. Venting of acid gases will be required during commissioning, periods of maintenance and equipment downtime associated with the injection equipment, or for reservoir constraints, as outlined below. A number of operational events associated with the Foundation Project Carbon Dioxide Injection System may result in non-routine venting from the Fourth Train Proposal, including planned and unplanned events. Planned events include:

- CO_2 injection compressor maintenance; single compressor maintenance activity is forecast to occur once every two years, for up to four days each time
- CO_2 pipeline inspection/maintenance, which is expected to occur once every five years from start-up of the pipeline. Hundred percent of the CO_2 removed during this time may be vented.

Unplanned events may include:

- process trip of a CO_2 injection compressor, which may occur approximately two to three times a year
- low flow rates into the compressors due to loss of Gorgon feed gas or other high CO_2 feed gas (Note: Gorgon feed gas can affect the Fourth Train Proposal due to commingled feed gas). This may require the CO_2 injection compressors to be shut down, thus venting the CO_2
- shutdown of the CO_2 injection compressors due to extreme weather events (e.g. high wind speeds).

A number of acid gas venting scenarios were identified for the Fourth Train Proposal. However, five were identified as either the most frequently occurring, or the most onerous in terms of acid gas venting rates, or both. These include:

- CO_2 injection compressor unavailability due to planned maintenance or a process trip condition
- high back-pressure from CO_2 wells or single well unavailability due to well workover resulting in high suction pressure to the compressor
- high back-pressure from CO_2 wells resulting in high suction pressure to the compressor, with unavailability of all four wells at a drill centre
- CO_2 injection compressor venting during start-up to meet pipeline specifications
- MEG compressor trip.

Refer to Section 11 for additional detail on CO_2 injection and venting.

When the CO_2 injection system is unavailable or when the MEG flash gas vapour is tripped, Hg containing MEG flash gas vapour is vented from the MEG Regeneration Unit. The Fourth Train Proposal gas fields are lower in Hg concentrations than the Foundation Project gas fields, therefore the overall concentration of Hg entering the Gas Treatment Plant is predicted to decrease as a result of the development of the Fourth Train Proposal gas fields. Thus, only a negligible incremental increase in Hg emissions is expected to occur as a result of the Fourth Train Proposal. Hg emissions are predicted to increase by approximately 6% over the emissions produced by the Foundation Project. As the incremental increase in the Hg emissions due to the Fourth Train Proposal is only marginal, no material increase in Hg in ambient air or Hg deposition on Barrow Island is predicted as a result of the Fourth Train Proposal.

LNG Shipping

Minor hydrocarbon emissions will be generated during condensate ship loading. Boil-off gas flaring may result from LNG vessels, including during purging or cooling down the vessels, prior to loading at the LNG Jetty. It is expected that most LNG vessels will retain some LNG to ensure that the ships' tanks remain cool. However, in some circumstances a warm LNG vessel may berth at Barrow Island and require cool down, or purge and cool down. It is predicted that approximately four warm LNG vessels per year will be received at Barrow Island in support of the Fourth Train Proposal. The Fourth Train Proposal in addition to the approved Foundation Project is predicted to receive approximately 16 warm LNG vessels per year. During the LNG vessel cooling and/or loading process, warm boil-off gas will be routed back into treatment process with the Gas Treatment Plant. However, if the amount of boil-off gas is too large to be recovered by the Boil-off Gas Compressors, or the Boil-off Gas Compressors are not operational, or the ship contains inert gases that cannot be routed back into the treatment process, the boil-off gas will have to be flared to control the ship's tank pressure. The contribution of warm LNG marine vessels is included in the predicted Boil-off Gas Flaring events described above.

Commissioning

During commissioning of the Fourth Train Proposal, atmospheric emissions will be produced, with most being emitted from the Gas Treatment Plant. The emissions are predicted to be similar to the Fourth Train Proposal operations phase emissions. The incremental atmospheric emissions resulting from the commissioning of the Fourth Train Proposal are expected to be less than those produced during the Foundation Project commissioning activities due to improved operational understanding of the Gas Treatment Plant by the time the Fourth Train Proposal is commissioned, and the smaller scale of the Fourth Train Proposal compared to the Foundation Project (one LNG train compared to three).

The dominant atmospheric emissions source during commissioning is predicted to be flaring; prolonged flaring is expected as sections of the Fourth Train Proposal are progressively commissioned.

Minor atmospheric emissions are expected from the commissioning of the Fourth Train Proposal, including nitrogen used to purge pipes and vessels and/or fill vessels with an inert material. As during commissioning, nitrogen will also be used to purge equipment during operations and maintenance and may be emitted to the atmosphere.

Flaring during commissioning will be limited by appropriate design and control of commissioning procedures; these are expected to be largely based on the commissioning of the Foundation Project. Lessons learnt during the commissioning of the Foundation Project will be applied during the commissioning of the Fourth Train Proposal, further limiting flaring.

5.2.3.3 Atmospheric Modelling Studies Methodology

Two atmospheric modelling studies were conducted to assess the impacts of emissions from the operation of the Fourth Train Proposal Gas Treatment Plant on ambient air quality:

- Air Quality Assessment of atmospheric pollutants (Appendix D1 [Gorgon Gas Development Fourth Train Proposal Air Quality Assessment])
- Acid Gas Vent Dispersion Modelling of air toxics (Appendix D2 [Gorgon Expansion Project Phase 2 Acid Gas Vent Dispersion Modelling])

These studies modelled different atmospheric emissions from the operation of the Fourth Train Proposal. The use of different models was required due to the varying characteristics of the emission plumes. Both studies were based on commingled feed gas with the Foundation Project.

The atmospheric pollutant Air Quality Assessment was conducted on a local scale, within approximately 10 km of the Gas Treatment Plant, and on a regional scale, including the northern Pilbara Region, to predict the ground-level concentrations of relevant atmospheric pollutants. Table 5-5 lists the local and regional modelling scenarios and the atmospheric pollutants relevant to the study. Note: The black start scenario was predicted to be the worst case of the non-routine scenarios modelled; therefore, no results relating to the other modelled scenarios are presented in this PER/Draft EIS.

Table 5-5: Atmospheric Pollutant Air Quality Modelling Scenarios and Relevant Atmospheric Pollutants Studied for the Fourth Train Proposal

Modelling Scale	Atmospheric Pollutant	Scenario
Local	CO SO_2 NO_2 PM_{10} $PM_{2.5}$	Routine Operations – Four LNG trains operating with one Acid Gas Removal Unit venting
		Non-routine Operations – Four LNG trains are starting up sequentially during a black start
Regional	NO_2	Routine Operations – Four LNG trains operating with one Acid Gas Removal Unit venting
	O_3	Non-routine Operations – Four LNG trains are starting up sequentially during a black start

Note: Background scenarios were also conducted to determine the impact of the Fourth Train Proposal on baseline ambient air quality

Venting from Acid Gas Removal Units is not predicted to occur during routine operations; however, at least 80% of the reservoir CO_2 (as a five-year rolling average) is required to be injected, which equates to approximately one acid gas vent operating (1:4 or 25% of the time). Therefore, one acid gas vent operating was included in the routine operations scenario to represent the worst-case for the ‘routine operations’ scenario. Section 5.2.3.2 outlines the operational circumstances where acid gas venting may occur.

The atmospheric pollutant air quality modelling study also included acid deposition for the deposition of nitrogen and sulfur compounds on Barrow Island and at Coral Bay, to assess the regional impacts of acid deposition.

Fugitive emissions are predicted to account for approximately 0.7% of the atmospheric emissions, as shown in Table 5-4; therefore, fugitive emissions were not included in the atmospheric pollutant air quality modelling study.

Appendix D1 [Gorgon Gas Development Fourth Train Proposal Air Quality Assessment] outlines the inputs, assumptions, and methodology used in the study, including predicted emission rates. Refer to Appendix D1 [Gorgon Gas Development Fourth Train Proposal Air Quality Assessment – Section 5, Model Validation against Meteorology] for a description of the verification of the weather predictions (e.g. temperature, wind speed, wind direction, humidity, and rainfall) used in the atmospheric pollutant air quality modelling study.

The Acid Gas Vent Dispersion Modelling study investigated acid gas venting for a range of air toxics in the scenarios listed in Table 5-6.

Table 5-6: Air Toxics Pollutant Dispersion Modelling Scenarios and Relevant Atmospheric Pollutants Studied for the Fourth Train Proposal

Air Toxics	Scenario
H_2S Benzene, toluene, ethylbenzene, and xylene compounds (BTEX)	Venting from the Fourth Train Proposal Acid Gas Removal Unit
	Simultaneous venting from four Acid Gas Removal Units (Fourth Train Proposal in addition to Foundation Project)

Note: WA Oil air toxics emissions were not included in the Acid Gas Venting Dispersion Modelling as WA Oil is a minor emitter of air toxics, including BTEX, as shown in Table 5-7.

Table 5-7: Comparison of Air Toxics (BTEX) Emissions

Air Toxics	Annual Emissions (tonnes)	
	WA Oil [1]	Fourth Train Proposal in addition to the approved Foundation Project [2]
Benzene	2.50	~150.00
Toluene	1.40	~350.00
Ethylbenzene	0.12	~2.00
Xylenes	0.35	~110.00

[1] WA Oil figures are from data presented for the most recent National Pollutant Inventory reporting period (2009–2010) available from: http://www.npi.gov.au/npidata/action/load/emission-by-individual-facility-result/criteria/state/null/year/2010/jurisdiction-facility/WA0014.

[2] Predicted Foundation Project and Fourth Train Proposal BTEX emissions reflect anticipated emissions due to acid gas venting.

Appendix D2 [Gorgon Gas Expansion Project Phase 2 Acid Gas Vent Dispersion Modelling] outlines the inputs, assumptions, and methodology used in the study.

5.2.3.4 Atmospheric Modelling Results

5.2.3.4.1 Atmospheric Pollutant Air Quality Modelling Study Results

The atmospheric pollutant air quality modelling study conducted on the operation of the Fourth Train Proposal Gas Treatment Plant predicted the dispersion of atmospheric pollutants and the resultant ambient air quality. The results were presented over the relevant averaging period to allow comparison to the Ambient Air NEPM.

The results of the atmospheric pollutant air quality modelling study are summarised in Table 5-8, with a comparison of the relevant criteria from the Ambient Air NEPM.

The modelled regional ambient concentrations of ozone (O_3), which represents the highest percentage comparison of a modelled scenario against the Ambient Air NEPM, are shown in Figure 5-2.

The atmospheric pollutant air quality modelling study also predicted acid deposition from the Fourth Train Proposal and other regional sources. During routine operations with the Fourth Train Proposal Acid Gas Removal Unit venting, the cumulative maximum predicted sulfur and nitrogen deposition loads are shown in Table 5-9.

Appendix D1 [Gorgon Gas Development Fourth Train Proposal Air Quality Assessment] provides additional detail on the atmospheric pollutant air quality modelling study inputs, assumptions, and results.

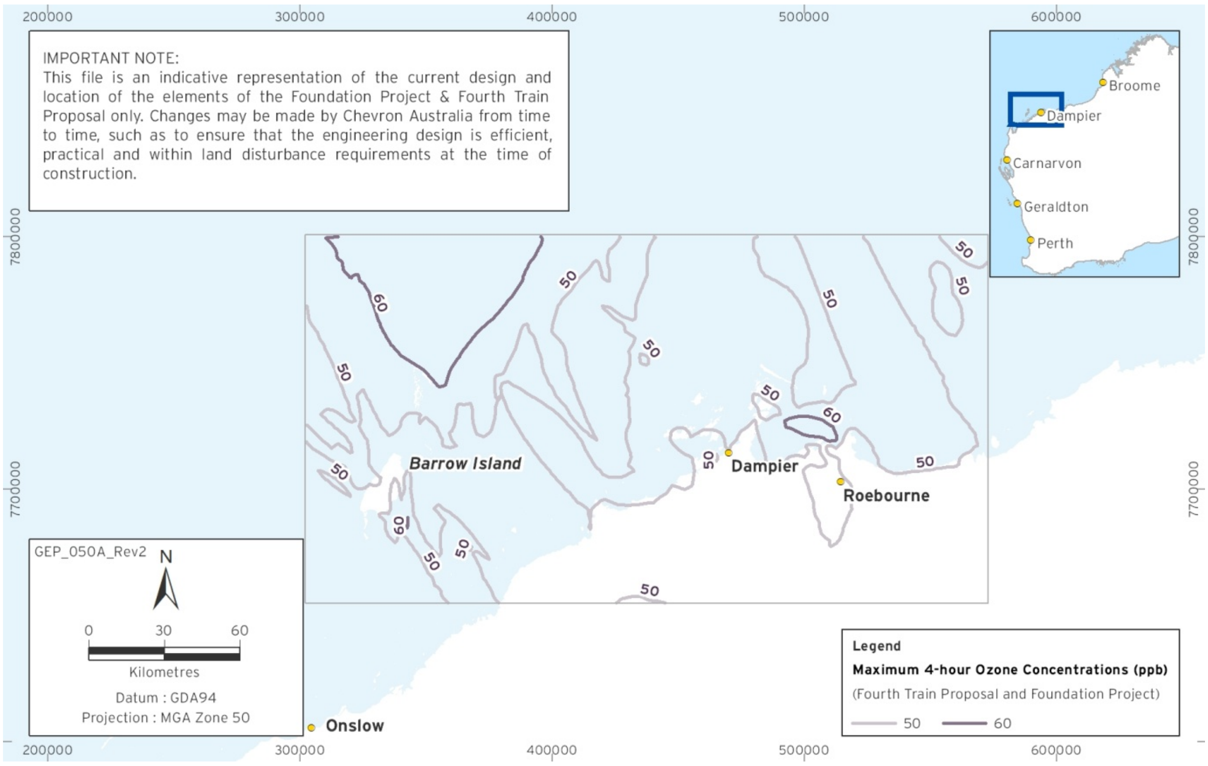


Figure 5-2: Predicted Maximum 4-hour Ozone Concentrations (ppb) including the Fourth Train Proposal and Foundation Project under Routine Operations

Table 5-8: Predicted Maximum Ground-level Concentrations for the Fourth Train Proposal and their Comparison to the Ambient Air NEPM

Pollutant	Averaging Period	Units	Ambient Air NEPM Criteria	Baseline (including Foundation Project)	Fourth Train Proposal (including Baseline)		
					Routine Operations	Difference in Fourth Train Proposal and Foundation Project Routine Operations	Black Start
Local Scale Modelling							
CO	8-hour	ppb	9000	467	467	0	466 [1]
NO_2	1-hour 1-year	ppb ppb	120 30	65 27	65 27	0 0	65 27
SO_2	1-hour 24-hour 1-year	ppb ppb ppb	200 80 20	24 4.2 0.13	24 4.2 0.13	0 0 0	24 4.2 NA
PM_{10}	1-day	$\mu g/m^3$	50	32.4	32.4	0	32.4
$PM_{2.5}$	1-day 1-year	$\mu g/m^3$ $\mu g/m^3$	25 8	11.4 6.9	11.4 6.9	0	11.4 6.9
Regional Scale Modelling							
NO_2	1-hour 1-year	ppb ppb	120 30	48.5 9.5	49.6 9.8	1.1 0.3	48.8 9.8
O_3	1-hour 4-hours	ppb ppb	100 80	84 70	81 69	-3 [2] -1 [2]	75 70

Note:

1. *This improvement in air quality occurs as the black start case makes a smaller contribution to the air emissions than the normal Fourth Train Proposal scenarios.*
2. *This improvement (reduction in ground-level concentration) is due to the additional NO_X from the Fourth Train contributing to increase the NO_2 concentrations, but decreasing the O_3 concentrations as there are no additional VOCs emitted (i.e. the formation of O_3 as a secondary pollutant depends on the availability of both NO_X and VOCs).*
3. *The predicted maximum local concentration of pollutants is dominated by existing/background sources, with both the Foundation Project and the Fourth Train Proposal emissions being only minor contributors on the local scale; hence the difference in predicted pollutant levels between the Baseline (including the Foundation Project) and the Fourth Train Proposal can only be gauged at a regional scale.*
4. *The black start emissions are dominated by flaring. Flaring produces a very buoyant plume that has no impact on the local scale modelling, but is measurable at the regional scale.*

Table 5-9: Sulfur and Nitrogen Deposition Loads Due to the Fourth Train Proposal and other Regional Sources

Acid Type	Units	WHO Guidelines Criteria	Location	Deposition Rate
Sulfur	kg/ha/year	4 to 8	Barrow Island Coral Bay	0.32 0.29
Nitrogen	kg/ha/year	15 to 20	Barrow Island Coral Bay	0.97 0.93

Source: WHO 2000

5.2.3.4.2 Air Toxics Dispersion Modelling Study Results

The air toxics dispersion modelling study determined the maximum ground-level concentrations at occupational locations on Barrow Island for comparison with the occupational-based criteria, and at accommodation locations for comparison with the residential-based criteria. A number of occupational and accommodation locations were modelled; however, only the results from within the Gas Treatment Plant and Butler Park (Construction Village) are presented in this PER/Draft EIS as these two locations represent the worst-case ambient air quality for the locations modelled, due to their proximity to the acid gas vents.

The modelling results within the Gas Treatment Plant, compared to the occupational-based criteria, are shown in Table 5-10, with a comparison with the approved Foundation Project to show the incremental increase in ambient air quality due to the operation of the Fourth Train Proposal.

The modelling results within Butler Park (Construction Village), compared to the residential-based criteria, are shown in Table 5-11, with a comparison with the approved Foundation Project to show the incremental change in ambient air quality due to the operation of the Fourth Train Proposal.

Table 5-10: Maximum Ground-level Concentrations of Air Toxics, within the Gas Treatment Plant, from a Fourth Train Proposal Acid Gas Vent and Foundation Project Acid Gas Vents

Air Toxics	Predicted Maximum Ground-level Concentration (ppb)		Occupational-based Criteria Concentration (SWA 1995) (ppb)
	Venting from the Fourth Train Proposal Acid Gas Removal Unit	Venting From Fourth Train Proposal in addition to the Foundation Project	
Hydrogen sulfide	36	47	10 000
Benzene	50	65	1000
Toluene	100	130	100 000
Ethylbenzene	< 1	< 1	100 000
Xylene	28	50	80 000

Table 5-11: Maximum Ground-level Concentrations of Air Toxics, within Butler Park (Construction Village), from a Fourth Train Proposal Acid Gas Vent and Foundation Project Acid Gas Vents

Air Toxics	Predicted Maximum Ground-level Concentration (ppb)		Residential-based Criteria Concentration (NSW DEC 2005) (ppb)
	Venting from the Fourth Train Proposal Acid Gas Removal Unit	Venting From Fourth Train Proposal in addition to the Foundation Project	
Hydrogen sulfide	0.4	1.3	1.5
Benzene	< 1	2	9
Toluene	1	3	90
Ethylbenzene	< 1	< 1	1800
Xylene	< 1	< 1	40

Note: The impact on air quality due to the implementation of the Fourth Train Proposal—with one Acid Gas Removal Unit venting—is expected to be very similar to that of the Foundation Project, as the acid gas venting emission rate and composition is predicted to be similar. However, due to the implementation of the Fourth Train Proposal there is an increased likelihood of an equipment or process failure resulting in acid gas venting, compared to the Foundation Project. The likelihood is predicted to increase by approximately one-third.

Refer to Appendix D2 [Gorgon Expansion Project Phase 2 Acid Gas Vent Dispersion Modelling] for additional results.

5.2.3.5 Atmospheric Emissions from Decommissioning Activities

While it is not possible to accurately predict the atmospheric emissions rates of decommissioning activities at this stage, it is anticipated that the emissions arising from sources such as generators and shutdown flaring would not be significant and the duration would be temporary. Therefore, air quality impacts are not expected to be significant.

5.2.4 Proposed Management Actions

The GJVs consider that the potential impacts of the Fourth Train Proposal can be effectively managed under the environmental management plants (EMPs) for the approved Foundation Project. No measures or controls additional to those required for the approved Foundation Project have been assessed as being necessary to manage the atmospheric emissions associated with the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the relevant approved Foundation Project EMPs, as amended or supplemented from time to time, to ensure that those documents also apply to the Fourth Train Proposal.

The existing EMPs that are relevant to addressing potential impacts to atmospheric emissions for the Fourth Train Proposal are:

- Terrestrial and Subterranean Environment Protection Plan and associated Procedures
- Horizontal Directional Drilling Management and Monitoring Plan
- Offshore Feed Gas Pipeline Installation Management Plan (or equivalent Environment Plan)
- Best Practice Pollution Design Control Report
- Air Quality Management Plan
- Decommissioning and Closure Plan.

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

5.2.4.1 Construction Activities

As outlined in Section 4, Fourth Train Proposal onshore construction activities will be substantially less than the construction activities conducted for the approved Foundation Project. The combination of the greatly reduced infrastructure required to be installed on Barrow Island for the Fourth Train Proposal and the use by the Fourth Train Proposal of the existing infrastructure installed by the approved Foundation Project, is anticipated to result in less atmospheric emissions being produced.

The atmospheric emissions resulting from the construction activities are expected to be short term and are not expected to contribute a significant proportion of the atmospheric emissions produced by the Fourth Train Proposal. Further, such emissions will not be concentrated in a single location for an extended period. Section 1.3.6 outlines the construction schedule.

Vehicles used on Barrow Island for Fourth Train Proposal construction will be powered by engines using ultra-low sulfur diesel fuel.

Flaring during offshore construction is only expected to be conducted for short-term duration testing and will be done in a manner that optimises combustion. Air emissions from offshore vessels are regulated by Annex VI, Prevention of Air Pollution from Ships, of MARPOL 73/78.

5.2.4.2 Operations Phase

The operations phase emissions of the Fourth Train Proposal are expected to be similar in nature (and about one-third in volume) of those of the approved Foundation Project. Approval is sought for the Fourth Train Proposal to be implemented, subject to minor amendments to the approved Foundation Project Best Practice Pollution Control Design Report (Chevron Australia 2012) and Air Quality Management Plan (Chevron Australia 2011). At the time of publication of this PER/Draft EIS, both documents have been endorsed by DPaW as part of the Works Approval for the Gas Treatment Plant, but have been updated to support the works approval amendment for the additional mercury management facilities, which is under assessment. The Fourth Train Proposal plans to amend the Best Practice Pollution Control Design Report and the Air Quality Management Plan developed and implemented by the approved Foundation Project, where required, to address the impacts of the Fourth Train Proposal and make these documents fit-for-purpose for the Combined Gorgon Gas Development.

The approved Foundation Project Best Practice Pollution Control Design Report:

- demonstrates that the proposed works adopt best practice pollution control measures to minimise emissions from the Gas Treatment Plant
- sets out the base emission rates for major sources for the Gas Treatment Plant and the design emission targets
- addresses normal operations, shutdown, start-up, and equipment failure conditions.

The objectives of the Foundation Project Air Quality Management Plan, as stated in the Ministerial Conditions are to:

- ensure air quality meets appropriate standards for human health in the workplace
- ensure air emissions from the Gas Treatment Plant operations do not pose a risk of Material or Serious Environmental Harm to the flora, vegetation communities, fauna, and subterranean fauna of Barrow Island.

Management measures have been selected to ensure that these objectives are achieved. The atmospheric emissions illustrative management measures contained in the Air Quality Management Plan and that are expected to be relevant to the operation of the Fourth Train Proposal are outlined in Table 5-12.

Table 5-12: Atmospheric Emissions Illustrative Management Measures Applicable to the Operation of the Fourth Train Proposal

Source	Management Measure
Exhaust emissions from the Gas Turbine Generators	• Dry Low NO_X burners used • Low sulfur content in fuel gas
Exhaust emissions from the Gas Turbine Drivers	• Dry Low NO_X burners used • Waste heat recovery units on the Gas Turbine Driver exhaust stacks • Low sulfur content in fuel gas
Exhaust emissions from the Heating Medium Heaters	• Low NO_X burners used • Low sulfur content in fuel gas
Fugitive emissions from valves, flanges, pump seals, connectors, diesel tanks, etc.	• Material selection in design phase and corrosion testing • Operator area inspections • Process control and performance monitoring systems and/or alarms used • Preventive maintenance programs implemented where appropriate
Exhaust emissions from diesel combustion in temporary diesel generators, infield marine support vessels (e.g. pilot boats and tugs), and road transport	• Ultra-low sulfur content diesel fuel used • Diesel fuel composition and consumption monitoring
Acid gas venting at the Acid Gas Removal Unit	• CO_2 injection system is designed to deal with the entire quantity of acid gas separated from the feed gas • Acid gas vent system is designed to facilitate dispersion of vented gas

5.2.5 Predicted Environmental Outcome

The modelling studies indicate that the predicted change to the ambient air quality due to the incremental emissions from the Fourth Train Proposal on Barrow Island will be negligible. The predicted change to the ambient air quality on Barrow Island due to the Fourth Train Proposal in addition to the approved Foundation Project will be small and within statutory requirements and acceptable standards.

The ambient air quality resulting from the Fourth Train Proposal cumulatively with baseline air quality resulting from the Foundation Project, WA Oil, and regional sources (where relevant) is predicted to be within statutory requirements and acceptable standards.

Therefore, the GJVs consider that the atmospheric emissions from the Fourth Train Proposal will be adequately managed such that the impacts are environmentally acceptable and the environmental objective (Section 5.2.1.1) is met.

Atmospheric emissions from the Fourth Train Proposal are considered to be able to be managed to acceptable levels to meet the assessment objective by implementation of the Foundation Project EMPs (with minor amendments).

Note: This section does not assess the impact of atmospheric emissions on environmental factors other than air quality. Refer to Sections 9, 10, 13, and 15 for an assessment of atmospheric emissions on other environmental factors (e.g. flora, fauna).

5.3 Light Emissions

5.3.1 Assessment Framework or Policy

5.3.1.1 Environmental Objective

The environmental objective established for light emissions in this PER/Draft EIS is:

> *To avoid or manage potential impacts from light overspill.*

This section predicts the light emissions as a result of the implementation of the Fourth Train Proposal but does not assess the impacts on environmental factors (e.g. fauna) from light emissions. Refer to Sections 9, 10, and 13 for this assessment.

5.3.1.2 Environmental Protection Authority Guidance

The Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts (EPA 2010) is designed to improve scientific understanding of the effects of light on turtles, demonstrate how light impacts can be avoided and mitigated, and improve understanding of the EPA's expectations where light emissions are a factor. The Guideline establishes the legal and policy framework for protecting marine turtles from light impacts and provides a range of solutions and key principles for light management (EPA 2010). The Guideline has been considered in the preparation of this PER/Draft EIS.

5.3.2 Baseline Light Sources

The baseline ambient light levels on Barrow Island when the implementation of the Fourth Train Proposal is scheduled to occur are a combination of natural (e.g. moon, stars) and artificial light sources. The approved Foundation Project and WA Oil operations contribute to the baseline artificial light sources on Barrow Island. Both are expected to generate artificial light sufficient for safe and reliable operations from these locations and sources:

- Gas Treatment Plant (including both construction and operational light from the approved Foundation Project)
- WA Oil Base
- Terminal Tanks offices
- WAPET Landing
- Materials Offloading Facility
- LNG Jetty
- Permanent Operations Centre
- Butler Park (Construction Village)
- Chevron Australia Camp
- vehicles
- marine vessels.

The Foundation Project Gas Treatment Plant is located adjacent to Bivalve Beach and will have artificial light installed to allow personnel safe access to worksites and to provide sufficient light to complete work tasks. Artificial light is also expected to be produced by the approved Foundation Project and WA Oil flare systems, which are required for the safe operation of those facilities. Note: There are several other beaches affected by light spill; however, Bivalve Beach receives the highest level of illuminance, therefore the potential light impacts are discussed in detail for Bivalve Beach only.

The approved Foundation Project was not operational when this PER/Draft EIS was prepared; therefore, no monitoring data from the operational Gas Treatment Plant could be used to determine the baseline. As such, the baseline illuminance levels have been calculated using modelling. The baseline illuminance due to the operation of the Foundation Gas Treatment Plant under routine operations is shown in Figure 5-3.

In addition to the lights of the Gas Treatment Plant, other facilities—such as WAPET Landing, the Materials Offloading Facility, and the LNG Jetty—also produce artificial light, sufficient for their safe night-time operations, including the loading and unloading of marine vessels for the approved Foundation Project and WA Oil.

There are also light emissions from Butler Park (Construction Village) and the Chevron Australia Camp near Yacht Club Beach South. These light emissions are from artificial lighting of facilities such as pathways, sports courts, and accommodation rooms.

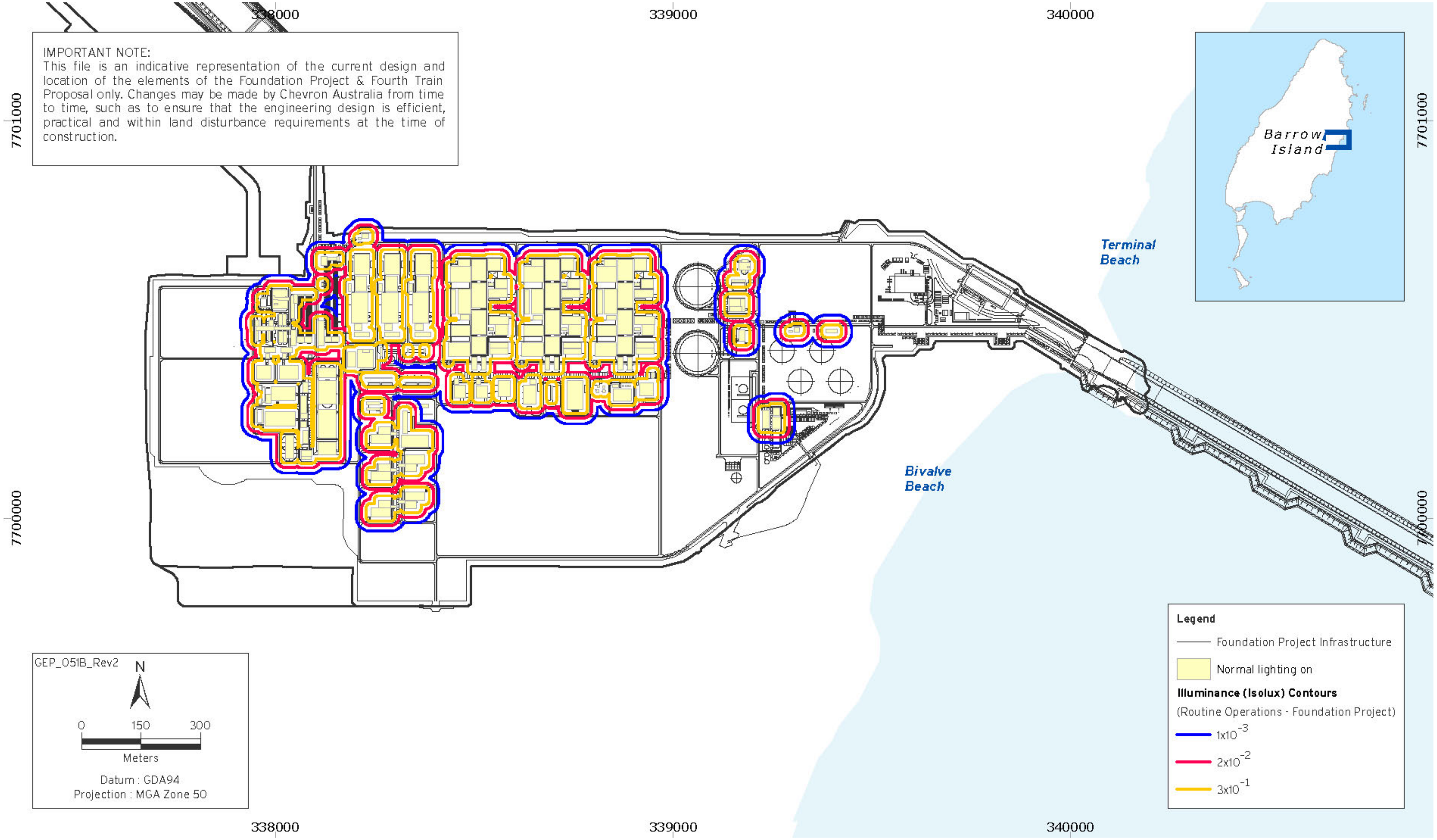


Figure 5-3: Modelled Baseline Illuminance Levels due to the Foundation Project Gas Treatment Plant during Normal Operations

5.3.3 Assessment of Potential Impacts

Light will be generated by the Fourth Train Proposal as a result of artificial lighting required to enable safe operations. The Fourth Train Proposal is not expected to result in new types of light emissions sources compared to the Foundation Project; e.g. light sources such as flaring and artificial luminaires. However, the Fourth Train Proposal is expected to emit additional light as a result of increased flaring events, an increased number of luminaires, and an increase in export vessel frequency.

The light impact depends on the emitted light wavelength, intensity of the light, location of the light source, duration of illumination, orientation, and light attenuation. Light emissions may result in direct light spill brightening the environment.

Light emissions may also result in sky glow, where the atmospheric scattering of light on suspended particles results in a luminescent background or sky. To a much lesser extent sky glow will also contribute to light spill.

5.3.3.1 Light Sources from Construction Activities

The GJVs expect that some construction activities will occur 24 hours a day; therefore, artificial lighting will be used to allow this work to occur safely.

The offshore construction program for the Fourth Train Proposal, which will generally occur 24 hours a day, will require construction vessels—such as drilling rigs, pipe-lay barges, tugs, barges, roll-on/roll-off vessels, and module carriers—to be lit at night in accordance with safety requirements. These vessels are expected to be operating off the east and west coasts of Barrow Island.

Where onshore night construction is required, including at the horizontal directional drilling site and the Gas Treatment Plant site, artificial light sources will be used to provide safe lighting levels for those workers. Typically, these artificial light sources will be temporary structures, such as mobile light towers and construction vehicles. However, some temporary construction facilities may have luminaires installed, including offices and construction utilities; these temporary facilities are expected to be removed when the construction facility is removed.

Construction of the Fourth Train Proposal will prolong the need for construction lighting at various sites on Barrow Island and will also require personnel to occupy the existing accommodation facilities on Barrow Island.

The use of existing accommodation by Fourth Train Proposal personnel will result in prolonged emissions of light due to sports court lighting, walkway lighting, internal lighting, and other light sources. These light emissions are predicted to be the same as the accommodation light emissions from the approved Foundation Project.

Light emissions during construction will be short term and limited to the duration of the Fourth Train Proposal construction activities. Section 1.3.6 outlines the construction schedule.

5.3.3.2 Light Sources from Operational Activities

During the commissioning and operations of the Fourth Train Proposal, light will be generated from the following infrastructure and activities:

- lighting of the Gas Treatment Plant
- increased use of the approved Foundation Project Ground Flares
- increased use of Boil-off Gas Flares (including approved Foundation Project flares and an additional Fourth Train Proposal flare, if required)
- additional shipping and associated support vessels and infrastructure
- additional use of lighting at Butler Park (Construction Village).

Lighting at the Gas Treatment Plant will be segregated into four lighting regimes, each resulting in different light emissions:

- **Normal Lighting**: This is intended to form the normal ingress and egress lighting system; it will normally be 'on' at night when the Gas Treatment Plant is operational and is expected to be photocell-controlled.
- **Area Task Lighting**: This is intended to be normally 'off' and only switched on to provide the necessary task lighting when required. This lighting is intended to be organised into discrete work areas on floor levels (e.g. Ground, Compressor Deck, Fin Fan Deck) to further manage the potential for light spill. The control of switching such lighting on and off will be manual, with remote indication at the Central Control Room.
- **Safety Lighting**: Critical operations areas will have safety lighting. These light fittings will be battery-backed.
- **Emergency Lighting**: This lighting will facilitate the safe and orderly evacuation from an area along escape routes if there is a total power failure. Emergency escape lighting design shall be incorporated into normal lighting, thus reducing the total number of installed luminaires.

Flaring will occur via the approved Foundation Project Ground Flares and Boil-off Gas Flare (an additional Boil-off Gas Flare maybe installed by the Fourth Train Proposal). The increased use of the Ground Flares and the Boil-off Gas Flares is expected due to the operation of the Fourth Train Proposal; this increased use will produce light emissions that are additional to those of the approved Foundation Project. Section 5.2.3.2 outlines the expected duration of flare events resulting from the implementation of the Fourth Train Proposal.

The Fourth Train Proposal is expected to increase the frequency of LNG and condensate shipments (Section 4.4.3.7). Depending on the export vessel's size, each vessel is expected to take approximately 24 hours to load with LNG or condensate. Vessel loading will be a 24-hour a day operation; both the ship and the berth will be lit to the minimum acceptable levels that can provide a safe working environment.

Note: The Fourth Train Proposal will use the approved Foundation Project infrastructure to conduct LNG and condensate loading; the level of lighting associated with this facility was previously approved under the Foundation Project. The increased use of the LNG Jetty for loading due to the Fourth Train Proposal will add to the duration of light emissions produced from the LNG Jetty and the vessels. Assuming 330 vessels per year are loaded, light emissions are expected, at worst, to be generated for approximately 90% of the year (up 21% from the approved Foundation Project), based on only one vessel loading at a time. In practice, there is likely to be an overlap between vessel loadings as the LNG Jetty has two loading berths, therefore the increased loading time estimate is conservative. Further to this, when two LNG vessels are berthed at the same time, the light spill from the loading area is less, due to the shielding effect of the second LNG vessel.

The increase in logistics shipments to and from the Materials Offloading Facility due to the implementation of the Fourth Train Proposal is also expected to increase the frequency and/or duration of light emissions of this facility. However, the GJVs predict that the increase in light emissions will not be significant due to the expected small increase in vessel movements during the operations phase.

5.3.3.3 Light Spill Modelling

A light spill modelling study was conducted to predict the horizontal light spill produced by the operation of the Fourth Train Proposal Gas Treatment Plant. A range of scenarios were modelled representing the lighting at the Gas Treatment Plant during a variety of operational and maintenance activities. Two of the lighting regimes—normal and area task lighting—were modelled, as these are expected to be the most commonly used within the Gas Treatment Plant. Area task lighting was modelled to be normally 'off' and was switched on in specific modelled scenarios to represent various maintenance activities. Note: The light modelling only considers the Gas Treatment Plant, as the Fourth Train Proposal infrastructure that increases light emission intensity during the operations phase is located within the Gas Treatment Plant.

Lighting sources from the Materials Offloading Facility and LNG Jetty were not included in the modelling study as the Fourth Train Proposal will not increase the intensity of light emitted from these facilities (as outlined in Section 5.3.3.2).

The predicted illuminance levels for normal operations of the Fourth Train Proposal together with the approved Foundation Project are shown in Figure 5-4.

Figure 5-4 shows that the isolux contours diminish to less than 10×10^{-4} lux within 100 m from the source. Indirect, lateral light spill intensity, resulting from atmospheric scattering (sky glow), at the nearby beaches is predicted to be typically less than 0.2×10^{-4} lux due to reflection from various surfaces of the Gas Treatment Plant.

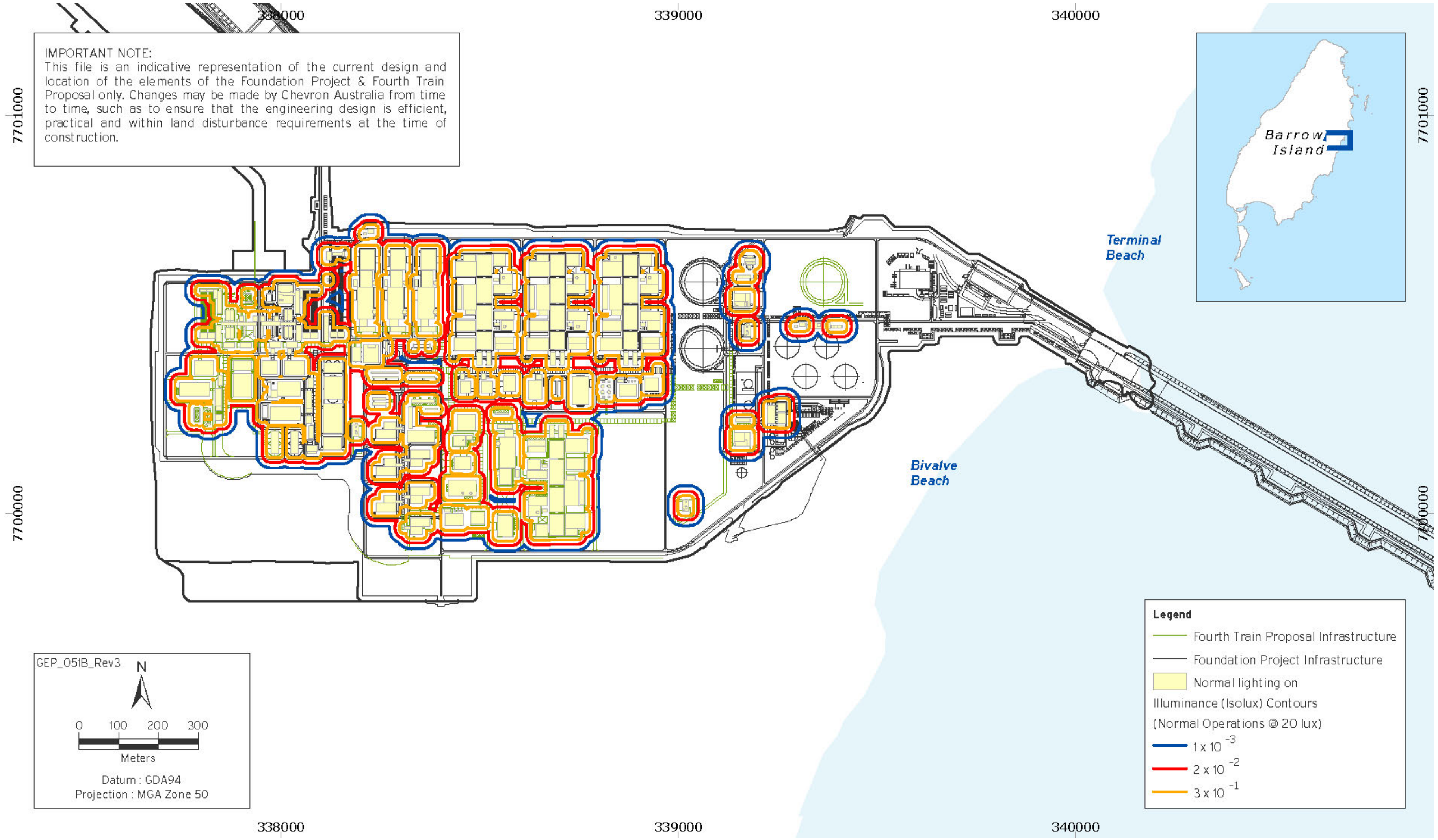


Figure 5-4: Modelled Illuminance Levels Predicted for the Fourth Train Proposal together with the Approved Foundation Project during Normal Operations

Table 5-13 briefly outlines the inputs and assumptions used in the light spill model for each scenario and summarises the illuminance levels at Bivalve Beach (the beach closest to the Gas Treatment Plant) from the Fourth Train Proposal light sources in addition to the approved Foundation Project light sources. For additional detail on the inputs and assumptions in the light modelling study, refer to Appendix D3 [Gorgon Light Emissions Study – Fourth Train Proposal].

When comparing the light spill modelling study conducted for the Fourth Train Proposal (Appendix D3 [Gorgon Light Emissions Study – Fourth Train Proposal]) to the light spill modelling study conducted for the approved Foundation Project (Chevron Australia 2008), there has been a substantial reduction in light spill from the levels assessed and approved for the Foundation Project and that predicted for the Fourth Train Proposal (light spill predicted from Foundation Project and the Fourth Train Proposal together).

The Fourth Train Proposal modelling predicted less illuminance (by two orders of magnitude) at Bivalve Beach compared to the approved Foundation Project light spill modelling study (Chevron Australia 2008). The following major contributing factors led to this reduction in the predicted illuminance levels:

- The Basis of Design for Lighting (Chevron Australia 2009) was developed after the light spill modelling study for the approved Foundation Project was completed; therefore, the light spill model inputs were higher for the Foundation Project model than those used for the Fourth Train Proposal light spill modelling. For example:
  - In the 2008 Foundation Project study, the Gas Treatment Plant was assumed to be illuminated by 250 W high-pressure sodium lights on 10 m poles, while in the Fourth Train Proposal modelling study most of the lights were 36 W fluorescent lights positioned 2 to 3 m above the work platforms to provide no more than 20 lux illuminance during normal operations.
  - In the Foundation Project study, the roadways, including the perimeter roads, were assumed to be illuminated, while in the Fourth Train Proposal modelling study most roads are kept dark and only delineated by solar-powered studs.
  - The Foundation Project study did not take into consideration the height of the foredunes that provide barriers to horizontal light spill, while the Fourth Train Proposal study did consider this significant shading effect.
  - The Fourth Train Proposal study, as opposed to the Foundation Project study, has not only considered the topography of the foredunes, but has also considered shielding of the lights by equipment and buildings, further reducing the light spill onto the beaches.

Table 5-13: Illuminance Levels at Bivalve Beach

Modelled Scenario	Scenario Input and Assumptions	Illuminance from the Fourth Train Proposal and the Foundation Project (lux)	Incremental Illuminance due to the Fourth Train Proposal only
Normal operations	Relevant areas with normal lighting (20 lux average). No area task lighting.	$<4 \times 10^{-4}$	0
Maintenance works on the fourth LNG train (all task areas lit)	Relevant areas with normal lighting (20 lux average). Area task lighting ‘on’ in the entire fourth LNG train (50 lux minimum with a 1:3 uniformity ratio).	$<6 \times 10^{-4}$	0

Modelled Scenario	Scenario Input and Assumptions	Illuminance from the Fourth Train Proposal and the Foundation Project (lux)	Incremental Illuminance due to the Fourth Train Proposal only
Maintenance works on the fourth LNG train (two task areas lit)	Relevant areas with normal lighting (20 lux average). Area task lighting 'on' in two task areas of the fourth LNG train (50 lux minimum with a 1:3 uniformity ratio).	$<6 \times 10^{-4}$	0
LNG Storage Tank rooftop maintenance	Relevant areas with normal lighting (20 lux average). Area task lighting 'on' on the third LNG Storage Tank roof (50 lux minimum with a 1:3 uniformity ratio).	$<20 \times 10^{-4}$	0
Maintenance at the General Utilities Area	Relevant areas with normal lighting (20 lux average). Area task lighting 'on' within the General Utilities Area (50 lux minimum with a 1:3 uniformity ratio).	$<4 \times 10^{-4}$	0

Source: Appendix D3 [Gorgon Light Emissions Study – Fourth Train Proposal]

The area task lighting uniformity ratio accounts for the variation in light levels within the regime and resulted in a minimum illumination of 50 lux and a maximum illumination of 150 lux.

For reference, 1×10^{-3} lux is the equivalent of a moonless clear night sky, 1×10^{-4} lux is the equivalent of a moonless overcast night sky, and 20×10^{-4} lux is roughly equivalent to the illuminance of a moonless clear night sky with sky glow.

The incremental illuminance (as per Table 5-13) shows that the predicted illuminance increase at the sensitive receptors due to the Fourth Train Proposal is zero, compared to the Foundation Project. In all the modelled scenarios no discernible increase in illuminance at Bivalve Beach was detected at the level of rounding. This was predicted as the Fourth Train Proposal infrastructure will be located away from the beach areas, compared to some of the approved Foundation Project infrastructure, which is located closer to the beach.

The modelled scenario of rooftop maintenance activities on the third LNG tank, with routine operations continuing in the rest of the Gas Treatment Plant (both the Fourth Train Proposal and approved Foundation Project), was predicted to result in the highest amount of illuminance to Bivalve Beach: $<20 \times 10^{-4}$lux, roughly equivalent to the illuminance level of a moonless clear night sky with sky glow. Due to safety reasons, planned LNG tank rooftop maintenance is not expected to occur at night; therefore, this scenario is overly conservative. Note: the values listed in Table 5-13 were predicted at the centre points of the respective beaches. For further details on the modelled locations see Appendix D3 [Gorgon Light Emissions Study – Fourth Train Proposal, Table 1-1].

Figure 5-5 shows the light spill predicted by the modelling for the 'third LNG tank rooftop maintenance activities' scenario.

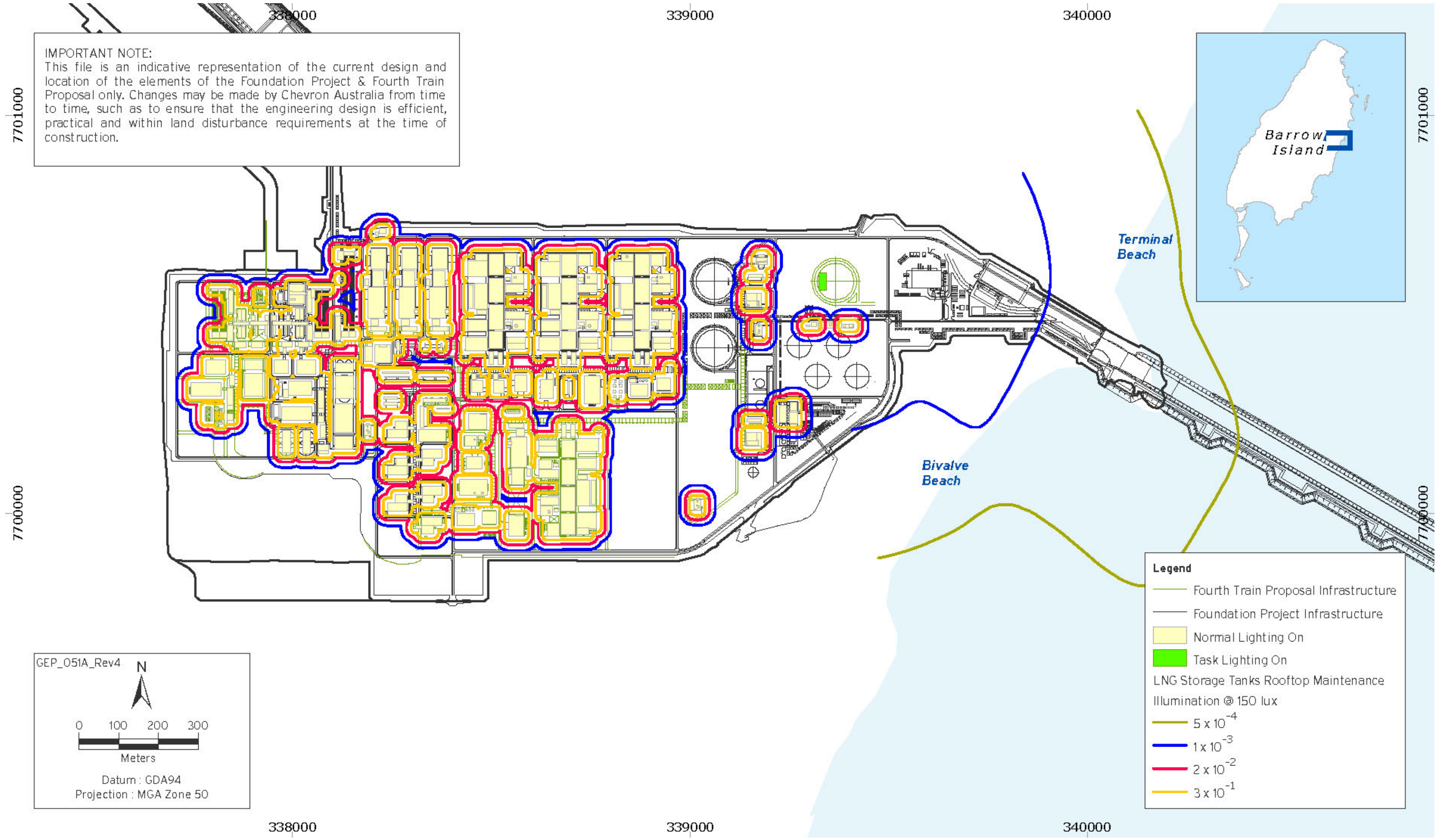


Figure 5-5: Light Spill Predicted during Rooftop Maintenance Activities on the Third LNG Tank

Due to the proximity of the third LNG Storage Tank to Terminal and Bivalve Beaches, these beaches were subdivided into smaller transects to more accurately model the impact of light spill at these locations, which is significantly influenced by variations in coastline topography. The results of the light spill modelling are discussed in terms of illuminance levels at each of these additional locations.

The predicted maximum illuminance level of the eight evenly spaced transects at Bivalve Beach (<30 × 10^{-4} lux) is roughly equivalent to the illuminance level of a moonless clear night with sky glow. Note: This maximum illuminance was predicted to occur only at one short section of Bivalve Beach, and even this maximum light spill does not result in higher illuminance than equivalent to, or less than low natural background light.

More detailed inputs, assumptions, and results are presented in the technical consultant's report in Appendix D3 [Gorgon Light Emissions Study – Fourth Train Proposal]).

5.3.3.4 Light Sources from Decommissioning Activities

The Fourth Train Proposal will be decommissioned when it is no longer economically viable.

The actual methodology for decommissioning will be determined at the time of decommissioning, taking into account all regulatory requirements and industry standards, relevant safety and environmental issues, economic analysis, and practicability that will apply at the time of decommissioning.

At the time of preparation of this PER/Draft EIS, the GJVs do not know if decommissioning activities (refer to Section 4.8) will be conducted at night and thus will require artificial lighting. If artificial lighting is required, it is expected that this will be a combination of the lighting installed for the operations phase and temporary lighting infrastructure similar to that used during construction.

It is expected that flaring will occur during decommissioning; however, the duration and frequency is unknown. Flaring is expected to occur via the Ground Flares and the Boil-off Gas Flare.

The GJVs are required by the Western Australian Ministerial Conditions to develop a Decommissioning and Closure Plan for the approved Foundation Project prior to decommissioning. It is anticipated that the decommissioning of the Fourth Train Proposal will be managed in accordance with these future plans.

5.3.4 Proposed Management Actions

The GJVs consider that the potential light emissions from the Fourth Train Proposal can be effectively managed under the EMPs for the approved Foundation Project. No additional measures or controls are expected to be necessary to manage the potential light emissions associated with the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the relevant approved Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal.

The existing construction and operations EMPs that are relevant to addressing potential impacts to light emissions for the Fourth Train Proposal are:

- Terrestrial and Subterranean Environment Protection Plan and associated Procedures
- Long-term Marine Turtle Management Plan
- Horizontal Directional Drilling Management and Monitoring Plan
- Offshore Feed Gas Pipeline Installation Management Plan (or equivalent Environment Plan).

An objective of the approved Foundation Project Long-term Marine Turtle Management Plan (Chevron Australia 2014), as required by Ministerial Conditions, is to specify design features, management measures, and operating controls to manage, and where practicable, avoid adverse impacts to marine turtles, with specific reference to reducing light and noise emissions as far as practicable. The lighting management strategies included in the Long-term Marine Turtle Management Plan (Chevron Australia 2014) follow a hierarchy of controls, starting with the most efficient through to the least efficient:

- **Elimination**: Removing the stressor (e.g. removal/elimination of a light source, or ensuring its complete shielding).
- **Substitution**: Replacing a more hazardous characteristic of the stressor with a less hazardous one (e.g. change in spectral properties of lighting—use long-wavelength lights where safety considerations allow).
- **Reduction**: Reducing the amount/dose or duration of time that the stressor is active (e.g. reducing the amount of light escaping from a light source by shielding, shrouding, or screening).
- **Administrative Controls**: Designing operating procedures to restrict exposure to the stressor, or monitoring one or more properties of a stressor, etc.

It is expected that these management strategies will be applied to the Fourth Train Proposal through the application of the approved Foundation Project Long-term Marine Turtle Management Plan (Chevron Australia 2014) with minor changes.

The above management strategies comply with the requirements of the Environmental Assessment Guidelines No. 5 – Environmental Assessment for Protecting Marine Turtle from Light Impacts (EPA 2010), which are:

- keep lights off
- keep lights low
- keep lights shielded.

Ministerial Conditions require the GJVs to establish a Marine Turtle Expert Panel (MTEP) to provide advice to the Commonwealth and State Ministers for Environment and to Chevron Australia on matters relating to marine turtle monitoring and management for the approved Foundation Project. Condition 15.2 (iv) and Condition 16.4 (iv) of Statement No. 800 requires the MTEP to advise the GJVs and the Western Australian Minister for Environment of management measures, including design features and operating controls, in relation to light emissions. The MTEP provides advice on the implementation of the Long-term Marine Turtle Management Plan (Chevron Australia 2014) and the effectiveness of this implementation.

The GJVs consider that the light impacts of the Fourth Train Proposal can be managed by including minor amendments to the existing approved Foundation Project EMPs to incorporate impacts of the Fourth Train Proposal.

5.3.4.1 Construction Activities

The focus of the construction lighting management strategies and measures is to adequately manage artificial lighting sources. Artificial lighting management procedures will be developed and included in contractor construction lighting management plans, where relevant; these will address how light spill from artificial lighting will be reduced where practicable without compromising the safe execution of the work. The contractor lighting management plans allow internal assessment of the lighting to ensure compliance with regulatory and Chevron Australia requirements, as outlined in the Long-term Marine Turtle Management Plan (Chevron Australia 2014).

Illustrative artificial lighting management measures applicable to equipment associated with activities operating 24 hours a day during the turtle hatchling season are outlined in the Long-term Marine Turtle Management Plan (Chevron Australia 2014) and include requirements such as:

- the use of shielded light fittings, directional lights, and/or artificial or natural screens where practicable
- temporary artificial lighting to be mounted as low as practicable and focused on areas being worked on
- where colour definition is not required for safety or operational purposes, use lighting types that are least disruptive to turtles; e.g. long-wavelength lights
- where minimal colour definition is required, use shielded reduced spectrum type light
- outside artificial lighting on vessels to be kept to a minimum; e.g. navigational lights and necessary lighting as required for safety
- accommodation windows and portholes will have blinds or curtains fitted to block out artificial light emissions from vessels.

It is expected that the same management measures will be employed by the Fourth Train Proposal via the implementation of a Long-term Marine Turtle Management Plan (Chevron Australia 2014) and the Ministerial Conditions.

5.3.4.2 Operations Phase

The focus of the operations phase lighting management strategies and measures is to adequately manage artificial lighting sources from operations facilities and infrastructure so as to avoid adverse lighting impacts on marine turtles. These strategies include engineering controls and administrative (operating) controls, as outlined below.

The design and construction of operational lighting for the Fourth Train Proposal is guided by the objectives of the Long-term Marine Turtle Management Plan (Chevron Australia 2014) and the Ministerial Conditions. The GJVs expect that the lighting design of operational facilities will be similar to that used for the approved Foundation Project. Lighting procedures will be adjusted following annual audits and monitoring results, as required.

Light emissions resulting from increased LNG and condensate loading will be managed in a similar manner to those for the approved Foundation Project (e.g. switching lights off at the LNG Jetty head when vessel loading is not occurring). Similarly, the light generated on the Materials Offloading Facility resulting from the increased logistics movements due to the operation of the Fourth Train Proposal will be managed using measures consistent with those used for the approved Foundation Project, as outlined in the Long-term Marine Turtle Management Plan (Chevron Australia 2014) (e.g. switching lights off at the Materials Offloading Facility when vessel loading is not occurring).

The safety objectives for the Gas Treatment Plant require safe and adequate lighting levels to ensure that hazards can be identified and that safe operations (including access and egress) can occur. However, environmental objectives to mitigate lighting effects on fauna, including marine turtles, require a dark horizon. As a result of these conflicting requirements, the operations lighting management strategy uses a multi-layered engineering approach, which relies on a variety of elimination, substitution, and reduction engineering design measures that consider the principles of the lighting strategy in terms of safety, operability, and environmental protection. This multi-layered engineering approach is outlined below.

As outlined in Section 5.3.3.2, four lighting regimes are intended to be adopted to reduce levels of external artificial light within the process and utilities areas of the Fourth Train Proposal Gas Treatment Plant. These lighting regimes will allow the light generated within the Fourth Train Proposal Gas Treatment Plant to be segregated into two ‘working’ lighting regimes, i.e. normal lighting and task lighting. This strategy will have the following benefits for managing light spill:

- On average, general illumination levels at the Fourth Train Proposal Gas Treatment Plant under the normal lighting regime are expected to be only a fraction of the illumination levels if the Plant were to be lit to the task lighting levels of most oil and gas facilities in the world.
- The Fourth Train Proposal Gas Treatment Plant can further be subdivided into smaller 'work' areas for task lighting purposes, which allows the higher lighting levels associated with area task lighting to be confined to a small area of the Plant where maintenance or other work activities take place.

The wavelength of light being emitted can be managed through the selection of light fittings. Where colour rendition is not required, it is expected that light fittings will be used that emit light mainly greater than 560 nanometres in wavelength (i.e. lights in the yellow to red colour spectrum). However, broad spectrum warm white light will be required to provide accurate colour rendition in some locations and for some specific tasks.

An additional Boil-off Gas Flare may be installed for the Fourth Train Proposal; if implemented, it will be constructed as an enclosed flare so as to manage lateral light spill. Light emissions from the use of the approved Foundation Project Ground Flares by the Fourth Train Proposal are managed through approved Foundation Project engineering measures, including the location of the flares (away from the ocean), design of the flares (radiation fence to manage direct light spill), and design of the Gas Treatment Plant (no routine flaring). Section 5.2.3.2 outlines the expected flaring events.

It is intended that large tanks installed for the Fourth Train Proposal (including a third LNG tank [if required], amine tank, and MEG tanks) will have emergency lighting circuits incorporated into the normal lighting circuits; these will be switched on manually. Task lighting will be provided at the top of the tank and in areas around the tanks, as required. This arrangement means that the tank rooftops effectively remain dark unless (in unplanned circumstances) work is required at night.

Lighting emissions from operational tugs and pilot vessels will be managed according to the requirements of the Long-term Marine Turtle Management Plan (Chevron Australia 2014).

The vessel masters of LNG and condensate vessels are required to provide a safe working environment for the vessel and will light the vessel in accordance with this requirement and the Barrow Island Port Regulations.

5.3.5 Predicted Environmental Outcome

The incremental light emissions from the Fourth Train Proposal on Barrow Island are predicted to be zero above the approved Foundation Project. The light spill modelling of the Fourth Train Proposal, in addition to the approved Foundation Project, predicted very low levels of illuminance at sensitive environmental receptors, including Bivalve Beach.

The GJVs consider that light emissions from the Fourth Train Proposal can be managed to acceptable levels by the approved Foundation Project EMPs, with minor changes, to meet the environmental objective (Section 5.3.1). The resultant light emissions are considered to be reduced to levels that are as low as reasonably practicable.

Note: This section does not assess the environmental impacts from light emissions. Refer to Sections 9, 10, and 13 for this assessment.

5.4 Noise and Vibration Emissions

5.4.1 Assessment Framework or Policy

5.4.1.1 Environmental Objective

The environmental objective established for noise emissions in this PER/Draft EIS is:

> *To avoid adverse noise and vibration impacts to terrestrial and marine fauna by benchmarking noise against statutory requirements and acceptable standards.*

This section predicts the noise emissions as a result of the implementation of the Fourth Train Proposal and compares them to statutory requirements and acceptable standards; it does not assess the environmental impacts from noise emissions (Sections 9, 10, and 13 assess noise emissions on relevant environmental factors [e.g. fauna]).

5.4.1.2 State Legislation

To satisfy the environmental objective (Section 5.4.1.1), the predicted noise was benchmarked against the noise limits cited by the *Environmental Protection Act 1986* (WA) (EP Act), the respective Environmental Protection (Noise) Regulations 1997 (Noise Regulations), and the EPA Guidance Statement No. 8 (EPA 2007). The Noise Regulations require that noise emitted from any premises must comply with assigned noise levels when received at any other premises. The assigned levels are specified under Regulation 8 of the Noise Regulations, according to the type of premises receiving the noise.

Barrow Island is a single industrial premise; therefore, these assigned noise levels are not binding on Barrow Island. However, the Chevron Australia Camp and Butler Park(Construction Village), which are approximately 3 km south of the Gas Treatment Plant, are potential noise-sensitive receptors for the Fourth Train Proposal. Therefore, for the purposes of assessment, in this document the assigned noise levels in the Noise Regulations were considered in respect of the Chevron Australia Camp and Butler Park (Construction Village).

5.4.1.3 State Guidelines

The noise assessment for the Fourth Train Proposal Gas Treatment Plant was conducted in accordance with the requirements of EPA Draft Guidance Statement No. 8 – The Assessment of Environmental Factors, Environmental Noise (EPA 2007).

5.4.2 Baseline Noise Levels

5.4.2.1 Offshore

Baseline underwater noise levels in the offshore Fourth Train Proposal Area are affected by a combination of naturally occurring and artificial noise sources.

Naturally occurring noise sources (e.g. wind, waves, marine animals) dominate the baseline ambient underwater noise in the offshore Fourth Train Proposal Area. Underwater sound pressure due to wind and wave activity may range from 90 dB re 1 µPA under very calm, low wind conditions, to 110 dB re 1 µPA under windy conditions (Woodside 2002).

Artificial sources also contribute to the baseline underwater noise in the offshore Fourth Train Proposal Area. Artificial sources may include fishing vessels and marine transport, as well as noise associated with existing or approved oil and gas construction and operations in or near the Fourth Train Proposal Area. This includes the development of the Pluto, Gorgon, Jansz, Io, and Wheatstone gas fields.

Existing fishing activities and large shipping vessels generate noise in the offshore Fourth Train Proposal Area. Underwater sound pressure levels generated by fishing trawlers have been found to be 160 dB re 1 µPa, whereas large ships can produce levels exceeding 180 dB re 1 µPa (Chevron Australia 2011a).

Baseline ambient noise levels due to existing or approved oil and gas developments in or near the Fourth Train Proposal Area are expected to be affected by the movements and positioning of marine vessels, including drilling rigs and pipe-lay barges. These emissions are generally intermittent and localised, but are expected to occur throughout the life of the Fourth Train Proposal.

5.4.2.2 Onshore

On Barrow Island, baseline noise conditions when the Fourth Train Proposal is expected to begin implementation will be affected by natural sound sources, such as wind and waves, and existing industrial operations, i.e. WA Oil and the approved Foundation Project. However, due to the small size of the WA Oil operations and their distance from Gorgon activities, WA Oil is considered to be a minor contributor to ambient noise levels on Barrow Island, compared to natural sources and the approved Foundation Project.

The baseline noise levels on Barrow Island include the noise emissions from the operation of the approved Foundation Project Gas Treatment Plant. The approved Foundation Project was not operational when this PER/Draft EIS was prepared; therefore, no monitoring data from the Gas Treatment Plant could be used to determine the baseline. Thus, baseline noise levels applicable to the Fourth Train Proposal have been predicted using mathematical modelling. Table 5-14 lists the predicted baseline noise levels resulting from the approved Foundation Project Gas Treatment Plant during normal operations. As normal operations are predicted to occur for more than 90% of the time this is considered to be an appropriate baseline.

Table 5-14: Baseline Noise Levels on Barrow Island (assuming normal operation of the Foundation Project Gas Treatment Plant)

Location	Calculated Sound Pressure Level [dB(A)]
Butler Park (Construction Village)	45.1
Chevron Australia Camp	45.4

For additional detail on the baseline noise levels from the Foundation Project, refer to Appendix D4 [Cumulative Noise Impact Study for the Gorgon Expansion Project Barrow Island LNG Plant].

5.4.3 Assessment of Potential Impacts

5.4.3.1 Noise and Vibration Generated by Construction Activities

5.4.3.1.1 Offshore Components

Noise will be generated due to Fourth Train Proposal construction activities such as drilling and pipe-laying vessel movements that support offshore construction. The offshore construction is expected to occur 24 hours a day, seven days a week. The actual noise characteristics and intensity generated will depend on the vessel used and the activity being conducted. The Fourth Train Proposal offshore construction noise emissions profile and intensity is expected to be similar to the baseline noise emissions from the existing and approved oil and gas construction activities in the area. It is expected that the Fourth Train Proposal will increase the number of noise emissions sources or the usage duration of the existing sources. However, the GJVs predict that the noise emissions from offshore construction activities of the Fourth Train Proposal will be short term and intermittent. The likely noise emissions from the offshore construction activities of the Fourth Train Proposal are summarised below.

A number of drilling and subsea infrastructure installation vessels are likely to be used for the Fourth Train Proposal. Rigs and support vessels generate noise during drilling and through their movement and positioning. Vertical seismic profiling may be used when drilling the production wells and this will generate anthropogenic marine noise. Primary sources of anthropogenic marine noise during pipeline installation are expected to be from the vessel thrusters as they maintain position. Sound levels and frequency characteristics depend on vessel size and speed, with noise levels varying among vessels of similar classes. Construction vessels are expected to be supported by helicopters, which will also generate anthropogenic marine noise.

Predicted anthropogenic marine noise levels have been determined from reviewing monitoring information available from similar operations; these are shown in Figure 5-6 and Figure 5-7.

Underwater trenching is another construction activity that will contribute to the offshore noise emissions generated. Various studies have been conducted to determine the anthropogenic marine noise levels due to trenching. Monitoring of the noise levels created by seabed trenching using water jetting—a technique that may be employed by the Fourth Train Proposal—was undertaken at North Hoyle in Wales. The cable trencher measured during the installation of cables at the North Hoyle wind farm in 2003 gave readings of 123 dB re 1 µPa at 160 m distance, which was interpreted as 178 dB re 1 µPa at 1 m (Nedwell *et al.* 2003). A separate field trial of a mechanical trencher was conducted to assess the resultant noise emissions. The trial found that during full trenching mode, the maximum noise level recorded was 80 dB re 1 µPa at 1 to 2 kHz (Chevron Australia 2010).

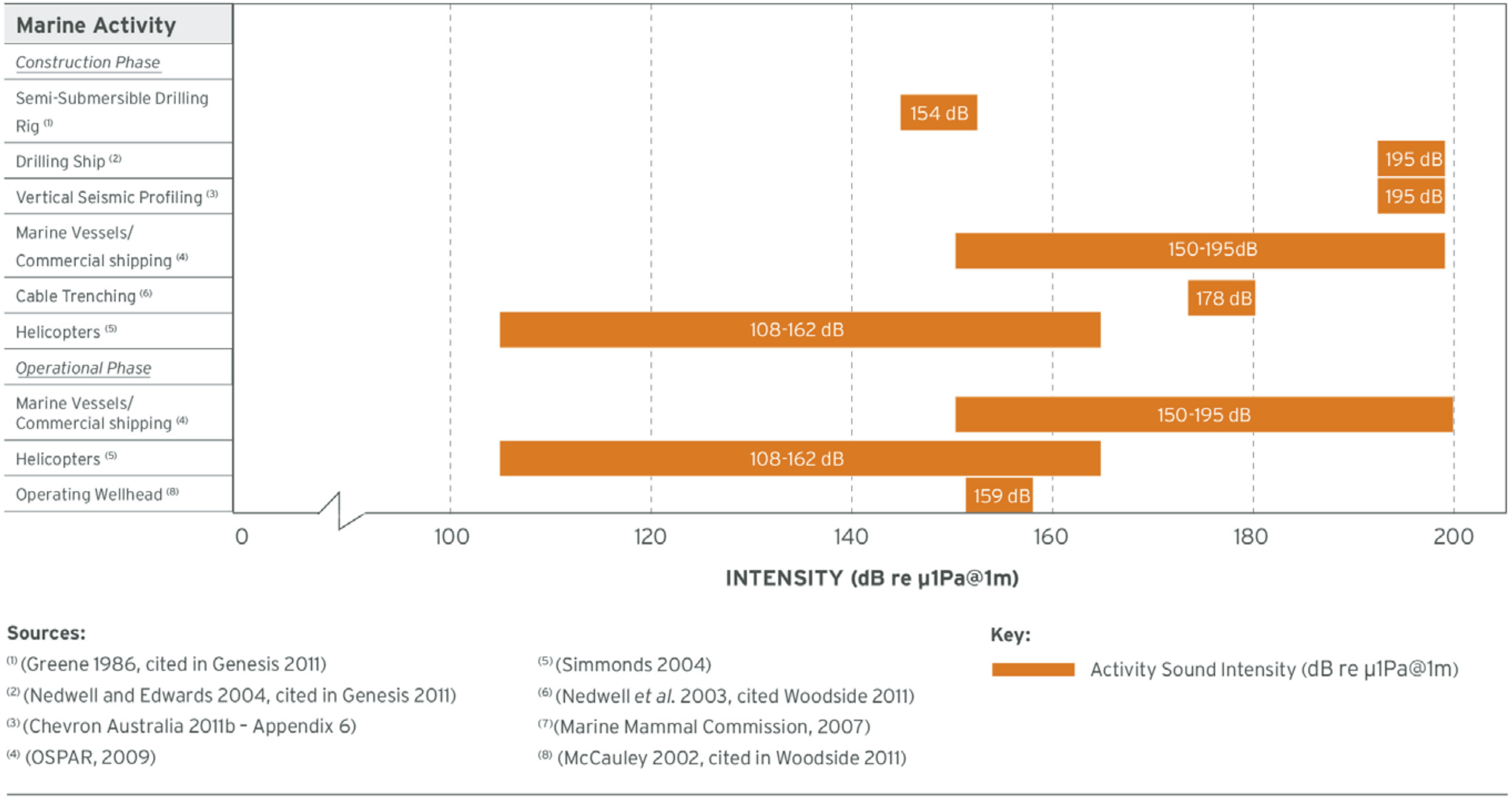


Figure 5-6: Intensity of Anthropogenic Marine Noise Predicted during the Construction and Operation of the Fourth Train Proposal

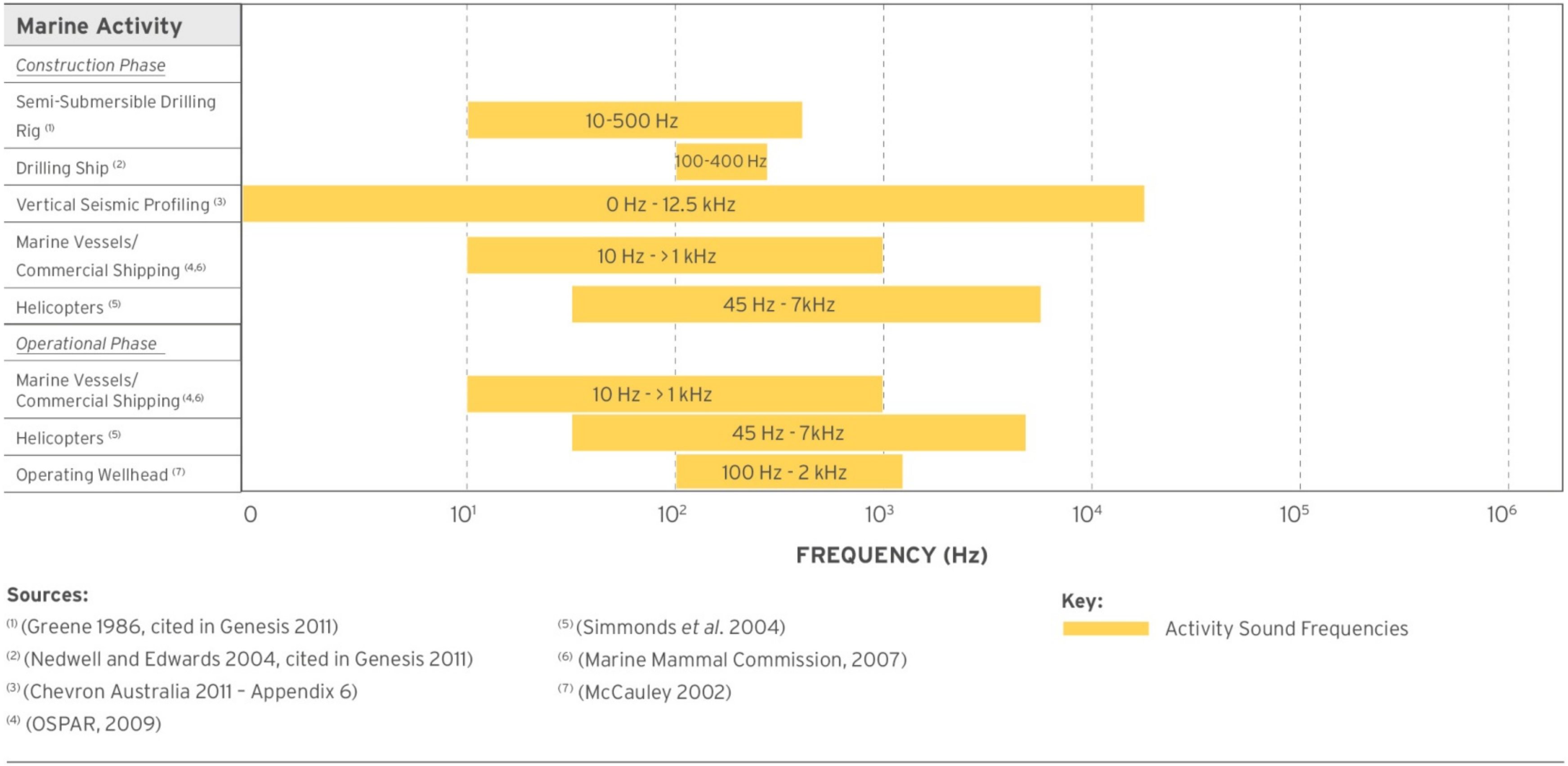


Figure 5-7: Frequency of Anthropogenic Marine Noise Predicted during the Construction and Operation of the Fourth Train Proposal

5.4.3.1.2 Onshore Components

Noise will be produced during various onshore construction activities (e.g. blasting, grading, excavating, trenching, levelling, materials offloading, grinding, erecting, etc.) as well as from equipment and vehicle engines and movement, power generators, use of air conditioning systems, etc.

Noise levels for typical equipment used during onshore construction activities are expected to be approximately 60 to 130 dB(A). Onshore construction may occur 24 hours a day, seven days a week.

Noise emissions due to onshore construction activities of the Fourth Train Proposal are expected to be less than the noise generated during construction of the approved Foundation Project, as many of the construction activities proposed are similar to those of the Foundation Project, although on a smaller scale. For example, the scale of earthworks required on the Fourth Train Proposal Gas Treatment Plant site will be substantially less than that for the approved Foundation Project. The Fourth Train Proposal will extend the duration of most construction activities on Barrow Island and therefore extend the duration of noise emissions from those construction activities.

The onshore construction noise emissions will be short term, with onshore construction activities limited in duration. The longest duration of onshore construction noise will occur at the Fourth Train Proposal Gas Treatment Plant site, where it is expected that the baseline ambient noise conditions of the operating Foundation Project will dominate the noise produced by the Fourth Train Proposal construction, rendering the construction noise negligible. Section 1.3.6 outlines the onshore construction schedule.

Onshore construction activities will also generate vibration emissions; these activities may include blasting, grading, excavating, trenching, levelling, materials offloading, grinding, erecting, and the vehicle operation. Monitoring conducted for the approved Foundation Project has found very low vibration levels, which is typical of ambient vibration levels on beaches in the north-west of Western Australia (SVT Engineering Consultants 2012). No increasing trends in vibration emissions since baseline monitoring began in December 2009 were observed for the Foundation Project. The monitoring found that vibration emissions have not increased with the increase in construction activities near vibration monitoring locations, including Bivalve Beach and Terminal Beach (SVT Engineering Consultants 2012).

Vibration emissions due to the onshore construction activities of the Fourth Train Proposal are expected to be less than the vibration emissions generated during construction of the approved Foundation Project, as many of the construction activities proposed are similar to those of the Foundation Project, although on a smaller scale.

5.4.3.2 Noise and Vibration Generated by Operations Activities

5.4.3.2.1 Offshore Components

Operation of the Fourth Train Proposal infrastructure in the offshore environment will generate low levels of anthropogenic marine noise, including noise from:

- marine vessels
- helicopter transfers
- subsea infrastructure.

Anthropogenic marine noise is expected as a result of operational shipping, including the increased numbers of LNG and condensate vessels, tugs, and pilot boats. This increase in marine vessel movements will not increase cumulative noise levels; however, it will increase the regularity of the noise source when marine vessels are present/operating in the Port of Barrow Island. The noise emissions from marine vessels will be concentrated around the LNG

Jetty and the Materials Offloading Facility, which are approximately 4 km and 2 km respectively from the beaches at Town Point.

Figure 5-6 and Figure 5-7 show the intensity and frequency of anthropogenic noise predicted to occur due to the operation of the Fourth Train Proposal.

In addition, maintenance of the offshore infrastructure will generate short-term localised noise associated with:

- pigging of the Feed Gas Pipeline System
- well workovers.

Production well workovers involve activities similar to those associated with the original well drilling and completion and may include anthropogenic marine noise generated by the mobilisation, positioning, and use of a drilling rig, underwater survey equipment, and associated supply and support vessel movements. Production well workovers may occur approximately every one to three years during the life of the Fourth Train Proposal.

5.4.3.2.2 Onshore Components

Onshore noise emissions will occur as a result of the operation of the Fourth Train Proposal. The primary noise source is expected to be the Gas Treatment Plant. A quantitative assessment of the noise emissions predicted from the Fourth Train Proposal Gas Treatment Plant was conducted using noise modelling.

Noise modelling was used to predict and assess the noise emissions from the Fourth Train Proposal Gas Treatment Plant, in addition to the emissions of the approved Foundation Project Gas Treatment Plant, with the results benchmarked against the Noise Regulations. Sound pressure levels were predicted at Butler Park (Construction Village) and the Chevron Australia Camp under a range of different operating scenarios for the Fourth Train Proposal, including normal operations and upset scenarios. Normal operations are expected to occur for more than 90% of the time during steady state operations; therefore, this scenario can be compared to the $L_{A\,10}$ assigned level in the Noise Regulations. Similarly, the LNG process start-up scenario was considered appropriate for comparison with the $L_{A\,1}$ assigned level from the Noise Regulations. Table 5-15 summarises the results of the noise modelling study.

For additional detail on the inputs and assumptions in the noise modelling study, refer to Appendix D4 [Cumulative Noise Impact Study for the Gorgon Expansion Project Barrow Island LNG Plant].

Table 5-15: Predicted Noise Levels from the Gas Treatment Plant with both the Foundation Project and the Fourth Train Proposal Operating and the Increase due to the Fourth Train Proposal

Location	Gas Treatment Plant Scenario		
	Normal Operations of Foundation Project and Fourth Train Proposal (Additional) dB(A)	Difference between Normal Operations Foundation Project and Normal Operations Fourth Train Proposal (Incremental) dB(A)	LNG Process Start-up and Dry Gas Flaring from Train 4 Normal Operations of the Foundation Project dB(A)
Butler Park (Construction Village)	47	1.9	55.4
Chevron Australia Camp	47	1.6	53.7
Relevant benchmark from Noise Regulations	$L_{A\,10}$ = 65	-	$L_{A\,1}$ = 80

The noise modelling predicted that noise levels at Butler Park (Construction Village) and the Chevron Australia Camp, a potential noise-sensitive receptor, will comply with the Noise Regulations.

Figure 5-8 shows the predicted noise level on Barrow Island during normal operations of the Fourth Train Proposal and the approved Foundation Project together. Figure 5-9 shows the noise resulting from the LNG process start-up and dry gas flaring from the fourth LNG train, while the approved Foundation Project operating normally.

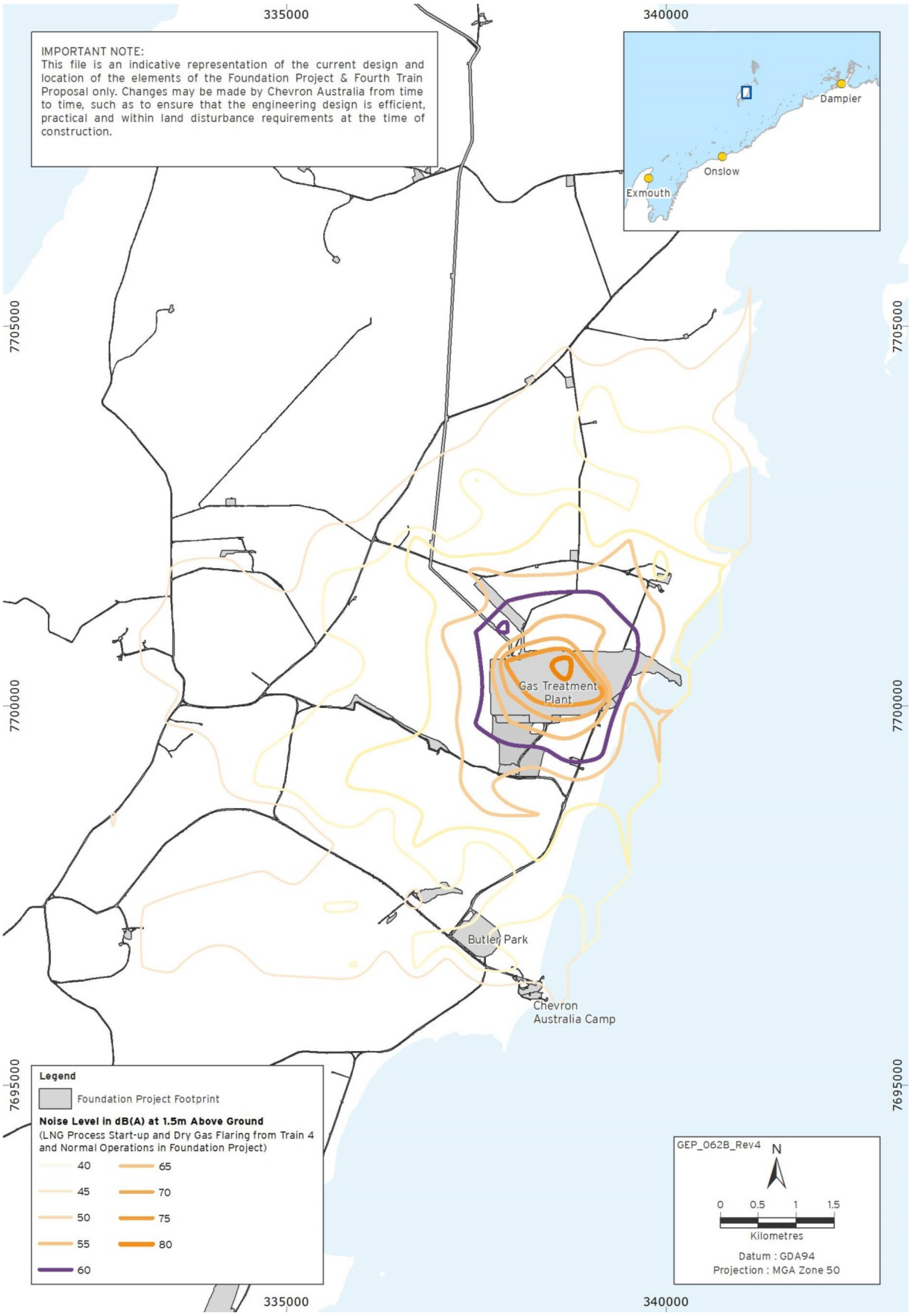


Figure 5-8: Noise Contours on Barrow Island during Normal Operations of the Fourth Train Proposal and the Approved Foundation Project

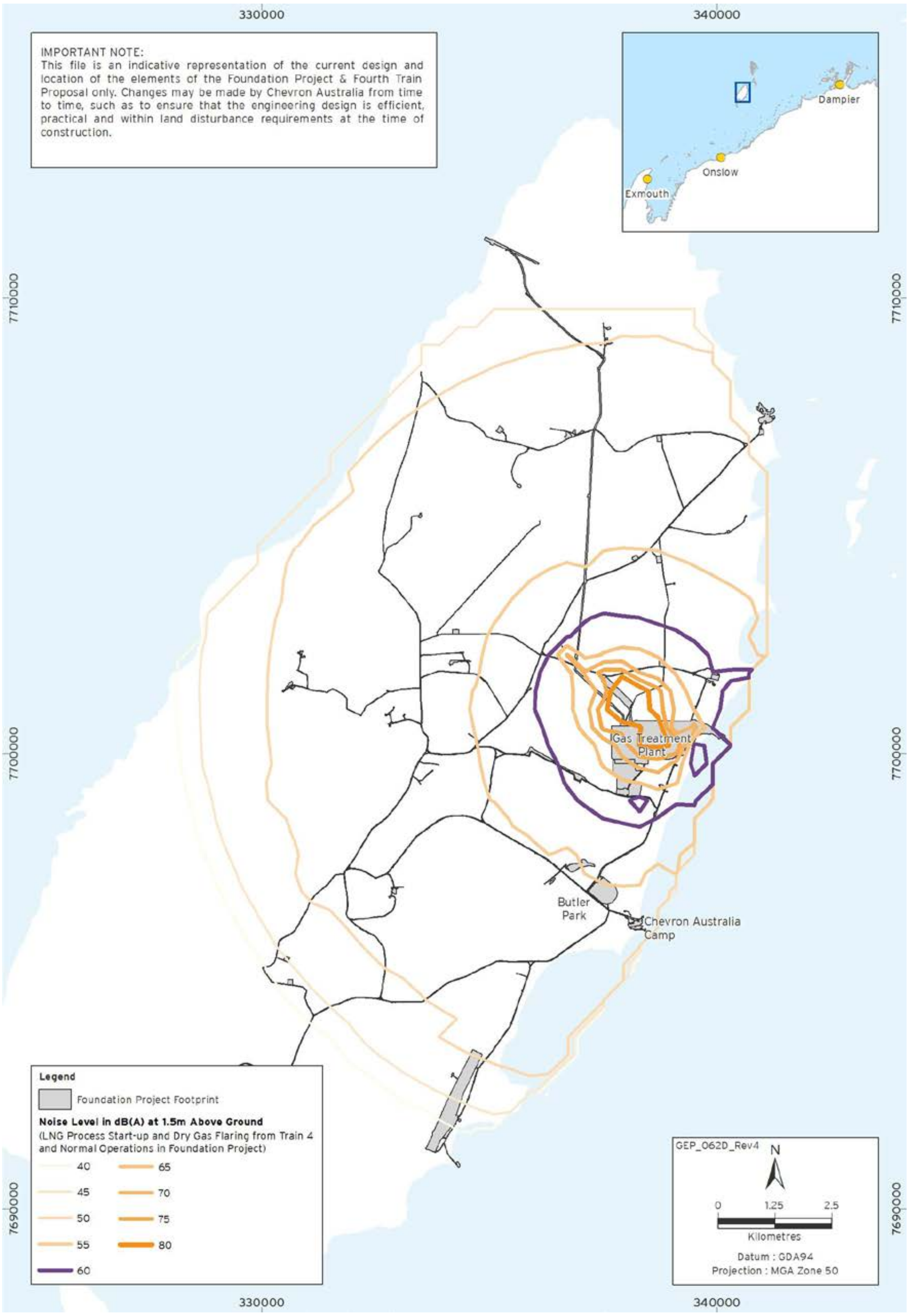


Figure 5-9: Noise Contours on Barrow Island during LNG Process Start-up and Dry Gas Flaring from Train Four, with Normal Operations in the Approved Foundation Project

For additional detail on the inputs, assumptions and results of the noise modelling study, refer to Appendix D4 [Cumulative Noise Impact Study for the Gorgon Expansion Project Barrow Island LNG Plant].

Vibration emissions will be generated onshore during the operations phase of the Fourth Train Proposal. The primary vibration source is expected to be the operation of the Gas Treatment Plant (Chevron Australia 2014a). Other potential sources of vibration include the Feed Gas

Pipeline System, the export pipelines for LNG, condensate, and Domestic Gas, and the operation of vehicles and equipment (Chevron Australia 2014a).

The incremental vibration emissions due to the onshore operation activities of the Fourth Train Proposal is expected to be minimal.

5.4.3.3 Noise Generated by Decommissioning Activities

In general, noise and vibration emissions during decommissioning are likely to be similar to those during construction (although different equipment may be used); these noise emissions will also be temporary, with noise returning to pre-Gorgon Gas Development background levels once decommissioning works are complete.

5.4.4 Proposed Management Actions

The GJVs consider that the potential impacts from the Fourth Train Proposal can be effectively managed under the EMPs for the approved Foundation Project. No additional measures or controls are anticipated to be necessary to manage the potential noise and vibration emissions associated with the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the relevant approved Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal.

The existing EMPs that are relevant to addressing potential impacts to noise emissions for the Fourth Train Proposal are:

- Terrestrial and Subterranean Environment Protection Plan and associated Procedures
- Long-term Marine Turtle Management Plan
- Horizontal Directional Drilling Management and Monitoring Plan
- Offshore Feed Gas Pipeline Installation Management Plan (or equivalent Environment Plan).

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

Environment Plans that include the management of noise and vibration are also required for the drilling and completion of the Fourth Train Proposal production wells, and for activities associated with the installation of the Fourth Train Proposal Feed Gas Pipeline System in the Commonwealth Marine Area. In addition to the relevant EMPs, subsidiary documents relevant to addressing potential impacts of noise emissions from the Fourth Train Proposal will be developed; these include Environmental Plans submitted to meet the requirements of the Offshore Petroleum and Greenhouse Gas Storage Regulations 2009 (Cth) for operations in the Commonwealth Marine Area. Equipment noise reduction measures have been used by the approved Foundation Project in the design of the Gas Treatment Plant, as outlined in the Terrestrial and Subterranean Environmental Protection Plan (Chevron Australia 2014a), and these measures are also expected to be implemented in the Fourth Train Proposal. Final design of equipment noise reduction measures will be completed during the detailed design phase for the Fourth Train Proposal. Illustrative equipment noise management measures for the approved Foundation Project include:

- ensuring gas turbines have air inlet silencers, acoustic enclosures, and exhaust gas silencers for exhaust stacks
- implementing measures to reduce noise and vibration from pumps, where practicable (e.g. pumps will have acoustic blanket and motor enclosures)
- providing an exhaust gas silencer for the diesel engine for firewater pumps
- ensuring the Emergency Diesel Generator Package includes an acoustic enclosure and exhaust gas silencer for the diesel engine

- ensuring facility piping has acoustic insulation on compressor suction/discharge/recycle piping, insulation on LNG/Mixed Refrigerant expander suction/discharge piping, acoustic insulation on large pump (>300 kW) suction/discharge/recycle piping, and acoustic insulation on high-pressure drop valves and piping
- providing acoustic insulation for vibration isolation between piping and pipe supports

It is expected that the Fourth Train Proposal will use the same noise management measures as the Foundation Project

5.4.5 Predicted Environmental Outcome

Incremental noise emissions from the construction of the Fourth Train Proposal will be short term. During offshore operations noise emissions will either be low level during routine operations, or intermittent in the case of non-routine operations. Noise modelling predicts that the incremental noise produced during the operation of the Fourth Train Proposal Gas Treatment Plant is only expected to increase the noise levels on Barrow Island marginally. Ambient noise levels at Butler Park (Construction Village) and Chevron Australia Camp resulting from the Fourth Train Proposal in addition to the approved Foundation Project were predicted to be within statutory requirements (Table 5-15).

The GJVs consider that the noise emissions from the Fourth Train Proposal can be managed by the approved Foundation Project EMPs, with minor changes such that the impacts from ambient noise are environmentally acceptable and the environmental objective (Section 5.2.1) is met.

Note: This section predicts the noise emissions from the Fourth Train Proposal for comparison to statutory requirements and does not assess the environmental impacts from noise emissions. Refer to Sections 9, 10, and 13 for an assessment of noise emissions on relevant environmental factors (e.g. fauna).

5.5 Discharges to Land and Water

5.5.1 Assessment Framework or Policy

5.5.1.1 Environmental Objective

The environmental objective established for discharges to land and water in this PER/Draft EIS is:

> *To meet statutory requirements and acceptable standards and thereby avoid or mitigate any adverse effects of discharges on the environmental values of the terrestrial or marine environment or the health, welfare, and amenity of people and land and sea uses.*

This section predicts the discharges to land and water from the Fourth Train Proposal and does not assess the impacts from discharges to land and water on environmental factors (e.g. water quality, fauna). Refer to Sections 9, 10, and 13 for this assessment.

5.5.2 Baseline Discharges

The baseline discharges affecting the Fourth Train Proposal occur as a result of existing activities on Barrow Island, including the Foundation Project and WA Oil, with both contributing to discharges to land and water. The Foundation Project and WA Oil discharges to land and water expected at the time of the implementation of the Fourth Train Proposal include discharges from the sources outlined in Table 5-16 and Table 5-17.

Table 5-16: Baseline Discharges to Land and Water Relevant to the Implementation of the Fourth Train Proposal on Barrow Island

Discharges	Originator	Disposal Method
Produced formation water	Foundation Project WA Oil	Deep well injection Deep well injection
Drainage water	Foundation Project WA Oil	Deep well injection and terrestrial discharge Terrestrial discharge
Treated effluent from sanitary wastewater treatment systems	Foundation Project WA Oil	Deep well injection Marine discharge
Reverse osmosis brine	Foundation Project WA Oil	Marine discharge Marine discharge
Hydrotest water	Foundation Project	Deep well injection Marine discharge

5.5.3 Assessment of Potential Impacts

The Fourth Train Proposal is expected to result in a range of discharges to land and water, including from the sources listed in Table 5-17.

Table 5-17: Discharges Resulting from the Implementation of the Fourth Train Proposal

Activity Type	Discharge
Construction	• Marine vessel discharges • Drilling fluids and cuttings, cementing and completion brine • Hydrotest water • Reverse osmosis reject brine • Treated effluent from sanitary wastewater systems • Drainage during construction (clean and contaminated)
Operations	• Marine vessel discharges • Reverse osmosis reject brine • Wellhead control fluids • Produced formation water • Glycol (spent MEG) solution • Drainage (clean and contaminated) • Hydrocarbons • Treated effluent from sanitary wastewater systems
Construction, Maintenance, and Decommissioning	• Discharges from cleaning, maintaining, or decommissioning equipment

The following sections describe these Fourth Train Proposal discharge sources. For proposed management and disposal of these discharges, refer to Section 5.5.4.

5.5.3.1 Marine Vessels

Marine vessels are likely to discharge brine from their reverse osmosis units to the marine environment, and sea water is likely to be used for engine cooling; if used, the brine and reject cooling water will be discharged immediately after use in the vicinity of each vessel.

The rates of seawater uptake vary with each vessel's horsepower and activities, and therefore will differ between vessels and activity types. For example, during construction a rock installation vessel may discharge approximately 700 m^3/h (16 800 m^3/day) of cooling water at a discharge temperature of approximately 1 to 2 °C above the ambient water temperature. A pipe-lay vessel may discharge approximately 2000 m^3/h (48 000 m^3/day) cooling water at a discharge temperature of up to 15 °C above the ambient water temperature. However, the plume of cooling water quickly loses heat and only a relatively small area around the discharge points will have elevated temperatures. During the operations phase the discharge from large vessels such as tugs will be significantly less due to the design of the tugs.

Engine cooling for tugs is expected to use a closed-loop cooler system, hence no physical discharge of cooling water will occur and there will be no cooling water circulation pumps. Reverse osmosis plants will not be installed on tugs; therefore, no reject brine discharge will occur.

Sewage treatment systems on marine vessels will discharge treated wastewater to the marine environment. The GJVs anticipate that approximately 135 litres of sewage per person per day will be treated on the offshore accommodation (barge accommodation or 'floatel').

The management of treated wastewater and brine discharges from offshore accommodation vessels will be subject to the following hierarchy:

- Eliminate; accommodation vessels will only be used to house some of the workforce as the last contingency
- Reduce; where possible, the treated wastewater will be collected and disposed of at land-based facilities either on Barrow Island or on the mainland (the preferred option)
- Substitute; replace chemical additives in the reverse osmosis and wastewater treatment processes with less hazardous ones
- Administrative controls and management:
  - Clean deck drainage water on vessels will be discharged overboard. If the deck drainage contains traces of oil, grease, or hydrocarbons, it will be directed to a sump, oily water separator, or storage tank.
  - Discharges from vessels' holding tanks will take into consideration the metocean conditions, when possible, to ensure maximum dilution/dispersion of contaminants.

The discharge of surfactants, dispersants, and detergents will be reduced, where practicable.

Wastes generated on offshore vessels are governed by regulatory requirements including MARPOL 73/78 (International Maritime Organization 1997); management measures are likely to include:

- maceration systems for food waste prior to marine disposal (regulated by Annex V of MARPOL 73/78)
- oil/water separator for bilge water/hydrocarbon-contaminated water prior to marine disposal
- sewage treatment systems prior to discharging treated wastewater, as required by Annex IV of MARPOL 73/78
- on-board incineration in accordance with Regulation 16 of Annex VI of MARPOL 73/78.

Greywater is not regulated under MARPOL 73/78, so in accordance with standard marine practice, untreated greywater may be discharged from vessels.

Ballast water discharge from the drilling rigs, heavy haul cargo ships, LNG and condensate vessels, and possibly pipe-lay barges is managed by the requirements of Department of Agriculture (2013). The GJVs expect that approximately 40 000 to 60 000 tonnes of ballast water will be discharged per LNG and condensate vessel arrival. The discharge of ballast water from marine vessels operating in the waters surrounding Barrow Island can be managed by the measures in the approved Foundation Project Terrestrial and Marine Quarantine Management System (Chevron Australia 2014b), with minor amendments to make it suitable for the Fourth Train Proposal. Section 12 outlines the Quarantine Management System (QMS).

Discharges from marine vessels are expected to occur in different locations and rarely in the same area. Therefore, the volumes of discharges from marine vessels associated with the Fourth Train Proposal in addition to the approved Foundation Project are not discussed.

5.5.3.2 Drilling

5.5.3.2.1 Production Wells

Drilling fluids used for drilling production wells in the Fourth Train Proposal are likely to be a combination of water-based and non-aqueous drilling fluids (NADFs). NADFs are low-toxicity synthetic-based fluids, which are commonly used in north-west Australia with regulatory approval. The introduction of NADFs into the marine environment is associated with fluid adhering to discharged cuttings following treatment.

Drilling cuttings are generated throughout the drilling process as formations are cut and removed; higher quantities of cuttings are generated when drilling the first few hundred metres of the well because the borehole diameter is the largest during this stage. During riserless drilling, the fluids and cuttings will be discharged at the seabed and dispersed via subsea currents.

If NADFs are used, drilling fluid residues on the cuttings will be reduced through the use of cleaning technology, such as dryers or centrifuges, prior to the disposal of cuttings overboard.

Excess cement and washings as well as completion brine used during the drilling and completion activities may also be discharged overboard.

Blowout preventer control systems are designed to discharge water-soluble control fluid into the sea upon operation of the blowout preventer stack, which will be tested at a frequency of approximately seven days during drilling or well maintenance activities. A full function test may discharge approximately 2 m^3 of diluted hydraulic fluid. The selected hydraulic fluid is expected to be water-soluble and biodegradable with a low toxicity rating.

5.5.3.2.2 Horizontal Directional Drilling

During horizontal directional drilling, drilling cuttings generated from drilling the pilot hole are intended to be collected for possible re-use or disposal. However, once the hole breaks through the seabed, drilling cuttings will not be able to be recovered and will be discharged to the marine environment. A modelling study conducted for the approved Foundation Project Horizontal Directional Drilling Management and Monitoring Plan (Chevron Australia 2011b), predicted that approximately 1200 tonnes of material would be discharged to the marine environment. Nearly 90% of this material is expected to range from coarse gravel to coarse sand, and is expected to settle into mounds close (<50 m) to the drilling exit holes. The remaining material is expected to be finer material that would be effectively dispersed by current and wave action over large distances (approximately 4 km), generally northward from the horizontal directional drilling exit point. The model predicted maximum total suspended sediment levels to be approximately 12 mg/L within 25 m of the exit holes. However, the spatial extent would quickly reduce so that the maximum total suspended sediment levels at 400 m distance would be expected to be 1 mg/L. Concentrations of the far-field sediment plume are expected to be very low (<1 mg/L), such that the sediment plume would not be discernible above background levels (Chevron Australia 2011b). The GJVs expect similar, although lesser sediment plumes when implementing the Fourth Train Proposal due to the similarity of the horizontal drilling campaigns. The decreased scope of the Fourth Train Proposal horizontal directional drilling campaign (fewer drilled holes compared to the Foundation Project) is expected to result in less material being discharged to the marine environment, although the type of material is expected to be similar.

5.5.3.3 Hydrotest Water

Hydrotest water will be produced from the pre-commissioning of offshore components (including the Offshore Feed Gas Pipeline System and intrafield flowlines) and onshore components (including the onshore Feed Gas Pipeline, portions of the Gas Treatment Plant, and third LNG tank [if required]). Chemical additives (such as oxygen scavenger, biocide, and indicator dyes) may be added to the hydrotest water. It is expected that the chemical additives used in pre-commissioning will be biodegradable.

For the Feed Gas Pipeline, which is the largest component of the Feed Gas Pipeline System, approximately 150 000 m^3 of hydrotest water is expected to be required for the Northern Pipeline Route. For the Southern Pipeline Route, which is approximately 50 km longer, 200 000 m^3 of hydrotest water is expected to be required. Being longer, the Southern Pipeline Route would also require an additional 60 m^3 of hydrotest chemicals, as well as 250 m^3 more MEG than the volume needed for the Northern Pipeline Route.

Table 5-18 lists the hydrotest chemicals for Northern and Southern Pipeline Routes, the indicative amounts planned to be used, and the corresponding chemically treated seawater discharges.

Dispersion modelling was conducted for the approved Foundation Project Offshore Feed Gas Pipeline Installation Management Plan (Chevron Australia 2014c), based on the Gorgon and Jansz Feed Gas Pipelines. This study modelled a discharge of 120 000 m^3 and 220 000 m^3 of biocide-treated hydrotest water – far in excess of the volumes anticipated during the actual hydrotest, therefore representing the worst-case discharge for hydrotest discharge. The modelling found that, in general, the ocean currents are expected to disperse plumes in a north-easterly direction from the release site. The maximum distance from the release site to the trigger concentration of 1.98 ppm threshold was 460 m, with the area of coverage predicted to be 0.30 km^2. The peak biocide concentration was predicted to be 35 ppm adjacent to the release site (<50 m). Generally, the biocide concentrations at the release site were found to return to below the no-effect concentration within a few hours of the cessation of the discharge (Chevron Australia 2014c).

The Fourth Train Proposal is expected to use similar hydrotest chemicals to that of the Foundation Project. Therefore, the results of Foundation Project chemical and hydrotest water discharge modelling could be used for estimating the likely environmental impacts of the Fourth Train Proposal. This approach is justified by these factors:

- The volume of hydrotest water discharged for the Fourth Train Proposal is similar to the volume modelled for the Foundation Project.
- The active ingredients of the Fourth Train Proposal hydrotest chemicals are quaternary ammonium compound (biocide) and ammonium bisulfite (oxygen scavenger), both of which have been approved for use on the Foundation Project. The ammonium bisulfite concentration in the Fourth Train Proposal hydrotest chemicals is less than that used in the Foundation Project modelling, making this comparison conservative.
- Although the biocide compound in Fourth Train Proposal hydrotest chemicals is different to that used in the Foundation Project modelling, its toxicity (measured as LC_{50}) is similar, thus the modelling outcome of the Foundation Project is applicable to the Fourth Train Proposal.
- The maximum depth of discharge modelled for the Foundation Project was 200 m while the expected hydrotest water discharges for the Fourth Train Proposal is 1350 m, making this comparison very conservative.

The largest single component of the Fourth Train Proposal Gas Treatment Plant that requires hydrotesting will be the third LNG tank, if required. The GJVs expect that approximately 120 000 m^3 of hydrotest medium, likely to be sea water, will be used. Other smaller sections of the Fourth Train Proposal Gas Treatment Plant will also require hydrotesting, including the

Slug Catcher and stick-built infrastructure. Section 5.5.4.2 details the proposed management of the various hydrotest water streams, including their discharge locations.

5.5.3.4 Glycol Solution

MEG may be used to dehydrate the Feed Gas Pipeline and intrafield flowlines following hydrotesting; if used, MEG is expected to be transported to an onshore storage tank for later re-use, or be diluted with water and discharged subsea, offshore in deep water. During dewatering, the potable water and MEG slugs may be discharged subsea in slugs of approximately 40 m^3. MEG is considered to be readily biodegradable, with reported aquatic toxicity (LC_{50}) of around 10 000 ppm (Chevron Australia 2014c). Modelling the release of approximately 40 m^3 of MEG at 40 m water depth for the Foundation Project has predicted that the peak concentration of MEG would be 320 ppm, well below the reported toxicity value of 10 000 ppm. It is envisaged that the discharge of 40 m^3 MEG from the Fourth Train Proposal will not exceed the reported toxicity value, as discharges are anticipated to occur offshore at much greater depths (>1000 m) than the MEG discharges from the Foundation Project. Note: MEG is also used during operations to prevent hydrate formation in the gas stream; however, most of this MEG is recycled.

Table 5-18: Hydrotest Chemicals and Hydrotest Water Discharges

Infrastructure	Chemicals and Discharges	Northern Pipeline Route Approximate Volume	Southern Pipeline Route Approximate Volume
Hydrotest Chemicals Required			
Feed Gas Pipelines	Hydrotest Chemicals	170 m^3	230 m^3
Intrafield Pipelines	Hydrotest Chemicals	100 m^3	100 m^3
	Hydrotest Chemicals Total	**270 m^3**	**330 m^3**
Potential MEG Discharge			
Feed Gas Pipelines	MEG	350 m^3	600 m^3
Intrafield Pipelines	MEG	650 m^3	650 m^3
	Total MEG	**1000 m^3**	**1250 m^3**
Chemically Treated Seawater Discharge			
Feed Gas Pipelines	Treated sea water	154 000 m^3	200 000 m^3
Intrafield Pipelines	Treated sea water	84 700 m^3	84 700 m^3
	Feed Gas and Intrafield Pipelines Total	**238 700 m^3**	**284 700 m^3**

5.5.3.5 Reverse Osmosis Reject Brine

Dilution modelling studies were conducted for the reverse osmosis brine discharge from the approved Foundation Project temporary reverse osmosis facilities and the permanent reverse osmosis facilities. The dilution study conducted for the temporary reverse osmosis facilities concluded that a minimum 40-fold dilution factor of reverse osmosis brine could be achieved within the Zone of High Impact, as defined for the Foundation Project. The modelling also predicted that salinity concentrations of the seawater/brine mixture would remain within the natural range of salinity levels observed (Chevron Australia 2013). The permanent reverse osmosis facilities' dilution study found that a 100-fold dilution of the reject brine discharge was predicted within approximately 7 m of the diffuser discharge point (Chevron Australia 2012a). As a result of the spatial separation of the temporary and permanent discharge points (Figure 4-11) and the localised impact of the discharge, no overlap of the plumes was predicted, even when modelled with the plume from a possible Foundation Project accommodation barge (Chevron 2013). It is anticipated that the 40-fold dilution factor will still be achieved in the Zone of High Impact, as defined by the existing Marine Disturbance Footprint approved for the Foundation Project.

As outlined in Section 4, there is no change to the approved capacity of the Foundation Project reverse osmosis facilities due to the shared use by the Fourth Train Proposal; therefore, no additional assessment is provided in this section.

For an assessment of the extended duration of use of the approved Foundation Project temporary reverse osmosis facilities by the Fourth Train Proposal, refer to Section 10.

5.5.3.6 Produced Formation Water

The GJVs expect that the largest volume of liquid hazardous waste, or controlled waste, will be the produced formation water, which will be extracted from the gas fields with the hydrocarbons and separated from the gas and gas condensate (condensate). The produced formation water is expected to be composed primarily of saline water, with high levels of chlorides and traces of other constituents including MEG, hydrocarbons, and activated methyldiethanol amine. The GJVs predict that approximately 78 000 tonnes/year of produced formation water will be disposed of from the Fourth Train Proposal, which represents an increase of approximately 10% from the approved Foundation Project. The Fourth Train Proposal in addition to the approved Foundation Project is predicted to produce approximately 915 000 tonnes/year of produced formation water. Section 5.5.4.3 details the proposed management of produced formation water.

5.5.3.7 Drainage Systems

Class 1 contaminated drainage and Class 2 potentially contaminated drainage will contribute significant volumes of discharges during the operation of the Fourth Train Proposal. The Class 1 contaminated drainage will be collected from contaminated areas of the Fourth Train Proposal Gas Treatment Plant. The Class 2 potentially contaminated drainage will be collected from the first flush of rainfall on the areas of the Fourth Train Proposal Gas Treatment Plant that are classified as potentially contaminated. Class 1 contaminated drainage volumes are expected to be approximately 220 tonnes/year, while Class 2 potentially contaminated drainage volumes are expected to be approximately 3000 tonnes/year. The Fourth Train Proposal in addition to the approved Foundation Project is predicted to produce approximately 12 000 tonnes/year of Class 1 and Class 2 drainage.

Class 3 uncontaminated drainage captured within the Fourth Train Proposal Gas Treatment Plant site will consist of stormwater drainage collected from uncontaminated areas, or from potentially contaminated areas after the first flush of rainfall has been collected, and it will be released into the terrestrial environment on the south side of the Plant.

5.5.3.8 Treated Effluent

As outlined in Section 4, the Fourth Train Proposal will use the existing wastewater treatment plants on Barrow Island. There will be no change to the approved capacity of the wastewater treatment plants on Barrow Island due to the shared use by the Fourth Train Proposal; therefore, no additional assessment is provided. The treated effluent from the approved Foundation Project will be disposed via deep well injection, and from WA Oil via ocean discharge.

5.5.4 Proposed Management Actions

The GJVs consider that the potential impacts by the Fourth Train Proposal can be effectively managed under EMPs for the approved Foundation Project. No additional measures or controls are anticipated to be necessary to manage the potential impacts from the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the relevant approved Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal.

The existing EMPs that are relevant to addressing potential discharges to land and water from the Fourth Train Proposal are:

- Horizontal Directional Drilling Management and Monitoring Plan
- Offshore Feed Gas Pipeline Installation Management Plan (or equivalent Environment Plan)
- Solid and Liquid Waste Management Plan.

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

Environment Plans will also be required for the drilling and completion of Fourth Train Proposal production wells. Subsidiary documents relevant to addressing potential impacts of the Fourth Train Proposal will be developed, including Environment Plans submitted to meet the requirements of the Offshore Petroleum and Greenhouse Gas Storage Regulations 2009 (Cth), the Petroleum (Submerged Lands) (Environment) Regulations 2012 (WA), and the Petroleum Pipelines (Environment) Regulations 2012 (WA).

The Ministerial Conditions require that the GJVs prepare and submit a Solid and Liquid Waste Management Plan to the Commonwealth and State Ministers for Environment for approval.

An objective of the approved Foundation Project Solid and Liquid Waste Management Plan (Chevron Australia 2014d) is to ensure that:

- discharges from any wastewater treatment plant, reverse osmosis plant, or other process waters are disposed of via deep well injection, unless otherwise authorised by the Western Australian Minister (for Environment)
- deep well injection of liquid wastes for the Gorgon Gas Development is conducted in a manner that will not cause Material or Serious Environmental Harm to subterranean fauna and their habitats on Barrow Island.

5.5.4.1 Drilling Fluids and Cuttings

When NADF is used to drill the production wells, it is expected to be mixed onshore and stored, maintained, and recycled in surface tanks on the drilling rig. In a closed circulation system, which is used when drilling the lower hole sections with NADF, the fluids will return to the surface equipment where they will be processed and separated using a range of solids-control equipment. Drilling fluids and cuttings will become wastes at different stages of the drilling process.

Waste drilling fluid is handled at the completion of drilling as the entire drilling fluid system is removed from the hole and replaced by completion equipment and fluids. After the completion of drilling, fluid components can be recovered by a secondary cleaning technology, such as dryers or centrifuges at the rig or by returning the drilling fluids to the supplier. A small portion of fluids will be lost during the separation of drilling cuttings; this fluid will be disposed overboard with the treated cuttings. The drilling fluid components proposed by the GJVs are expected to have very low toxicity to marine life while still remaining technically suitable for the task.

Drilling fluids and cuttings from the horizontal directional drilled holes will be appropriately bunded or contained. All cuttings able to be recovered at the horizontal directional drilling hardstand area will be collected and disposed of on the mainland, or if suitable, used as construction fill. Prior to re-use, cuttings shall undergo an assessment of contaminants against the Contaminated Sites Management Series – Assessment Levels for Soil, Sediment and Water (Department of Environment [DoE 2003]) and Landfill Waste Classification and Waste Definitions (DoE 1996).

5.5.4.2 Hydrotest Water

The GJVs plan to use a hierarchy of disposal options for the disposal of hydrotest fluids from pre-commissioning of both offshore components (including the Offshore Feed Gas Pipeline) and onshore components (including the third LNG tank, if required). This hierarchy is the same as that used by the approved Foundation Project:

1. Multiple uses of hydrotest water to minimise quantities requiring disposal, where practicable.
2. Recycling and re-use of the hydrotest water (e.g. firewater).
3. Disposal via deep well injection.
4. Disposal to the marine environment in combination with other risk reduction measures (as approved by the regulator):
   - disposal in deep water; preferred option
   - disposal in shallow water; only as last resort.

Lessons learnt from the disposal of hydrotest water used in the approved Foundation Project will be used to develop the most suitable disposal options for the Fourth Train Proposal. However, hydrotesting of the approved Foundation Project infrastructure is not expected to commence until after the submission of this PER/Draft EIS.

5.5.4.3 Deep Well Injection

The GJVs plan to dispose of Fourth Train Proposal produced formation water, contaminated drainage, and treated effluent from sanitary wastewater systems via deep well injection, in accordance with the same management measures required by the Ministerial Conditions for the approved Foundation Project. The Fourth Train Proposal will use the approved Foundation Project deep injection wells. Prior to injection of the discharges, the liquid streams will be treated by oily water separation if required. Note: Reverse osmosis reject brine will not be disposed of via deep well injection.

The GJVs expect to dispose of liquid wastes by injection into the Flacourt and Malouet Formations at a depth of approximately 1500 m. Investigations into the ability of the subsurface formations to accommodate the Fourth Train Proposal deep well injection discharges have shown that the increased volumes can be accommodated safely.

At the time of submission of this PER/Draft EIS, the approved Foundation Project is using two existing deep injection wells previously used by WA Oil. Two new deep injection wells are currently being prepared by the approved Foundation Project and are scheduled to be ready for use by the time Fourth Train Proposal construction activities are anticipated to commence. These deep injection wells are expected to have sufficient capacity to cater for liquid wastes from the approved Foundation Project and the Fourth Train Proposal.

5.5.5 Summary of Liquid Waste Discharges

Table 5-19 summarises the estimated or actual quantities/volumes, disposal methods (including reinjection), and location of the liquid waste discharges for both construction and operation of the Fourth Train Proposal. The discharges from LNG and condensate export vessels, and discharges with negligible volumes (e.g. cementing and completion brine discharges) were not included in this summary table.

Table 5-19: Main Liquid Waste Discharges from the Fourth Train Proposal

Main Liquid Waste Discharges from the Fourth Train Proposal	Construction Discharges		Operations Discharges	
	Quantity or Volume Approx.	Location/Method of Discharge or Disposal	Quantity or Volume Approx.	Location/Method of Discharge or Disposal
Hydrotest fluid for the Feed gas and Intrafield Pipeline System – Southern Pipeline Route (m^3)	290 000	According to the hierarchy of disposal for hydrotest fluids	-	-
Hydrotest fluid for the Feed gas and Intrafield Pipeline System – Northern Pipeline Route (m^3)	240 000	According to the hierarchy of disposal for hydrotest fluids	-	-
Hydrotest fluid from the third LNG tank (m^3)	120 000	According to the hierarchy of disposal for hydrotest fluids	-	-
Reject brine from Reverse Osmosis Plants (m^3/day)	8000*	Discharged to sea adjacent to the Materials Offloading Facility	2600*	Discharged to sea adjacent to the Materials Offloading Facility
Treated effluent from sanitary wastewater systems (m^3/day)	2710*	Deep well injection on Barrow Island	2000*	Deep well injection on Barrow Island
Drilling fluids from drilling 16 production wells (m^3)	120 000	Discharged from drilling rig to sea in deep water	-	-
	2000	Disposed in a licensed disposal facility according to its waste classification	-	-
Drilling fluids from Horizontal Directional Drilling (m^3)	75 000	Lost to formation due to the geology of site	-	-
	25 000	Lost to sea at the break-through point	-	-
	200	Disposed in a licensed disposal facility according to its waste classification	-	-
Produced formation water (T/year)	-	-	78 000	Deep well injection on Barrow Island
Class 2 drainage (T/year)	-	-	3000	Deep well injection or discharged to terrestrial environment if tests find it clean

Main Liquid Waste Discharges from the Fourth Train Proposal	Construction Discharges		Operations Discharges	
	Quantity or Volume Approx.	Location/Method of Discharge or Disposal	Quantity or Volume Approx.	Location/Method of Discharge or Disposal
Cooling water from marine vessels; construction discharge is based on a typical pipe-lay vessel; operation discharge is based on cooling water discharge from tugs (m^3/hour/vessel)	2000	Discharged from vessel to sea	NA	The cooling water quantity or volume cannot be determined. The waste heat from the tug is rejected to the sea via box coolers on the bottom of the vessel; no pumps are used, therefore there is no measurable flow
Glycol (MEG) solution (T/year)	1400	Once-off process of dehydrating pipelines after hydrotesting. Discharged subsea in slugs of approximately 40 m^3	1400	Deep well injection on Barrow Island
Class 1 drainage (T/year)	-	-	220	Deep well injection on Barrow Island
Hydrocarbons (T/year)	-	-	120	Disposed in a licensed disposal facility according to its waste classification

* *The Reject Brine and Treated Effluent discharge volumes are based on the maximum capacity of the respective plants*

5.5.6 Predicted Environmental Outcome

No different discharges to land and water are predicted for the Fourth Train Proposal compared to the approved Foundation Project. The GJVs consider that the Fourth Train Proposal will have similar discharges to land and water as the approved Foundation Project with only a small increase in volume. The Fourth Train Proposal in addition to the approved Foundation Project is expected to result in an increased duration of construction-related discharges to land and water, including reverse osmosis brine and treated effluent from sanitary wastewater systems. The operation of the Fourth Train Proposal will increase the volume of discharges to land and water produced on Barrow Island, with similar types of discharges as those expected for the operational Foundation Project.

Therefore, the GJVs consider that the discharges to land and water from the Fourth Train Proposal will be adequately managed by the approved Foundation Project EMPs (with minor amendments) such that they are environmentally acceptable and the environmental objective (Section 5.5.1.1) is met.

Note: This section predicts the discharges to land and water from the Fourth Train Proposal and does not assess the impacts from discharges to land and water on environmental factors (e.g. water quality, fauna). Refer to Sections 9, 10, and 13 for this assessment.

5.6 Solid and Liquid Waste Management

5.6.1 Assessment Framework or Policy

5.6.1.1 Environmental Objective

The environmental objective established for solid and liquid waste in this PER/Draft EIS is:

> *To prevent or mitigate against wastes adversely affecting groundwater or surface water quality or leading to soil contamination.*

This section predicts the solid and liquid waste generated by the Fourth Train Proposal and does not assess the impacts from solid and liquid waste on environmental factors (e.g. water quality). Refer to Section 9 for this assessment.

5.6.1.2 State Legislation

The Environmental Protection (Controlled Waste) Regulations 2004 (WA) are designed to ensure the safe transportation of controlled waste to an approved location and to monitor and track controlled waste to prevent unauthorised discharge into the environment. Materials classified as Controlled Wastes are listed in Schedule 1 of the Regulations.

Monitoring, handling, transporting, and disposing of radioactive substances, including naturally occurring radioactive materials (NORM), are regulated by the *Radiation Safety Act 1975* (WA) and its subsidiary legislation.

5.6.2 Assessment of Potential Impacts

5.6.2.1 Solid and Liquid Waste from Construction Activities

The waste streams that the GJVs predict will result from the construction of the Fourth Train Proposal are expected to be very similar to the waste streams produced by the construction of the approved Foundation Project; no different waste streams are predicted. However, some waste streams that occurred in the construction of the Foundation Project will not occur in the Fourth Train Proposal, due to the difference in work scopes. These include waste associated with the dredging program and construction of the Materials Offloading Facility and the LNG Jetty (primarily dredge spoil).

A variety of solid and liquid wastes will be produced during the construction of the Fourth Train Proposal. As outlined in the Solid and Liquid Waste Management Plan (Chevron Australia 2014d), the wastes produced on Barrow Island can broadly be categorised into:

- general waste
- solid hazardous or controlled waste
- liquid hazardous or controlled waste
- quarantine risk material.

General waste is any material that is free of hazardous chemicals or pathological, infectious, or radioactive contamination. Solid hazardous or controlled waste is any waste solid that has the potential to harm the environment or living organisms. Solid controlled waste includes materials classified as Controlled Wastes as listed in Schedule 1 of the Environmental Protection (Controlled Waste) Regulations 2004 (WA). Similarly, liquid hazardous or controlled waste is any waste that has the potential to harm the environment or living organisms or that is listed in Schedule 1 of the Environmental Protection (Controlled Waste) Regulations 2004 (WA). Quarantine risk material is any material that has a higher probability than general freight and cargo of harbouring non-indigenous species. Note: This includes materials that may harbour species found on Barrow Island but that are not found on the mainland. Table 5-20 lists the waste streams for each waste type from both terrestrial and marine activities.

Table 5-20: Waste Streams Expected to be Produced during Construction of the Fourth Train Proposal

Waste Type	Typical Waste Streams
General waste	Cleared vegetation, excess spoil, cigarette butts, plastics, excess cabling, aluminium cans, pipe offcuts, pipe end caps, welding rods, air filters, cardboard, paper, toner/printer/fax cartridges, light globes, storage containers, clean drums, scrap metals, cable reels, waste concrete
Solid hazardous or controlled waste	Hydrocarbon-contaminated soil and absorbents, containers or drums contaminated with residues of hazardous waste, medical/sanitary wastes, oil and fuel filters, batteries
Liquid hazardous or controlled waste	Used oils, hydraulic fluids, engine coolant, chemicals, contaminated drill waste, solvents, acids, alkalis, aviation gas, firefighting materials, waste from wastewater treatment facilities, bilge water
Quarantine risk material	Any material that has a higher probability than general freight and cargo of harbouring non-indigenous species, including: • soil, plant material, vertebrates, and invertebrates found on goods and personnel • cardboard packaging • sweepings and vacuum cleaner bags from the camp • vessel ballast water • putrescible wastes • kitchen wastes (food wrappings) • grease trap residues • crib lunch wastes and wrappings • shrink-wrap plastic • anything discarded in the Quarantine Approved Premises on Barrow Island • sediment trap material and filter residue from the Quarantine Approved Premises washdown area • sediment trap material from drains in the Quarantine Approved Premises

These typical waste streams are generally expected to increase only incrementally due to the implementation of the Fourth Train Proposal, compared to the Foundation Project. For example, increases of approximately one-third, compared to the Foundation Project, are generally expected for most construction-related waste streams.

5.6.2.2 Solid and Liquid Waste from Operational Activities

In addition to the general waste and quarantine risk material identified during construction activities, operation of the Fourth Train Proposal is expected to produce a higher proportion of hazardous solid and liquid waste streams than during construction. However, the Fourth Train Proposal is not expected to produce different hazardous or controlled wastes compared to the approved Foundation Project.

Table 5-21: Waste Streams Expected to be Produced during Operation of the Fourth Train Proposal

Waste Type	Typical Waste Streams
Solid hazardous, controlled or intractable waste	Solid hazardous wastes include: • spent molecular sieves (alumino-silicates and silica gel) • spent adsorbents, such as spent mercury adsorbent and spent activated carbon contaminated with amine residues • pigging wastes (produced solids including NORM, corrosion products, and waxy residues) • produced sand from inlet facilities (sand contaminated with MEG/corrosion inhibitors, hydrocarbons etc.) • MEG salt solids • hydrocarbon-contaminated sludge • contaminated soil • biological sludge from wastewater treatment facilities • spent filter cartridges contaminated with hydrocarbons, chemicals, and fine particles • settled sediment and fines in the Class 1 and 2 (contaminated and potentially contaminated) drainage system • lubricating oils, oily rags etc. • laboratory wastes
Liquid hazardous or controlled waste	Liquid hazardous wastes include: • MEG slurry • spent MEG • spent amine solution • laboratory chemical residues and wastes • spent lubricating oil • waste from wastewater treatment facilities • slop oil (oil and water) • chemical wash water • acidic water produced from carbon dioxide injection reservoir pressure relief wells

5.6.2.2.1 Contaminated Sludge

The GJVs expect that contaminated sludge will be the largest solid hazardous or controlled waste stream generated within the Fourth Train Proposal Gas Treatment Plant; it is expected to be produced continuously during the operation of the Gas Treatment Plant. Contaminated sludge will be removed for disposal intermittently from the approved Foundation Project shared facilities such as the:

- oily water separator
- disposal water tanks (the Fourth Train Proposal may install an additional disposal water tank)
- sanitary wastewater systems.

The GJVs estimate that approximately 600 tonnes/year of contaminated sludge will be produced by the Fourth Train Proposal during its operations phase, an amount approximately one-third of that approved for the Foundation Project. The Fourth Train Proposal in addition to the approved Foundation Project is predicted to produce approximately 2300 tonnes/year of contaminated sludge.

5.6.2.2.2 Molecular Sieve and Mercury Removal Adsorbent

The GJVs predict that other solid hazardous or controlled waste streams, such as molecular sieves and spent mercury removal adsorbent, will be produced during non-routine operational situations such as maintenance and shutdowns. Molecular sieves are used in the gas treatment process to remove water from the gas within the Dehydration Unit, and mercury removal adsorbent is used to remove mercury from the gas stream in the Mercury Removal Units.

Approximately 150 tonnes/year of spent molecular sieves are predicted to require disposal; this is approximately one-third of amount of waste sieves expected from the Foundation Project. The Fourth Train Proposal in addition to the approved Foundation Project is predicted to produce approximately 600 tonnes/year of molecular sieves. The above figures are conservative, because the calculation assumes an annual change-out of the molecular sieves; however, less frequent changes are expected.

Mercury removal adsorbent change-outs for the Fourth Train Proposal are expected to occur periodically (i.e. approximately every four years) for each Mercury Removal Unit. Volumes of spent mercury removal adsorbent requiring disposal per year are predicted to range from zero, in years where no adsorbent change-out is required, to approximately 525 tonnes during a full mercury removal adsorbent change-out for the Fourth Train Proposal; however, a full change-out is not expected to occur as maintenance and adsorbent change-out is generally staggered. On average, approximately 130 tonnes/year of spent mercury removal adsorbent is expected to require removal from the Fourth Train Proposal.

The predicted maximum annual volume of spent mercury removal adsorbent requiring disposal from the Foundation Project is approximately 590 tonnes, a full mercury removal adsorbent change-out is required. Although the annual average is predicted to be approximately 400 tonnes.

The Combined Gorgon Gas Development is predicted to produce an average of approximately 530 tonnes/year of spent mercury removal adsorbent. The highest volume of spent mercury removal adsorbent from the Combined Gorgon Gas Development per year is not predicted to be above that of the Foundation Project, as this value is derived by changing out each type of Mercury Removal Unit in a year.

5.6.2.2.3 Spent Filters

Spent filter elements requiring disposal are expected to be sourced from a number of locations in the Fourth Train Proposal Gas Treatment Plant; these elements filter a range of materials, including hydrocarbons, chemicals, nitrogen, and air.

Filters processing hydrocarbons and chemicals are solid hazardous or controlled waste, and are expected to comprise approximately 50 tonnes/year. Air filters and nitrogen filters are predicted to account for approximately 5 tonnes/year of general waste. These figures represent an amount approximately one-third of that approved for the Foundation Project. The Fourth Train Proposal in addition to the approved Foundation Project is predicted to produce approximately 200 tonnes/year of hazardous or controlled waste spent filters and approximately 20 tonnes/year of general waste spent filters.

5.6.2.2.4 Glycol Solution

Waste glycol solution, including lean MEG, coolant streams, and aqueous solutions with MEG, is expected to be injected into deep wells when it is no longer required in the Fourth Train Proposal Gas Treatment Plant or Feed Gas Pipeline System. Approximately 1400 tonnes/year of waste glycol solution is expected to be produced, which represents an amount approximately one-third of that approved for the Foundation Project. The Fourth Train Proposal in addition to the approved Foundation Project is predicted to produce approximately 5700 tonnes/year of waste glycol solution.

5.6.2.2.5 Naturally Occurring Radioactive Material

There are very low levels of NORM detected in the produced water from the Fourth Train Proposal gas fields, similarly to that of the Foundation Project. These NORM levels are two orders of magnitude lower than the 1 Bq/g threshold level recommended for regulatory assessment and control (Australian Radiation Protection and Nuclear Safety Agency 2008). However, there is potential for radionuclides to form scale in flowlines/pipework, pumps, and tanks, which will build up over time. Although this may not immediately be a hazard, over the life of the project there is potential for the accumulated NORM to present a health hazard to workers who might use, rework, and/or recycle contaminated equipment/material during maintenance activities or during decommissioning of equipment or plant.

The monitoring, control, and management requirements of NORM and other ionising radiation sources are summarised in Ionising Radiation Management OE Procedure (Chevron Australia 2012b). The Ionising Radiation Management OE Procedure identifies that:

- When not in use, all sources of ionising radiation will be kept securely in dedicated storage that complies with the requirements of the Department of Health, Radiation Health Section.
- Radioactive materials will be transported by appropriately licensed transporters in compliance with Western Australian Radiation Safety (Transport of Radioactive Substances) Regulations and with the Code of Practice for the Safe Transport of Radioactive Material (Radiation Protection Series Publication No. 2) (Australian Radiation Protection and Nuclear Safety Agency 2001).
- In the absence of practically available destruction, disposal or management technologies in Australia, radioactive waste will be disposed of at a Class V Landfill site.

Figure 5-10 provides an overview of the NORM management system from monitoring and detection to disposal.

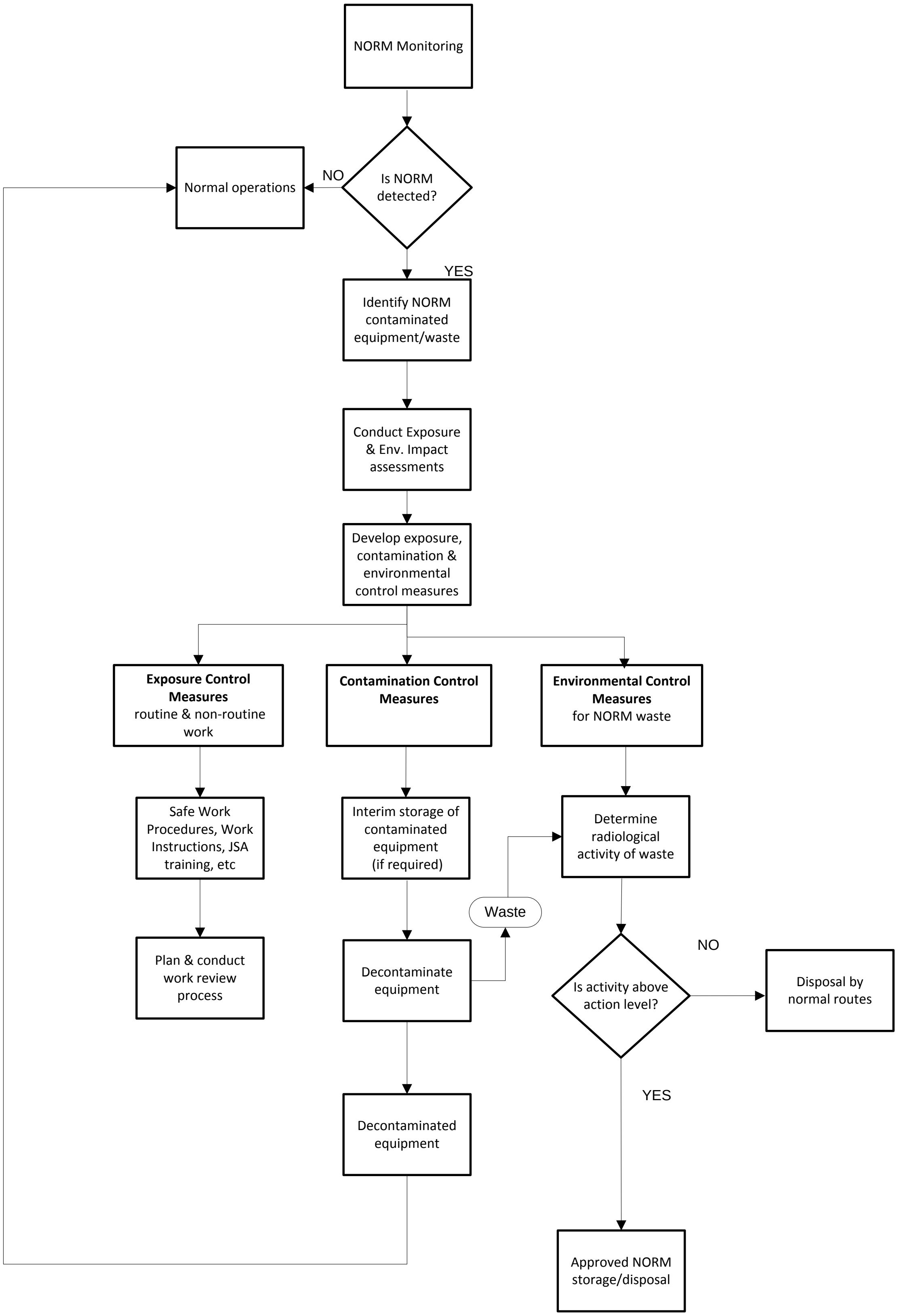


Figure 5-10: NORM Risk Management System

5.6.2.2.6 Solid and Liquid Waste from Decommissioning Activities

The generation, management, and disposal of wastes, both non-hazardous (e.g. scrap metal, concrete) and potentially contaminated or hazardous wastes (e.g. pipes, valves, entrained liquids/sludge), will be key aspects of the decommissioning phase. Wastes generated will be managed in accordance with prevailing regulatory and safety requirements at the time of decommissioning. Efforts will need to be made during decommissioning planning to ensure that maximum re-use and recycling of wastes is achieved. With the implementation of the

Fourth Train Proposal, waste streams from decommissioning activities are generally expected to increase only incrementally (by approximately one-third) compared to the approved Foundation Project.

5.6.3 Proposed Management Actions

The GJVs consider that the potential impacts from the Fourth Train Proposal can be effectively managed under EMPs for the approved Foundation Project. No additional measures or controls are anticipated to be necessary to manage the potential impacts to the environment associated with the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the relevant approved Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal.

The EMPs that are relevant to addressing potential solid and liquid waste from the Fourth Train Proposal are the:

- Solid and Liquid Waste Management Plan
- Horizontal Direction Drilling Monitoring and Management Plan
- Terrestrial and Subterranean Environment Protection Plan
- Decommissioning and Closure Plan.

The Solid and Liquid Waste Management Plan is the primary mechanism for managing solid and liquid wastes for the approved Foundation Project. Further details of the changes needed to be made to the Solid and Waste Management Plan to incorporate the Fourth Train Proposal are outlined in Table 16-2.

An objective of the approved Foundation Project Solid and Liquid Waste Management Plan (Chevron Australia 2014d), as required by Ministerial Conditions, is that all Proposal (approved Foundation Project)-related solid and liquid wastes are either removed from Barrow Island or, if not, that all practicable means are used to ensure that waste disposal does not cause Material or Serious Environmental Harm to Barrow Island and its surrounding waters. The following management measures are taken from the Solid and Liquid Waste Management Plan (Chevron Australia 2014d); these are also expected to be implemented for the Fourth Train Proposal.

The hierarchical application of measures to ensure responsible waste management is:

1. Source reduction
2. Re-use
3. Recycling/Recovery
4. Treatment
5. Responsible disposal.

Elements of these practices are detailed in Table 5-22.

Table 5-22: Outline of Illustrative Waste Management Measures

Waste Management Practice	Outline
Source reduction	Eliminate or decrease, where practicable, the volume, concentration, or toxicity of a waste stream through: • process optimisation and proper maintenance • substitution • material elimination • management and control of inventories • improved housekeeping. Where wastes cannot be reduced at source, the next preferred waste management options are re-use and recycle. A number of waste streams are candidates for re-use or recycling if they are correctly segregated.
Re-use	Use the materials or products more than once, in their original form
Recycling/recovery	Convert wastes into usable materials and/or extract energy or materials from wastes
Treatment	Destroy, detoxify, and/or neutralise residues through processing
Responsible disposal	Use appropriate methods to responsibly dispose of any waste streams that remain after practicable source reduction, re-use, recycle/recovery, and treatment options have been implemented. From Barrow Island, appropriate wastes will be sent to Chevron Australia-approved, and appropriately licensed, landfill or treatment facilities on the mainland.

The similarity of expected waste streams between construction and operations activities of the Fourth Train Proposal means that similar management techniques can be used throughout the implementation of the Fourth Train Proposal.

A number of waste streams expected to be produced by the Fourth Train Proposal are expected to be managed and disposed of at Barrow Island, including:

- drilling cuttings
- concrete.

Drilling cuttings collected during onshore drilling, including the horizontal directional drilling and concrete waste generated on Barrow Island, may be re-used for fill material or reinjected into existing wells on Barrow Island, where practicable. Prior to the re-use of drilling cuttings, the material will be assessed for contamination according to the following criteria:

- Contaminated Sites Management Series – Assessment Levels for Soil, Sediment and Water (DEC 2010)
- Landfill Waste Classification and Waste Definitions (DoE 1996).

Prior to waste concrete being used as a source of fill material, it will undergo an evaluation by Chevron Australia to determine if it is suitable for its final proposed destination.

Waste generated on Barrow Island that cannot be re-used, recycled, or disposed of on Barrow Island (such as drilling cuttings and waste concrete), is expected to be sent to Chevron Australia-approved facilities on the mainland for recycling, treatment, or disposal. It is expected that Fourth Train Proposal waste will be managed using the approved Foundation Project waste management facilities, including a waste transfer station on Barrow Island. The waste transfer station will handle, consolidate, and temporarily store most of the waste produced on Barrow Island before removal to the mainland for appropriate re-use, recycling, recovery, treatment, or disposal. The waste materials will be stored in accordance with the relevant Australian Standards and will be covered and bunded, where appropriate.

For wastes sent to landfill on the mainland for disposal, the Landfill Waste Classification and Waste Definitions (DoE 1996) shall be applied to ensure that wastes are only sent to landfills that are permitted to receive them. Any waste sent to landfill will only be disposed of to a relevant Chevron Australia-approved and appropriately licensed facility. Transport and disposal of Controlled Wastes will be undertaken in compliance with the Environmental Protection (Controlled Waste) Regulations 2004 (WA).

5.6.4 Summary of Solid Wastes

Table 5-23 summarises the estimated or actual quantities/volumes and disposal method and location of key solid wastes for both construction and operation of the Fourth Train Proposal.

Table 5-23: Key Solid Wastes of the Fourth Train Proposal

Solid Waste Discharges of the Fourth Train Proposal	Construction		Operations	
	Quantity or Volume	Location/Method of Discharge or Disposal	Quantity or Volume	Location/Method of Discharge or Disposal
Cuttings from drilling 16 production wells (tonnes)	11 300	Discharged from drilling rig to sea	-	-
Cuttings from Horizontal Directional Drilling (m^3)	250	Recycled for construction or disposed in a licensed disposal facility according to waste classification	-	-
Contaminated sludge (T/year)	-	-	600	In a licensed disposal facility according to waste classification
Molecular sieve T/year)	-	-	150	In a licensed disposal facility according to waste classification
Spent Filters (T/year)	-	-	55	In a licensed disposal facility according to waste classification
Spent mercury removal adsorbent (T/year)	-	-	130*	In a licensed disposal facility according to waste classification

* *Annual average calculation; see Section 5.6.2.2.2 for further details*

5.6.5 Predicted Environmental Outcome

The GJVs expect that the Fourth Train Proposal will create similar waste streams to those of the approved Foundation Project. No different waste streams are predicted for the Fourth Train Proposal compared to the approved Foundation Project. During construction activities, the incremental waste generated by the Fourth Train Proposal is predicted to be less than one-third of the waste generated by the approved Foundation Project. During operations, the Fourth Train Proposal incremental waste is predicted to increase by approximately one-third the solid and liquid waste generated by the approved Foundation Project.

The Fourth Train Proposal in addition to the approved Foundation Project is expected to increase the duration of construction waste generation. The operation of the Fourth Train Proposal will increase the volume of waste produced on Barrow Island, with similar waste streams predicted as those expected for the operational Foundation Project.

The GJVs consider that the solid and liquid waste from the Fourth Train Proposal can be managed by the approved Foundation Project EMPs, with minor changes, such that they are environmentally acceptable and the environmental objective (Section 5.6.1.1) is met.

Note: This section predicts the solid and liquid waste generated by the Fourth Train Proposal and does not assess the impacts from solid and liquid waste on environmental factors (e.g. water quality). Refer to Section 9 for this assessment.

5.7 Accidental Releases (Spills and Leaks) to the Marine Environment

5.7.1 Assessment Framework or Policy

5.7.1.1 Environmental Objective

The environmental objective established for accidental releases to the marine environment in this PER/Draft EIS is:

> *To handle and store hydrocarbons and other chemicals in a manner that reduces the potential for leaks, spills, and emergency situations to impact on the environment to as low as reasonably practicable.*

This section predicts the transport and fate of spills and leaks to the marine environment; it does not assess the impact of a spill or leak on environmental factors. Refer to Sections 10 and 13 for this assessment.

5.7.2 Assessment of Potential Impacts

Spills and leaks to the marine environment may result from offshore components of the Fourth Train Proposal. Potential releases to the marine environment from the Fourth Train Proposal may be a result of:

- a well blowout releasing formation fluids including hydrocarbons (a mixture of gas and condensate) and produced water
- a rupture or leak from the intrafield flowlines, cluster manifolds, or Feed Gas Pipeline System, which has the potential to release the contents of the pipeline including production fluids (gas, condensate, and produced water with production chemicals), MEG, and hydraulic fluids
- a marine vessel incident during offshore activities, which has the potential to release diesel into the marine environment
- an incident on the Materials Offloading Facility, which could potentially release diesel into the marine environment
- a grounded condensate vessel, which could potentially release condensate, light crude oil, or heavy fuel oil.

5.7.2.1 Fate and Transport of Spilled Hydrocarbons (Oil Spill Modelling)

The fate and transport of hydrocarbon spills to the marine environment, in terms of their trajectory and nature, will change due to transportation and weathering mechanisms. An oil spill modelling study was conducted for the Fourth Train Proposal to determine the fate and transport of hydrocarbons spilled to the marine environment.

A number of possible scenarios were modelled for the Fourth Train Proposal, including:

- well blowout at the Chandon Gas Field
- rupture from the intrafield flowlines
- marine vessel diesel spill at the Chandon Gas Field.

In addition, previously modelled scenarios used to assess potential impacts of the approved Foundation Project were also used to assess the implementation of the Fourth Train Proposal. These Foundation Project scenarios include:

- Feed Gas Pipeline rupture
- diesel spill adjacent to the Materials Offloading Facility and along the Gorgon Feed Gas Pipeline route
- grounded condensate vessel.

Table 5-24: Hydrocarbon Spill Modelling Scenarios Relevant to the Fourth Train Proposal

<table>
<tr><th>Scenario</th><th>Spill Volume</th><th>Spill Location</th></tr>
<tr><td>Well blowout (11-week release)</td><td>28 757 kL</td><td>Chandon Gas Field (1200 m depth at seabed)</td></tr>
<tr><td rowspan="2">Intrafield flowline rupture</td><td>200 kL</td><td>Chandon Manifold Intrafield Flowline Tie-in (1200 m depth at seabed)</td></tr>
<tr><td>200 kL</td><td>Jansz Pipeline Termination Structure Tie-in (1345 m depth at seabed)</td></tr>
<tr><td>Major diesel spill from marine vessel</td><td>80 kL</td><td>Chandon Gas Field</td></tr>
<tr><td rowspan="5">Minor diesel spill from marine vessel</td><td>2.5 kL</td><td>Chandon Gas Field</td></tr>
<tr><td>2.5 kL</td><td>Feed Gas Pipeline Route 2.5 km west of Barrow Island</td></tr>
<tr><td>2.5 kL</td><td>Feed Gas Pipeline Route 5 km west of Barrow Island</td></tr>
<tr><td>2.5 kL</td><td>Feed Gas Pipeline Route 10 km west of Barrow Island</td></tr>
<tr><td>0.1 kL to 10 kL</td><td>Adjacent to Materials Offloading Facility</td></tr>
<tr><td rowspan="3">Grounded condensate vessel</td><td>10 kL to 100 kL of Gorgon condensate</td><td>Adjacent to Tanker Terminal</td></tr>
<tr><td>10 kL to 100 kL of light crude oil</td><td>Adjacent to Tanker Terminal</td></tr>
<tr><td>10 kL to 100 kL of bunker fuel oil</td><td>Adjacent to Tanker Terminal</td></tr>
</table>

The minor diesel spills were assumed to occur along the Northern Pipeline Route

Chandon was selected as being representative of the worst-case gas field for use in the hydrocarbon spill study, as this gas field is predicted to have the highest liquid release volume based on the combination of maximum flow rate per well and the gas-to-oil-ratio of the Fourth Train Proposal gas fields (Table 5-25). Therefore, despite its remote location, a spill from the Chandon Gas Field is expected to have the highest environmental impact. The numbers of wells of the four gas fields are all similar; therefore, the predicted liquid release volume was the determining factor for the modelling.

Table 5-25: Comparison of Reservoir Properties from the Fourth Train Proposal Gas Fields in a Blowout Scenario

Parameter	Chandon	Geryon	Orthrus	Maenad
Release depth (m)	1200	1224	1197	1219
Oil density (g/cm^3)	0.74	0.78	0.79	0.79
Oil viscosity (cP)	1.00	0.95	1.05	1.05
Oil temp (C°)	73	80	87	87
GAS:OIL ratio (m^3/m^3)	31 275	72 887	58 028	58 028
Oil flow rate (bbl/day)	2349	1153	1163	915

Note: Diameter of pipe is the consistent across all fields.

As the Chandon Gas Field is representative of the worst case, no releases from other Fourth Train Proposal gas fields were modelled.

To understand the potential environmental risks associated with spills and leaks to the marine environment, three aspects were examined:

- Primary Risk: The likelihood that a spill will occur
- Secondary Risk: If a spill occurs, the way that the material moves with wind, currents, and ambient water temperature (seasonal aspects), and how the material behaves with other natural processes such as evaporation, dissolution into the water column, and natural degradation
- Tertiary (Joint) Risk: Given the above two aspects, and for any given spill scenario in specific weather conditions, the likelihood of the spill reaching sensitive receptors and its possible impact on those receptors. Impacts on receptors are assessed in Sections 10 and 13.

The primary risk was determined by assessing the likelihood of the spill occurring. Statistical probabilities for primary risk for each of the spill scenarios were derived from industry databases. Refer to Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill, Section 5] for additional detail on the determination of primary risk.

Hydrocarbon spill modelling was used to determine the secondary risk by quantifying the transport and behaviour of the potential releases. The secondary risk for the Fourth Train Proposal spill scenarios is discussed in detail in Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill, Appendix 1], and for the approved Foundation Project discussed in detail in Modelling Spills and Discharges (APASA 2005). In both studies, the modelling was conducted over different seasons to reflect the seasonality of meteorological conditions, including ocean currents and weather patterns.

For additional details of the inputs and assumptions used in this modelling for the Fourth Train Proposal, including water depth, duration, drilling complexity, historical context, and geophysical and geochemical characteristics, refer to Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill].

5.7.2.1.1 Fourth Train Proposal Hydrocarbon Spill Modelling Methodology

The hydrocarbon spill modelling was based on the assumption of no intervention to contain the spill; thus, the modelling represents the worst-case probabilities for each spill scenario. Refer to Section 5.7.3 for the proposed hydrocarbon spill response planned to be used by the Fourth Train Proposal.

Threshold concentrations were defined to allow the probability of oil contact to be determined at meaningful levels. The judgement of meaningful levels is complicated and depends upon the sensitivity of biota contacted, the duration of the contact, and the particular toxicity of the oil mixture that is involved in the contact. It is important to note that direct environmental impact cannot be implied from the exceedance of the thresholds alone, but requires consideration of a range of parameters including impact pathways (e.g. smothering), contact toxicity, receptor sensitivity, dosage, and specific chemical/physical composition of the spill. Toxicity is further complicated by the change in the composition of an oil type over time due to weathering processes. Such considerations were beyond the scope of the hydrocarbon spill modelling study. Hence, a conservative approach was followed. Contact was judged for a number of thresholds, commencing at levels expected to be conservatively low. Table 5-26 lists the threshold concentrations of oil used in the hydrocarbon spill modelling study. For additional detail on the establishment of the thresholds, refer to Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill, Section 3.1 Fates and Trajectory Modelling Outcomes, Overview].

To show the potential for exposure to oil concentrations of varying magnitude, probability contours for surface oil were produced for varying concentrations of oil. These probabilities were used as the secondary risk. Note: The results in this section present the highest probability of a threshold being exceeded for each scenario.

Table 5-26: Summary of Thresholds Applied in this Modelling Study

Surface Oil (g/m^2)	Entrained Oil (ppb)	Dissolved Aromatics (ppb)
1 (rainbow sheen)	10	5
10 (dull metallic sheen)	100	50
	500 (blowouts only)	500 (blowouts only)

Source: Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill]

Once the modelling was completed, the results were compiled from each of the sample trajectories to give a statistical weighting to the likelihood of exposure for a given location. The results are summarised according to the:

- probability of exposure at the water surface and shorelines for oil exceeding a defined threshold concentration
- probability of exposure from entrained oil for in-water concentrations exceeding a defined threshold concentration
- probability of exposure from dissolved aromatic hydrocarbons for in-water concentrations exceeding a defined threshold concentration
- potential concentrations that could arrive on defined sections of shoreline and emergent reefs.

Nine sensitive shoreline locations were selected as part of the modelling, including the Barrow/Montebello Islands and islands towards mainland Australia including Muiron Island and the Southern Island Group off the Pilbara Coast. For the purposes of matters of National Environmental Significance, the Ningaloo Coast was also included within the scope of the assessment. Two additional locations were used for possible exposure to the blowout scenario: Bernier and Dorre Islands (offshore from Carnarvon), and Abrolhos Islands (offshore from Geraldton).

For additional detail on the oil spill model and assumptions, including weather conditions and seasonality, refer to Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill].

5.7.2.1.2 Foundation Project Oil Spill Modelling Methodology

The potential locations of the spills modelled for the Fourth Train Proposal, and therefore the fate and transport of the spilled hydrocarbons, are similar to those for the approved Foundation Project. The approved Foundation Project Feed Gas Pipeline rupture scenario is an appropriate worst case for the assessment of the Fourth Train Proposal due to the similarities between the pipeline routes as they approach Barrow Island and the condensate-to-gas ratio from the Gorgon Gas Field being higher compared to the Chandon Gas Field. The Fourth Train Proposal will use the same diesel refuelling facilities on the Materials Offloading Facility and the condensate loading facilities on the LNG Jetty as the approved Foundation Project; therefore, the spill scenarios modelled from these locations are relevant for use by the Fourth Train Proposal.

Following the hydrocarbon spill modelling study and the determination of the secondary risk, the primary risk was determined by reviewing the context of historical incident frequencies and relevant guidance documents.

The ecological risk assessment report also assessed the likely impacts on matters of National Environmental Significance and the overall environmental risk from relevant spill scenarios, also referred to as the tertiary risk or joint risk; this information is included in Sections 10 and 13.

5.7.2.1.3 Hydrocarbon Spill Modelling Results

To summarise the results of the Fourth Train Proposal hydrocarbon spill modelling study, annualised probabilities (probabilities calculated over a single year) of an hydrocarbon spill occurring and then subsequent contact at receiving locations by oil concentrations exceeding the defined thresholds, were determined. A probability was determined as a factor of both the likelihood of the spill occurring (primary risk) and the likelihood of the spilled hydrocarbons reaching sensitive areas (secondary risk). Then an annualised probability of a spill occurring and the material reaching sensitive receptors (tertiary risk) was determined.

The probability of a well blowout on the Fourth Train Proposal and the approved Foundation Project was determined to enable a comparison and to establish the increase in well blowout risk due to the Fourth Train Proposal. The Fourth Train Proposal is predicted to drill approximately 16 wells and the approved Foundation Project is expected to drill approximately 25 wells. It was determined that the Fourth Train Proposal in addition to the approved Foundation Project had a 0.09% probability that a blowout would occur. This represents a 0.03% increase due to the implementation of the Fourth Train Proposal only, compared to the approved Foundation Project.

Table 5-27 shows the results of worst-case exceedances of threshold concentrations at a receiving location for each scenario modelled in the hydrocarbon spill modelling (for more details refer to Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill]. The environmental impacts that are reasonably expected to occur from the modelled hydrocarbon spills are outlined in Sections 10 and 13.

Table 5-27: Results of the Worst-case Outcomes from the Hydrocarbon Spill Modelling at Sensitive Shoreline Receptor Locations

Scenario	First Contact Point – Sensitive Area	Oil State and Threshold Concentration	Seasonal Contact	Min. Travel Time to Sensitive Shoreline Location (days)	Highest Probability of Threshold breach (%)	Max. Concentration During any Season	Worst-case Seasonal Likelihood	Worst-case Annualised Probability	Furthest Contact at 1% Probability	General Direction of Travel across Seasons
APASA 2012										
Well blowout at Chandon Gas Field	Ningaloo Coast World Heritage Area (WHA)	Surface (1 g/m^2)	Winter	29	3	60 g/m^2 (summer)			>1350 km (Entrained)	Surface: SW or NW in summer and winter; NE or WSW in autumn; NNW (some SSW) in spring. Entrained: SSW in summer; SSW and SW in autumn and spring; SW, W and N in winter. Dissolved aromatics: E for each season
		Surface (10 g/m^2)	No Contact (NC)	-	-					
		Entrained (10 ppb)	All seasons	10	70 (autumn)	2940 ppb (spring)	3.85 × 10^{-6} (summer)	9.63 × 10^{-6} (1 in 104 000 chance of a spill resulting from a well blowout reaching the shoreline of the Ningaloo Coast WHA, per year)		
		Entrained (100 ppb)	All seasons	10	36 (spring)					
		Entrained (500 ppb)	All seasons	16	23 (spring)					
		Dissolved aromatics (5 ppb)	Summer, winter, spring	NA	23 (spring)	30 ppb (spring)				
		Dissolved aromatics (50 ppb)	NC	-	-					
Intrafield pipeline rupture – Chandon Manifold Tie-in	Ningaloo Coast WHA	Surface (1 g/m^2)	NC	-	-	-			480 km (Entrained)	Surface: All directions during each season. Entrained: SSW to SW during each season; NNW in summer, winter and spring. Dissolved aromatics: NA
		Entrained (10 ppb)	Spring	13	1	60 ppb (spring)	2.00 × 10^{-6} (spring)	2.00 × 10^{-6} (1 in 500 000 chance of a spill resulting from a pipeline rupture reaching the shoreline of the Ningaloo Coast WHA per year)		
		Entrained (100 ppb)	NC	-	-					
		Dissolved aromatics (5 ppb)	NC	-	-	-				

Scenario	First Contact Point – Sensitive Area	Oil State and Threshold Concentration	Seasonal Contact	Min. Travel Time to Sensitive Shoreline Location (days)	Highest Probability of Threshold breach (%)	Max. Concentration During any Season	Worst-case Seasonal Likelihood	Worst-case Annualised Probability	Furthest Contact at 1% Probability	General Direction of Travel across Seasons
Intrafield Pipeline rupture – Jansz Pipe Termination Structure Tie-in	Ningaloo Coast WHA	Surface (1 g/m^2)	NC	-	-	-			600 km (Entrained)	Surface: W and SW in summer and autumn SW in winter and spring Entrained: SSW to SW during each season NNW also for winter and spring Dissolved aromatics: NA
		Entrained (10 ppb)	Summer	12	1	25 ppb (summer)	1.00×10^{-5} (summer)	1.00×10^{-5} (1 in 100 000 chance of a spill resulting from a pipeline rupture reaching the Ningaloo Coast WHA per year)		
		Entrained (100 ppb)	NC	-	-					
		Dissolved aromatics (5 ppb)	NC	-	-	-				
Major diesel spill (80 m^3)	Ningaloo Coast WHA	Surface (1 g/m^2)	NC	-	-	-			460 km (Surface/ Entrained)	Surface: WNW in summer W and SW in autumn W and NW in winter NNW in spring Entrained: SSW to SW during each season WNW in summer N to NNE in autumn, winter and spring Dissolved aromatics: NA
		Entrained (10 ppb)	Spring	12	1	120 ppb (spring)	1.08×10^{-7} (spring)	1.08×10^{-7} (1 in 9 259 000 chance of a spill resulting from a major diesel spill reaching the shoreline of the Ningaloo Coast WHA per year)		
		Entrained (100 ppb)	NC	-	-					
		Dissolved aromatics (5 ppb)	NC	-	-	-				
Minor diesel spill (2.5 m^3)	NC	-	NC	-	-	-	-	-	260 km (Surface)	Surface: SW in summer and autumn SW in winter N in spring Entrained: NW and NE in summer W and SW in autumn and spring NE, SE and SW in spring Dissolved Aromatics: NA

Scenario	First Contact Point – Sensitive Area	Oil State and Threshold Concentration	Seasonal Contact	Min. Travel Time to Sensitive Shoreline Location (days)	Highest Probability of Threshold breach (%)	Max. Concentration During any Season	Worst-case Seasonal Likelihood	Worst-case Annualised Probability	Furthest Contact at 1% Probability	General Direction of Travel across Seasons
APASA 2005										
Rupture of Feed Gas Pipeline 14 km west of Barrow Island	NA[a]	Surface ($0.3 g/m^2$)	All seasons	NA[b]	63 (summer)	NA	8.8×10^{-6} (summer)	9.79×10^{-6} (1 in 102 000 chance of a spill resulting from a rupture of the Feed Gas Pipeline reaching any shoreline per year)	60 km[d] (Dissolved aromatics)	Surface: ENE Dissolved aromatics: NE
		Dissolved aromatics (10 ppb)	All seasons	NA	10–20[e] (annual)	1754 ppb (summer)[c] at Montebello Islands				
Rupture of Feed Gas Pipeline 200 m west of Barrow Island	NA	Surface ($0.3 g/m^2$)	All seasons	NA	99 (summer)	NA	1.39×10^{-5} (summer)	2.76×10^{-5} (1 in 36 000 chance of a spill resulting from a rupture of the Feed Gas Pipeline reaching any shoreline per year)	75 km (Dissolved aromatics)	Surface: N Dissolved aromatics: NNE
		Dissolved aromatics (10 ppb)	All seasons	NA	90–100 (annual)	4524 ppb (summer) at Barrow (west)				
Diesel spill Feed Gas Pipeline – 10 km west of Barrow Island	NA	Total hydrocarbons ($0.1 g/m^2$)	All seasons	NA	16 (summer and winter)	103 ppb (transitional) at Barrow (west)	3.28×10^{-3} (summer)	6.29×10^{-3} (1 in 160 chance of a spill resulting from a diesel spill reaching any shoreline per year)	25 km (Surface)	Surface: NNE
Diesel spill Feed Gas Pipeline – 5 km west of Barrow Island	NA	Total hydrocarbons ($0.1 g/m^2$)	All seasons	NA	60 (summer)	56 ppb (summer) at Barrow (west)	1.23×10^{-2} (summer)	1.45×10^{-2} (1 in 69 chance of a spill resulting from a diesel spill reaching any shoreline per year)	30 km (Surface)	Surface: NNE
Diesel spill Feed Gas Pipeline – 2.5 km west of Barrow Island	NA	Total hydrocarbons ($0.1 g/m^2$)	All seasons	NA	84 (summer)	440 ppb (summer) at Montebello Islands	1.72×10^{-2} (summer)	2.43×10^{-2} (1 in 41 chance of a spill resulting from a diesel spill reaching any shoreline per year)	30 km (Surface)	Surface: N
Diesel spill during refuelling adjacent to the	NA	Total hydrocarbons ($0.1 g/m^2$)	All seasons	NA	84 (summer)	2372 ppb (winter) at Barrow (east)	2.86×10^{-3} (summer)	4.03×10^{-3} (1 in 248 chance of a spill as a result of a diesel spill reaching any shoreline	85 km (Surface)	Surface: ENE

Scenario	First Contact Point – Sensitive Area	Oil State and Threshold Concentration	Seasonal Contact	Min. Travel Time to Sensitive Shoreline Location (days)	Highest Probability of Threshold breach (%)	Max. Concentration During any Season	Worst-case Seasonal Likelihood	Worst-case Annualised Probability	Furthest Contact at 1% Probability	General Direction of Travel across Seasons
Materials Offloading Facility								per year)		
Condensate release from a grounded tanker adjacent to the Tanker Terminal	NA	Surface (0.3 g/m^2)	All seasons	NA	95 (winter)	NA	4.43×10^{-6} (winter)	7.51×10^{-6} (1 in 133 000 chance of a condensate spill resulting from a tanker grounding reaching any shoreline per year)	90 km (Surface)	Surface: NE Dissolved aromatics: N
		Dissolved aromatics (10 ppb)	All seasons	NA	<5	117 ppb (winter) at Barrow (east)				
Light crude oil release from a grounded tanker adjacent to the Tanker Terminal	NA	Surface (0.3 g/m^2)	All seasons	NA	95 (winter)	NA	4.43×10^{-6} (winter)	1.01×10^{-6} (1 in 990 000 chance of a light crude oil spill resulting from a tanker grounding reaching any shoreline per year)	>110 km (Surface)	Surface: NE Dissolved aromatics: NE and SE
		Dissolved aromatics (10 ppb)	All seasons	NA	10–20 (annual)	264 ppb (winter) at Barrow (east)				
Bunker fuel oil release from a grounded tanker adjacent to the Tanker Terminal	NA	Surface (0.3 g/m^2)	All seasons	NA	95 (winter)	NA	4.43×10^{-6} (winter)	8.26×10^{-6} (1 in 121 000 chance of a bunker fuel oil spill resulting from a tanker grounding reaching any shoreline per year)	100 km (Surface)	Surface: Variable Dissolved aromatics: WSW
		Dissolved aromatics	All Seasons	NA	5–10 (annual)	150 ppb (transitional) at Lowendal Islands				

Notes:

a. *APASA 2005 does not specify first point of contact locations. Maximum concentration locations are provided in the above table.*

b. *APASA 2005 does not specify minimum travel time to sensitive shoreline locations.*

c. *APASA 2005 maximum concentrations are for aromatic hydrocarbons in inshore waters, except for diesel spill scenarios, which are total hydrocarbons.*

d. *Maximum travel distances from the spill site have been estimated from APASA 2005 figures.*

e. *Highest probability of threshold breach ranges for dissolved aromatics are taken from APASA 2005 figures and are for all seasons. Seasonal threshold breaches are not provided in APASA 2005 for dissolved aromatics.*

5.7.3 Proposed Management Actions

Mitigation measures for spills and leaks of hydrocarbons and chemicals to the marine environment can be divided into control measures, which are designed to reduce the primary risk (risk of the spill or leak occurring), and response measures, which are designed to reduce the secondary risk (risk of the spill or leak affecting an environmentally sensitive area).

The GJVs consider that the risks and the potential impacts of the Fourth Train Proposal can be effectively managed under the EMPs and Subsidiary Documents for the Foundation Project. No measures or controls additional to those required for the Foundation Project have been assessed as being necessary to manage the potential spills and leaks to the marine environment associated with the Fourth Train Proposal. Therefore, the GJVs propose that minor changes are included in the relevant Foundation Project EMPs and Subsidiary Documents to ensure that those documents also apply to the Fourth Train Proposal.

The following EMPs address the potential impacts of spills and leaks to the marine environment and the control and response measures planned to minimise the respective risks and impacts:

- Gorgon Gas Development Drilling and Completion Program Environment Plan
- Offshore Feed Gas Pipeline Installation Management Plan (or equivalent Environment Plan)
- Offshore Feed Gas Pipeline Installation – Oil Spill Operational Response Plan
- Decommissioning and Closure Plan.

Subsidiary Documents that are relevant to spills and leaks to the marine environment include:

- Commonwealth Environment Plans (and Oil Pollution Emergency Plans) submitted to the regulatory authority to meet the requirements of the Offshore Petroleum and Greenhouse Gas Storage Regulations 2009 (Cth) for activities within the Commonwealth Marine Area
- State Environment Plans (and Oil Spill Contingency Plans) submitted to the regulating authority to meet the requirements of the Petroleum (Submerged Lands) (Environment) Regulations 2012 (WA), and the Petroleum Pipelines (Environment) 2012 (WA) for activities within State jurisdiction.

These Environment Plans are required to assess and address all environmental risks from operations, accidents, and other emergency conditions, and to include measurements of whether specific environmental objectives and performance standards are met. These Environment Plans are also required to include a plan for oil spill response that is kept up-to-date throughout operations, and to include a description of emergency response arrangements that are regularly tested.

Further details on these EMPs and Subsidiary Documents are outlined in Table 16-2.

The following sections include illustrative measures to mitigate (control measures) and manage (response measures) the potential impacts to the marine environment from spills and leaks taken from approved Foundation Project EMPs and Subsidiary Documents, for assessment purposes. For details on these control and response measures refer to the Offshore Feed Gas Pipeline Installation – Oil Spill Operational Response Plan (Chevron Australia 2014e).

5.7.3.1 Control Measures

5.7.3.1.1 Well Control

In accordance with safety and environmental considerations, and the respective legislative requirements administered by NOPSEMA, the wells proposed as part of the Fourth Train Proposal will be planned and engineered to minimise the likelihood of a loss of well control.

Well design and operations will be detailed in a Well Operations Management Plan, for assessment by NOPSEMA.

The Gorgon Gas Development Drilling and Completion Program Environmental Plan (Chevron Australia 2011a) approved for the Foundation Project contains a range of control measures designed to manage the risk of a well blowout during the well drilling and completion process. This document states:

- Wells will be suitable for all conditions that might be expected during drilling operations.
- Wells will be compliant with *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth) requirements for adequately rated and tested blowout preventers.

The Fourth Train Proposal will use the similar control measures as the approved Foundation Project. A number of barriers will be put in place with the aim of reducing the likelihood of a loss of well control. These barriers include preventive and mitigation, or recovery measures. Preventive barriers are engineering or administrative controls, while the mitigation or recovery measures ensure that if a loss of a well control event occurs, the severity of the event can be limited by controlling and recovering the situation.

Engineering controls include downhole barriers (such as cement plugs and the drilling fluid column), and surface barriers, including blowout preventers. Blowout preventers and casings are designed to prevent any releases of drilling or formation fluids to the marine environment in the event of the loss of hydrostatic pressure control.

Each well will be fitted with an arrangement of valves, controls, and instrumentation (known as a subsea tree), which will be located on the seabed. The Fourth Train Proposal is expected to use vertical tree systems. The subsea tree will be installed onto the wellhead to control the flow of fluids from the well. In addition to the valves, a subsurface safety valve will be installed in each well at a depth of approximately 300 m below the seabed to provide a fail-safe system to seal the well in the event of a system failure or damage to the production control facilities. Together, these valves are designed to close automatically if mechanical failure or loss of system integrity occurs during production via the well. A choke valve will also be included in the subsea tree to control the flow and pressure of hydrocarbons from the well to the intrafield flowlines and the Feed Gas Pipeline.

The GJVs undertook a selection process to determine the appropriate subsea tree for use on the Fourth Train Proposal. Two subsea tree systems were investigated: horizontal tree systems and vertical monobore tree systems. Horizontal tree systems are those where the production and annulus tree valves are located on the horizontal plane (i.e. not within the main vertical tree bore). Vertical monobore tree systems are those where the production tree valves are located within the vertical tree bore.

The GJVs prefer vertical tree systems, due to the permanent barriers in the vertical bore of the vertical tree systems (i.e. the production master and production swab valves). Vertical tree systems enable well intervention and kill operations without wireline operations, which is considered a weakness in horizontal tree systems where the crown plugs need to be removed to effectively kill the well.

Blowout preventers are maintained by a stringent testing regime to ensure that they can operate within the anticipated conditions, as required by the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth). The testing regime requires tests to be conducted prior to drilling with the blowout preventer in place, prior to drilling a new casing or liner shoe if a hydrocarbon zone is expected, and before commencing a completion or drill stem testing program. Testing will be carried out under suitable pressure conditions, depending on the expected operating pressure of the blowout preventer.

5.7.3.1.2 Refuelling Procedures

To reduce the risk of spillage from refuelling/bunkering operations during the installation of the Feed Gas Pipeline System to as low as reasonably practicable, best-practice refuelling procedures will be implemented, as outlined in the approved Foundation Project Offshore Feed Gas Pipeline Installation Management Plan (Chevron Australia 2014c). These procedures include:

- Refuelling and bulk transfer will only be undertaken when weather/ sea/ visibility conditions are appropriate, as determined by the Vessel Master.
- Dry-break couplings, breakaway couplings, and scupper plugs will be installed on vessels to mitigate against overboard loss in the event of a refuelling spill.
- Integrity checks are conducted for reinforced hoses and dry-break and breakaway couplings as part of bunkering checks.

5.7.3.1.3 Vessel Collision

Drilling rigs are restricted in their ability to manoeuvre during well construction and when under tow while relocating between well sites. Responsibilities between vessels are detailed in the Convention on the International Regulations for Preventing Collisions at Sea 1972, as amended.

There may be cases where the drilling rig may be moved to avoid overlap of work on the same site as the pipe-lay vessels. The planning and execution of this activity will be conducted carefully, and in line with the procedures already in place for the approved Foundation Project. A 500 m petroleum safety zone will be established around the drilling rig and a Notice to Mariners will be broadcast warning of the presence of the drilling rig.

To reduce the risk of accidental damage to vessels collision or grounding during the installation of the Feed Gas Pipeline System, the approved Foundation Project Offshore Feed Gas Pipeline Installation Management Plan (Chevron Australia 2014c) will be implemented including:

- Equipment function tests (e.g. DP trials) are conducted to ensure that equipment will adequately perform functions.
- Minimum lighting required for safety and navigational purposes, in accordance with the *Navigation Act 1912* (Marine Orders Part 30 [Prevention of Collisions]), is on board and operational.
- A 24-hour visual, radio and radar watch will be maintained for vessels in the vicinity of the operational area in accordance with Standards of Training, Certification and Watchkeeping (STCW95) (1978 STCW Convention).
- Notice to Mariners is issued prior to work scopes commencing.

The LNG and condensate vessels will have experienced navigational pilots, who are based at Barrow Island, controlling the vessel when within the Barrow Island boundaries, and will be escorted/assisted by tugs during berthing and departure. A tug will be on standby during cargo loadings. In the event of a cyclone, LNG and condensate vessels will depart the loading terminals and standby at sea until favourable docking and loading conditions return.

5.7.3.1.4 Intrafield Flowline and Feed Gas Pipeline Design and Management

The design of the Fourth Train Proposal Feed Gas Pipeline will provide leak protection as a result of appropriate design, as well as pipeline stabilisation constructed after installation. The design includes suitable corrosion-resistant alloy-clad carbon steel or similar, and the pipeline will be constructed in accordance with appropriate standards (e.g. Standards Australia 2008).

Stabilisation will also be installed, where required, to protect the pipeline from hydrodynamic forces such as waves and currents and, where necessary, to protect against external impacts such as ship anchors. Potential stabilisation measures include concrete coating, rock stabilisation, trenching and backfill into the seabed, and pipeline anchors. For additional detail on the stabilisation techniques proposed, refer to Section 4.3.4.6.

The horizontal directional drilling installation of the Fourth Train Proposal Feed Gas Pipeline System at the shore crossing will provide additional protection against a marine vessel potentially running aground onto the Feed Gas Pipeline System. The potential of a marine vessel sinking and impacting directly onto the Feed Gas Pipeline is very remote, given that the vessel traffic in the area is sparse. Should such an event occur, it is likely that only large vessels would result in significant pipeline damage; smaller vessels (e.g. crayfishing boats, recreational fishing, pleasure craft) would be unlikely to have sufficient mass to cause an accidental release. Information will be provided to the relevant authorities so that the Feed Gas Pipeline System can be clearly marked on navigation charts, with clear warnings to avoid anchoring within the exclusion zone along the pipeline.

5.7.3.1.5 Cyclone Contingency

During extreme weather events such as cyclones, there may be a requirement for marine vessels to evacuate the area. It is expected that larger vessels will travel out to deeper water away from the cyclone and smaller vessels will take shelter on cyclone-rated moorings until the weather has passed and the marine vessels can return to their duties.

5.7.3.2 Response Measures

Once a leak or spill has occurred a response will be implemented to manage the impact to the marine or coastal environments. The initial focus following a leak or spill is to stop the flow of hydrocarbon or contaminants, if safe to do so.

The level and type of response initiated for a leak or spill will depend on the size and nature of the release, and the location of the release. The purpose of a response is to reduce the impacts of a spill to environmental and social sensitive receptors. Response may include a single response technique or a combination of techniques that form a response strategy that varies with the nature and scale of a spill.

Several response techniques may be used including:

- monitoring, evaluation, and surveillance
- shoreline protection and deflection
- containment and recovery
- assisted natural dispersion
- dispersant application
- shoreline clean-up
- oiled wildlife response.

The monitoring, evaluation, and surveillance response technique involves a number of components including personnel in vessels and/or aircraft on site that collect data on the spill footprint, satellite imagery of the spill, and oil spill modelling that uses current metocean conditions and spill information to predict the trajectory of a spill. The primary objective of the monitoring, evaluation, and surveillance response technique is to determine the size and trajectory of an oil spill so that sensitive resources at risk can be identified. The response team can then use these results to deploy an effective response strategy that makes the most efficient use of resources. The monitoring, evaluation, and surveillance technique can also be used as a feedback mechanism to continually inform response team decision makers of the effectiveness of the response strategy or changes in the size or trajectory of the spill, and this technique should be implemented, where required, to track the spill.

The shoreline protection and exclusion tactics are based on pre-identifying and prioritising the sensitive areas to ensure the most effective deflection and exclusion tactics can be deployed.

The containment and recovery response technique may be conducted where the spill size, oil type and weather conditions allow. The primary objective of the containment and recovery response technique is to remove the oil from the environment; however, limiting restrictions (such as adverse weather conditions) can reduce its use and effectiveness during a response, particularly in the open ocean at remote locations. Vessels equipped with booms and skimmers contain and recover oil for on-board and onshore storage, treatment, and disposal.

Assisted natural dispersion can be an effective method of increasing the surface area of hydrocarbons with lighter fractions, thus enhancing natural degradation through evaporation and weathering. Agitation of the water surface may be promoted by vessel propellers, towing floating objects behind a work boat, and/or the use of water cannons.

For oil spills that contain dispersible hydrocarbons, the rapid application of dispersant can benefit the environment if sensitive habitats are threatened. Dispersants act by breaking surface oil into small droplets; wave action then transports the droplets into the water column. Dispersed oil droplets can then be entrained in the water column and sea floor where natural processes biodegrade the oil and dispersant. The primary environmental benefit of dispersant application is the removal of oil from the water surface where it can result in adverse impacts to sensitive receptors. However, the efficacy and toxicity of the dispersant must be considered prior to its use as a response technique.

Shoreline clean-up can be used if other response techniques are not possible, have failed, or are only partially successful. This technique has limited practicality, depending on environmental factors and location.

Oiled wildlife response is appropriate should a spill occur and result in oiling of wildlife, and may include establishing a wildlife response centre. Facilities may comprise collection points for clean-up and release or full rehabilitation, according to the nature and scale of the response required.

5.7.3.2.1 Response Capability

Implementation of the response strategy requires significant capabilities to effectively execute each response technique and the overall response strategy as intended. To ensure this occurs, an important element is to assess if the response capability is suitable to execute the response strategy. The sections below outline Chevron Australia’s (as the operator of the Fourth Train Proposal) response capability.

Marine Vessels

Due to nature and scale of Chevron Australia’s activities in or adjacent to the Fourth Train Proposal Area, a wide selection of vessel types is expected to be available in the event of an emergency response in the area, particularly around Barrow Island, offshore, and to a lesser extent, Onslow. These vessels are not dedicated to emergency/oil spill response; however, all are available through Chevron Australia’s Asset Emergency Management Team (AEMT). Vessel resources should not be a limiting capability factor when planning for oil spill response. Chevron Australia also has contractual arrangements with marine transport companies for a range of fast response and support vessels in the event of an oil spill.

Mobilisation of a response vessel, with suitably trained (e.g. Australian Marine Oil Spill Centre [AMOSC]) personnel, is predicted to be available within six hours of an Asset Emergency Management Team directive.

Aircraft

Due to nature and scale of Chevron Australia’s activities in or adjacent to the Fourth Train Proposal Area, a selection of aircraft types is expected to be available in the event of an emergency response in the area, particularly around Barrow Island, offshore, and to a lesser extent, Onslow. Chevron Australia has various contracts in place with aircraft operators, which include a range of aircraft types and capabilities. At the time of preparation of this PER/Draft EIS these capabilities include passenger aircraft operating from Barrow Island, smaller planes operated by Karratha Flying Services, and several helicopters operated by Bristow from Barrow Island.

Aircraft with suitably trained (e.g. AMOSC) personnel are predicted to be mobilised within two hours of an Asset Emergency Management Team directive to commence aerial observations, with an aircraft able to cover the entire Fourth Train Proposal Area. It is predicted that it will take approximately 70 minutes for helicopters to travel the approximately 130 km to the Chandon Gas Field, the most distant gas field from Barrow Island. The response time to other Fourth Train Proposal gas fields will be shorter.

Response Equipment

Chevron Australia maintains a range of oil spill response equipment designed to carry out effective response strategies (Section 5.7.3.2). This equipment is strategically located at Barrow Island, Onslow, and Dampier and includes absorbent materials, containment booms, skimmers, shoreline clean-up equipment, temporary storage receptacles, oiled wildlife response equipment, and other ancillary support materials. Additional resources can also be provided under the Australian Maritime Oil Spill Plan (AMOSPlan) for combating marine oil spills larger than can be handled by the operator's own resources. The AMOSPlan is a cooperative arrangement for response to oil spills by Australian oil and associated industries and is managed by AMOSC. Chevron Australia is a member of AMOSC (Australia's largest equipment stockpile holder) and has a contract with Oil Spill Response Ltd (OSRL, the world's largest equipment stockpile holder); both organisations can provide further equipment and personnel to reinforce Chevron Australia's first-strike capability within 24 hours of activation. The OSRL contract provides Chevron Australia with access to capping stack toolboxes and subsea dispersant hardware kits, both of which are designed for use in up to 3000 m water depth.

Personnel

Personnel working on the Gorgon and Wheatstone Projects could provide support in the event of a leak or spill. Where required, Chevron Australia can access personnel from its project sites who could be used as a source of labour for shoreline clean-up activities and other oil spill support activities such as waste management, logistics, utilities, general supervision, and safety management. Accommodation, food, transportation, and communication are available on Barrow Island and at Ashburton North Strategic Industrial Area.

At each of its operational locations, Chevron Australia maintains a group of oil spill responders trained by AMOSC who will be mobilised as required to carry out first-strike response measures to mitigate the effects of an oil spill. These personnel can be reinforced with personnel from AMOSC and OSRL within 24 hours of activation. Chevron Australia can also access Chevron Corporation's global resources via the World Wide Emergency Response Team, which consists of a range of oil spill response specialists, safety and environmental specialists, well control specialists, and marine specialists such as naval architects and salvage experts.

5.7.3.2.2 Response Prioritisation

The prioritisation of spill response actions considers sensitive environments and habitats at risk, based on their relative sensitivity/vulnerability to spills and leaks, the characteristics present, including species, wave energy, and substrate.

Sensitive receptors at risk are assigned a sensitivity rating, and this is combined with the time frame for a spill to impact (determined during the spill modelling) and other influences (including season, presence, abundance, and activity) to determine a protection priority ranking. This protection priority ranking is used during spill response to assign resources and spill response capability according to the priority. For example, in the event of a spill those receptors that are ranked as having extreme sensitivity would have a higher protection priority assigned than those receptors that are ranked with a low sensitivity. Thus, resources and personnel would be directed towards protection of the receptors that have a higher protection priority ranking, with remaining resources and personnel directed towards the receptors of decreasing sensitivity ratings.

5.7.3.2.3 Response Strategy Selection Process

Not all spill response techniques are appropriate for every hydrocarbon spill. Different types of hydrocarbon spill, spill locations, and spill volumes require different techniques, or a combination of techniques, to form an effective response strategy.

Net Environmental Benefit Analysis is used to assess and compare the risk to the environment associated with available oil spill response options. This analysis is coordinated during the planning stage by the Environment Unit Lead. Some information supporting the Net Environmental Benefit Analysis may also be provided by other specialists, incident response personnel, government, or external agents such as state ecologists. This analysis is to be undertaken prior to conducting spill response strategies to:

- confirm that planned response strategies will mitigate the consequence of an oil spill
- confirm or amend the protection priorities of the response
- support the choice of response strategies
- determine locations where the event response activity is considered to have a net environmental benefit
- ensure there is a net benefit to the environment by undertaking the response strategy; i.e. further environmental harm will not be caused by the strategy
- determine whether a response strategy should continue (i.e. be used as a termination criteria, where applicable).

Net Environmental Benefit Analysis uses information gathered on the spill (including type of hydrocarbon, volume, and location), modelling of hydrocarbon weathering and spill trajectory, time of the year, the long-range weather forecast, sensitive receptors present within the at risk areas (protection priorities), and potential response strategies that are appropriate for the situation. These factors determine the available appropriate response strategies for the spill event. The Net Environmental Benefit Analysis is revised, as required, throughout the spill response planning, coordination and execution process.

5.7.3.2.4 Response Coordination

The Commonwealth, State, and Northern Territory (NT) governments have agreed a national framework to enable effective response to marine pollution incidents, known as Australia's National Plan for Maritime Environmental Emergencies (the National Plan) (Australian Maritime Safety Authority [AMSA] 2013). The National Plan is fully integrated with the State plan as described below, and resources could be made available through the National Plan State Committee. In the event of a large spill, assistance from the National Plan may be activated by any member of the National Plan State Committee or the Department of Transport (DoT) (WA) Marine Emergency Operations Centre.

In accordance with the National Plan, a statutory and a combat agency is nominated based on the location and source of the spill. These agencies are defined as follows:

- Statutory Agency: The State/NT or Commonwealth agency having the statutory responsibility for marine pollution incidents in their area of jurisdiction. This agency is primarily responsible for ensuring an appropriate and adequate response is mounted by the Combat Agency.
- Combat Agency: The agency having operational responsibility in accordance with the relevant contingency plan to take action to respond to an oil spill in the marine environment.

In WA, the following term is also recognised:

- The Hazard Management Agency (HMA): the agency nominated as being responsible for ensuring that all activities are undertaken for the prevention of, preparedness for, response to, and recovery from a specific emergency.

In the event of a spill, Chevron Australia will coordinate and consult with the appropriate State and Commonwealth agencies.

Table 5-28: Response Coordination Arrangements

Location	Spill Source	HMA	Statutory Agency	Control Agency	
				Tier 1	Tier 2/3 (1)
Commonwealth Waters	Vessels	-	AMSA	AMSA	
	All petroleum activities	-	NOPSEMA	Chevron Australia	
State Waters	Vessels	DoT	DoT	DoT or designated agency	
	Oil and gas facility(2)	DoT	DMP	Chevron Australia	Chevron Australia / DoT
	Other/ unknown	DoT	DoT	DoT or designated agency	DoT
Designated Port Dampier / Onslow/Ashburton	Any	DoT	Port Authority	Port Authority or designated agency	Port Authority/ DoT
Thevenard Port	Thevenard Island	DoT	DoT	Chevron Australia	DoT
Private Port e.g. Barrow Island	Barrow Island	DoT	DoT	Chevron Australia	

(1) In State Waters, Chevron Australia can request the DoT as HMA to take over the combat agency role. Likewise, the DoT can take over combat agency role at any time.

(2) Onshore or offshore facilities included that result in marine oil spills.

Assistance from the Australian Maritime Safety Authority (AMSA) is available for spills in the Commonwealth Marine Area, and from the WA National Plan State Committee for Combating Marine Oil Pollution (commonly called the National Plan State Committee), if the spill threatens the coastline.

A Western Australian State Emergency Management Plan for Marine Oil Pollution (known as WestPlan – Marine Oil Pollution) has been prepared by the Western Australian DoT. WestPlan – Marine Oil Pollution details the management arrangements for preparation and response to a marine oil pollution incident to minimise the effects of oil pollution incidents occurring in State Waters. A response to a marine oil spill incident beyond the handling capacity of the operator can be supported by the activation of this Plan, which uses both Commonwealth and State Government resources. Within Western Australia, the same committee administers the WestPlan – Marine Oil Pollution and the National Plan.

Chevron Australia, as the operator of the GJV, is also party to the current Mutual Aid Agreement drafted for the industry through the Australian Petroleum Production and Exploration Association. This agreement involves the sharing of equipment used in a loss of well control situation with other operating companies, and includes access to rigs. In the unlikely event of an uncontrolled blowout on a Fourth Train Proposal well, it is expected that the first available drilling rig would, after safely securing the well it was drilling, be mobilised into position to drill a relief well to kill and seal the uncontrolled well. Depending on the circumstances, it may be possible to control the spill earlier using a capping stack while the relief well is being drilled.

5.7.4 Predicted Environmental Outcome

The modelling studies indicate that there is a very low probability of spills and leaks reaching environmentally sensitive areas above threshold concentration levels as a result of the implementation of the Fourth Train Proposal. The Fourth Train Proposal was determined to increase the primary risk of a blowout occurring (the worst-case scenario) by 0.03% (due to the Fourth Train Proposal only), which resulted in a risk of a blowout of 0.09% for the Fourth Train Proposal in addition to the approved Foundation Project.

Spills and leaks to the marine environment from the Fourth Train Proposal can be managed to acceptable levels to meet the environmental objective by implementing the Foundation Project EMPs (with minor amendments).

Therefore, the GJVs consider that the management of spills and leaks from the Fourth Train Proposal will be environmentally acceptable and the environmental objective (Section 5.7.1.1) is met.

Note: This section outlines the predicted transport and fate of spills and leaks to the marine environment; however, it does not assess the impacts from spills and leaks on environmental factors (e.g. marine fauna, marine water quality). Refer to Sections 10, 13, and 14 for this assessment.

5.8 References Cited in Section 5

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Section 6: Table of Contents

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6. Environmental and Social Baseline

This Section describes the physical, ecological, and social environment that could be potentially impacted by the Fourth Train Proposal, as illustrated in Figure 6-1. This information supports the assessment of impacts presented in Sections 9 to 15.

This baseline has been established using:

- data gathered as part of the Foundation Project impact assessment, subsequent Baseline Reports and Monitoring Programs undertaken in accordance with survey scopes and methods pre-approved by the Commonwealth Minister for Sustainability, Environment, Water, Populations and Communities (SEWPaC, now DotE) and/or the Western Australian DEC (now split into DPaW and DER) as required under the Ministerial Conditions for the Foundation Project (Appendix E1 [Key Foundation Project Survey, Audit and Environmental Reporting]), and the Gorgon Social Impact Management Plan
- predictions about the environmental baseline, which considered the operational Foundation Project, based on Foundation Project studies that reflect the most recent knowledge about the design of the approved Foundation Project
- secondary information available in the public domain (e.g. from BOM for meteorological data and from the Australian Bureau of Statistics [ABS] for statistical data).

Note that baseline information relevant to Barrow Island and its surrounding waters prior to the commencement of construction of the Foundation Project has been included in Sections 9 and 10 where relevant to enable assessment of impacts resulting from the Fourth Train Proposal additional to the approved Foundation Project.

Environmental and social baseline information relevant to air quality, noise emissions, and light emissions (where relevant) is provided in Section 5. The GJVs consider that the availability, geographic coverage, and validity of the baseline data are sufficient to support assessment of the terrestrial, marine, and social environments for the Fourth Train Proposal in this PER/Draft EIS.

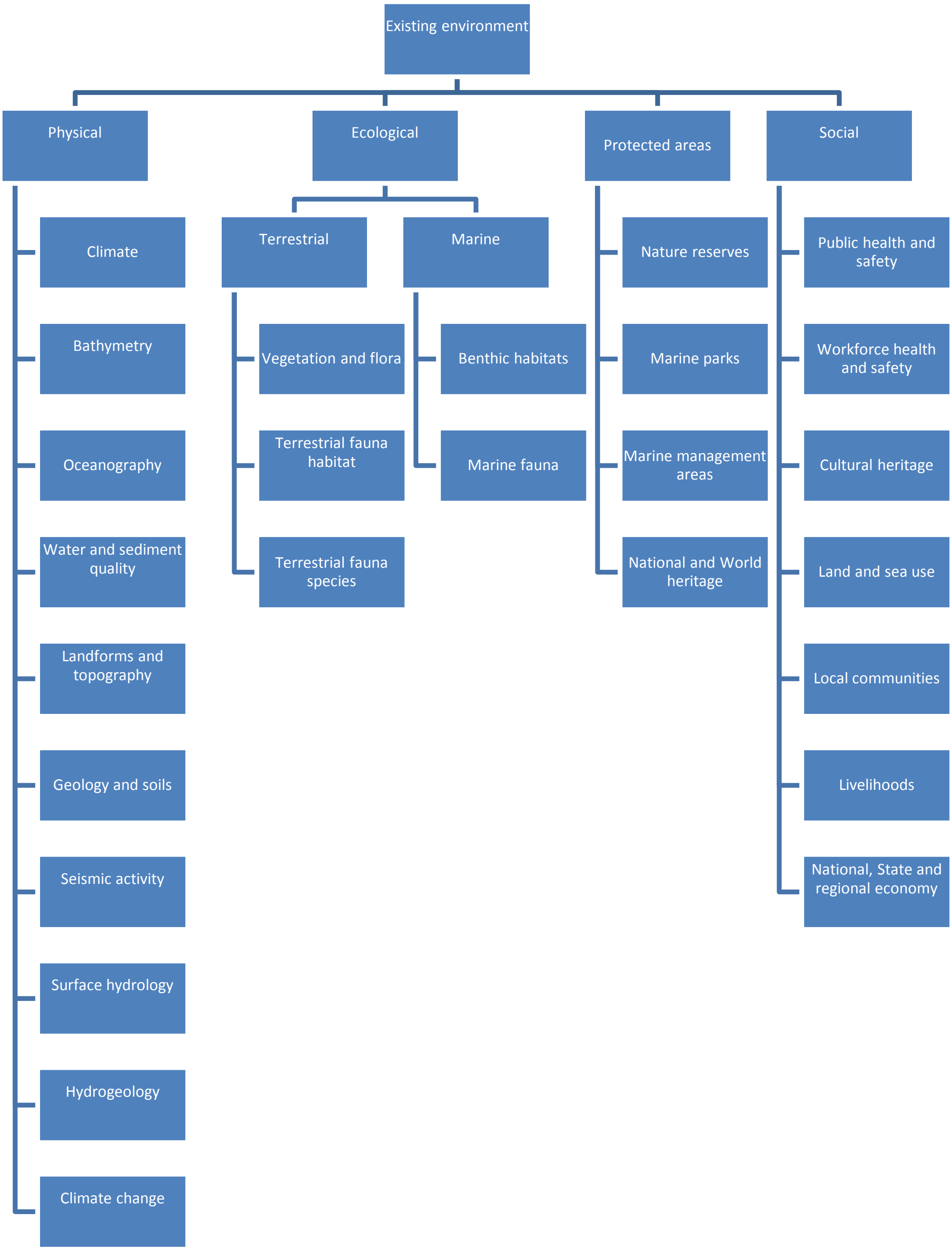


Figure 6-1: Overview of Environmental and Social Baseline

6.1 Environmental Baseline

The environmental baseline describes the general characteristics of the environment from a regional perspective and then for the Fourth Train Proposal Area. Additional detail is provided for the following areas:

- the marine and terrestrial environments of the west coast of Barrow Island where the shore crossing will be located (Section 4.5.2)
- the marine environment off the east coast of Barrow Island in the vicinity of the approved Foundation Project Materials Offloading Facility and LNG Jetty (Town Point), where Foundation Project and Fourth Train Proposal reverse osmosis reject brine will be discharged (Section 5.5.3.5)

- the marine environment off the east coast of Barrow Island in the vicinity of WAPET Landing, which has been upgraded for the Foundation Project. The WAPET Landing will be used by the Fourth Train Proposal as an alternative to the Materials Offloading Facility for shipments to Barrow Island and is a potential site for the floatel accommodation or the additional laydown area.

Greater detail is also included for shallow water environments than for deepwater environments, due to their greater environmental sensitivity.

The suite of species that are discussed within this Section have been derived from a combination of sources and the full approach and methodology is detailed in Appendix E1 [Key Foundation Project Survey, Audit and Environmental Reporting]. Additional details on the conservation-significant species relevant to the Fourth Train Proposal discussed within this Section are provided in Appendix E2 [Conservation-significant Species Considered for Assessment in this PER/Draft EIS].

6.2 Regional Setting

The Fourth Train Proposal Area is located in the Carnarvon Basin within the North West Shelf and falls within the North-west Marine Region. The North West Shelf is an extensive oil and gas region off the Pilbara coast of Western Australia, approximately 1200 km north of Perth and 120 km west south-west of Dampier (Figure 4-1). The North West Shelf includes a series of limestone islands, the largest of which is Barrow Island. The North-west Marine Region extends from the Western Australian–Northern Territory border to Kalbarri, south of Shark Bay in Western Australia (as defined by the SEWPaC 2012).

6.3 Fourth Train Proposal Area

The geographic area of the Fourth Train Proposal includes Barrow Island, State Waters surrounding Barrow Island and the Commonwealth Marine Area as illustrated in Figure 4-1. The boundaries of the Fourth Train Proposal were selected to encompass the proposed infrastructure and as the basis for conducting a protected matters database search to inform identification of matters of national environmental significance (NES). Water depths at the Fourth Train Proposal Gas Field locations range from approximately 440 m to 1250 m (Table 4-3), with maximum depths in the Fourth Train Proposal Area reaching approximately 1450 m in the north-east corner of the Jansz–Io Gas Field.

Barrow Island is reserved under the Western Australian *Land Administration Act 1997* as a Class A nature reserve for the purposes of ‘Conservation of Flora and Fauna’. Barrow Island is 25 km long, 10 km wide, and has an area of approximately 234 km^2 (approximately 23 500 ha).

The terrestrial components of the Fourth Train Proposal are largely contained within the approved Foundation Project Footprint on Barrow Island. Up to 10 ha of uncleared land will be required outside the approved Foundation Project Footprint for the horizontal directional drilling site (Section 4.5.2). Clearing will be within the allocated uncleared land available for tenure on Barrow Island under the *Barrow Island Act 2003* (WA).

6.4 Physical Environment

6.4.1 Climate

The Pilbara Region is characterised by two seasons: summer (September–April) and winter (May–August) (Pearce *et al*. 2003). Mean daily temperatures during summer on the mainland Pilbara Region range between 24 °C and 36 °C and in the winter between 15 °C and 30 °C (BOM 2012). Mean daily relative humidity for the mainland Pilbara Region ranges from a minimum 40% during winter (September) to 60% in the summer (February). The average annual rainfall for the Pilbara Region is approximately 375 mm, with a mean annual evaporation rate that varies from 3000 to 3600 mm for the mainland Pilbara Region (Green and Borden 2011). The southern portion of the North West Shelf region, including Barrow Island, is characterised by an arid, subtropical climate. Mean daily temperatures range between 20 °C and 34 °C in the summer and between 17 °C and 26 °C during the winter period (Chevron Australia 2008). Relative humidity at Barrow Island ranges from 61% in the winter months (September) to 70% in the summer (February). Rainfall on Barrow Island varies significantly each year and is dependent on rain-bearing low-pressure systems, thunderstorm activity. Average annual rainfall at Barrow Island is 306 mm with most rain (85%) occurring between January and July (BOM 2012).

Based on records from the Dampier Salt Weather Station, approximately 140 km east of Barrow Island, the mean annual evaporation rate is approximately 3500 mm with daily evaporation rates ranging from approximately 11 mm/day during summer to 7 mm/day during winter (Chevron Australia 2008).

In general, wind speeds are less than 10 m/s for more than 90% of the time around Barrow Island, but rarely fall below 3.6 km/h (2.2% of the time). The mean ambient wind speed reported during the summer period is 23.7 km/h, with a maximum summer wind speed of 58.3 km/h (Kellogg Joint Venture Gorgon [KJVG] 2008). The dominant wind directions during summer are from the south-west and west. During winter, winds approach from the east, south, and south-west with a mean speed of 20.9 km/h and a maximum speed of 69.8 km/h. Peak winds on Barrow Island during non-cyclonic conditions occur in the range of 115.2 to 158.4 km/h and are associated either with very strong breezes or storms (Asia-Pacific Applied Science Associates [APASA] 2009).

An average of five tropical cyclones per year occur in the Pilbara Region (BOM 2011), with an average of two per year passing through the Barrow Island area (Chevron Australia 2005). The Australian tropical cyclone season runs from 1 November to 30 April (BOM 2011), with cyclones most common between December and March. Tropical cyclones are unpredictable in occurrence, intensity, and behaviour and can generate extreme seas and swell. Since 1910 there have been 48 cyclones in the Karratha, Dampier, and Roebourne area that have had damaging wind gusts exceeding 90 km/h. Ten of these cyclones had very destructive wind gusts that were greater than 170 km/h. Large increases in precipitation are associated with cyclones, and the BOM reports that rainfall totals greater than 100 mm are common with tropical lows that move over land (BOM 2011).

6.4.2 Bathymetry

Barrow Island lies on the continental shelf (known as The Rowley Shelf) and is the furthest offshore island which forms part of the chains of islands running roughly parallel to the mainland coast. The shelf itself is composed predominantly of limestone, with patches of sediment of various thicknesses (Chevron Australia 2005). A maximum depth of approximately 1500 m is found at the most north-easterly point in the Jansz–Io Gas Field (Figure 6-2 and Figure 6-3). The bathymetry of the seabed off the west coast of Barrow Island to the furthest point within the Fourth Train Proposal Area is characterised by these features (Department of the Environment, Water, Heritage and the Arts [DEWHA] 2008):

- Continental shelf: A broad, flat to gently undulating sea floor with areas of moderate relief in water depths of less than about 175 m. Overall sea floor slopes are less than 2° and local relief is minimal. A drowned terrace [more commonly referred to as an ancient coastline (at the 125 m depth contour)] is considered an important seafloor feature that may aid minor upwelling as a result of internal wave activity and act as a migratory pathway for a range of marine species.
- Shelf break: The shelf break is a transitional zone between the continental shelf and the upper continental slope; in water depths between 300 m to 175 m. There are several distinct sea floor features within the shelf break area including numerous large-scale sediment wave bedforms and prominent sea floor escarpments. The overall slope in the

shelf break region is approximately 1°; however, slopes on escarpment faces range from 25° to 60°.

- Continental slope: The continental slope (the scarp), extends from approximately 1200 m to 300 m water depth and is divided into an upper, middle and lower slope based on distinctive changes in the sea floor gradient and sea floor morphology. At the base of the scarp, maximum sea floor slopes of up to 80° can be found. Average slopes in the upper scarp are 4° to 5°, while the average slope of the middle and lower scarp is more benign (2° to 5°).
- Kangaroo Syncline: The Kangaroo Syncline province extends seaward from water depths greater than 1200 m; average sea floor slopes are less than 1°.

Water depths between the east coast of Barrow Island and the Pilbara mainland vary but are generally less than 20 m and contain seabed features such as outcrops and pinnacles. Water depths in the vicinity of Town Point generally range from approximately 5 m to 12 m, but are shallower near areas of limestone pavement (Chevron Australia 2008).

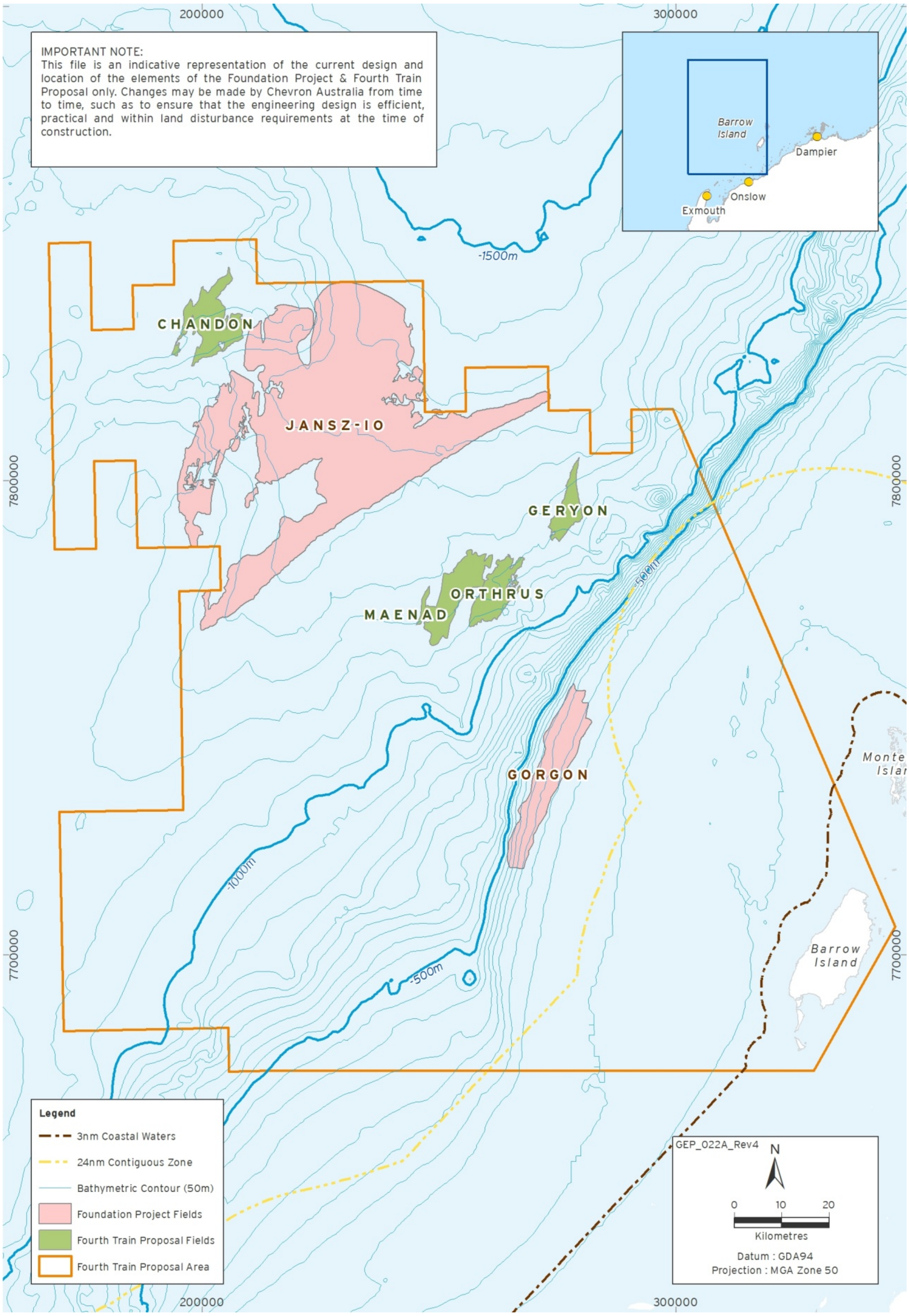


Figure 6-2: Bathymetry of the Fourth Train Proposal Area

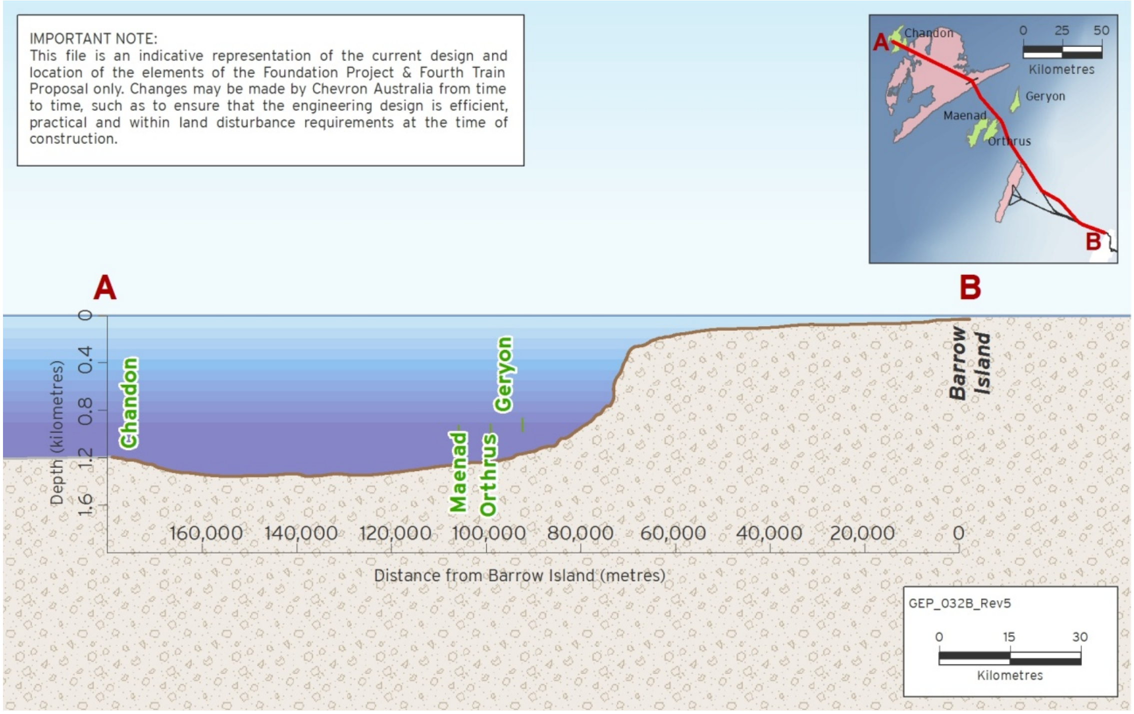


Figure 6-3: Indicative Cross-section of the Fourth Train Proposal Area

6.4.3 Oceanography

6.4.3.1 Ocean Temperatures

In deepwater areas of the Fourth Train Proposal, water temperatures at depths greater than 500 m range from a summer peak of approximately 10 °C to a winter low of about 4°C (Gorgon Upstream Facilities Team [GUFT] 2006). The mean temperature for depths between 200 and 250 m is approximately 10 °C (Chevron Australia 2005). On the outer continental shelf (depths 80 to 150 m), the waters become strongly stratified in summer (Chevron Australia 2005) with a thermocline occurring within the water column at depths between 30 and 60 m (DEWHA 2008). In winter, the temperature stratification collapses due to surface cooling and consequent overturning (Chevron Australia 2005); however, a thermocline remains present in deeper water (approximately 120 m depth) (DEWHA 2008).

Surface water temperatures offshore and around Barrow Island range between approximately 22 °C in winter and 31 °C in summer (Chevron Australia 2011). Surface water temperatures on the east coast of Barrow Island in the vicinity of the approved Foundation Project Reverse Osmosis brine outfall are expected to be near to ambient levels within approximately 20 m around the outfalls (Chevron Australia 2013). Stratification of nearshore waters surrounding Barrow Island rarely occurs (RPS Bowman Bishaw Gorham [BBG] 2007).

6.4.3.2 Circulation and Currents

Water circulation in the North-west Marine Region is strongly influenced by the southward-flowing Indonesian Throughflow which brings warm, low salinity waters which are low in nutrients to the region. The Leeuwin Current, a warm, shallow current centred along the shelf break also is a key surface current. Subsurface currents flowing towards the equator with waters derived from south of Australia are cooler, high salinity and oxygen rich. Variability in the strength and direction of these currents does occur. The weakening of the Indonesian Flowthrough and Leeuwin Current can result in the upwelling of cooler, more nutrient-rich waters, resulting in areas of biological productivity. In addition, the density differences of these surface and subsurface waters creates the occurrence of internal waves, which are considered particularly pronounced in the North-west Marine Region.

Currents in the Fourth Train Proposal Area are principally driven by semidiurnal tidal forcing (Chevron Australia 2005; ExxonMobil Development Company 2011). The direction of tidal currents is a flood flow towards the south-west and an ebb flow towards the north-east (ChevronTexaco Australia 2003). Local winds can influence water circulation, more so in the upper 200 m of the water column (ExxonMobil Development Company 2011). Maximum current speeds in upper regions of the water column (surface to 100 m deep) in the vicinity of the Jansz–Io Gas Field are generally predicted to range from 0.33 to 0.8 m/s in non-cyclonic conditions and may occasionally approach 1.1 m/s under extreme storm conditions (ExxonMobil Development Company 2011).

On the western side of Barrow Island, the driving forces for ocean currents are a complex balance. Tidal currents are weaker than on the eastern side of Barrow Island, particularly in the deeper waters, but are influenced by large-scale ocean circulations in the Indian Ocean, such as eddies and other geostrophic flows (Chevron Australia 2014).

On the eastern side of Barrow Island, current patterns are strongly dominated by the tide and its spring–neap cycle, with a flood flow towards the south-west and an ebb flow towards the north-east (for both spring and neap tides) (ChevronTexaco 2003). Longer-term transports over the inner- and mid-shelf are mainly controlled by wind-driven flow, which follows the seasonal switch from summer monsoon winds to south-easterly trade winds in winter (Chevron Australia 2014). Tidal currents in the vicinity of the Fourth Train Proposal Reverse Osmosis reject brine outfall dissipate through an offshore channel north of Town Point. The maximum current measured in the vicinity of Town Point was 0.62 m/s (ChevronTexaco 2003).

6.4.3.3 Waves

The North-west Marine Region typically experiences a persistent winter swell of around 2 m, generated by low-pressure systems in southern latitudes (Pearce *et al*. 2003). During winter, strong easterly winds can also generate 2 m seas. Both swell and seas tend to be smaller during summer (Pearce *et al*. 2003).

Local offshore wind-generated seas in the Fourth Train Proposal Area have variable wave heights, typically up to 4 m under non-tropical cyclone conditions (APASA 2009). Tropical cyclones generate waves propagating out in a radial direction from the storm centre, and generate swells from any direction, with wave heights between 0.5 and 9.0 m (APASA 2009).

The south-western to north-western sides of Barrow Island are exposed to the open ocean and a relatively vigorous wave climate, bringing long-period Southern Ocean swells (also referred to as the Indian Ocean swell) and shorter period local wind waves, particularly during the summer months, when winds prevail from the south-west. At times, the Southern Ocean swell can refract around the northern and southern ends of Barrow Island, but the shallow bathymetry prevents significant propagation (ChevronTexaco Australia 2003).

The eastern side of Barrow Island is largely sheltered from the westerly swell by Barrow Island, the Lowendal Shelf, and the shallow bathymetry between Barrow Island and the mainland (ChevronTexaco Australia 2003; KJVG 2008). The ambient nearshore wave climate of the eastern side of Barrow Island is dominated by locally generated sea states derived from easterly sea breezes between the mainland and Barrow Island, which mostly occur during winter. These cause a direct setup of waves against the east coast of Barrow Island. Typically wave heights are within the range of 0.2 to 0.5 m with peak periods of two to four seconds (RPS MetOcean 2008). The mean significant wave height at the Materials Offloading Facility is 0.47 m, with a maximum wave height of 2.11 m (KJVG 2008). Maximum wave heights are mostly the result of tropical cyclones. However, the maximum wave heights at the Materials Offloading Facility are limited by the shallow bathymetry (KJVG 2008).

6.4.3.4 Tides

Astronomical tides on the North West Shelf are semidiurnal and generally quite large, ranging from 0.95 m near Exmouth to more than 3 m on the inner shelf near Broome. Maximum spring tide amplitudes range from just over 2 m at Exmouth, 2.5 m at Onslow, 4.5 m at Dampier, to nearly 6 m at Port Hedland. The increase in tidal amplitude from south to north is most marked north of the Montebello Islands, where the width of the continental shelf increases significantly (Heyward *et al*. 2000). The dominant tidal current flows in summer are east-north-east and west-south-west, with speeds generally ranging from 0.1 to 0.3 m/s (Pearce *et al*. 2003).

The tidal range varies significantly around Barrow Island with a maximum spring tide range on the east coast of just over 4 m, while on the west coast the tidal range is less than 2.5 m (Australian Geological Survey Organisation 1988; Australian Hydrographic Service 2008; KJVG 2008). The significant tidal ranges and shallow bathymetry result in large areas of exposed seabed at low tide (WAPET 1989).

6.4.4 Water and Sediment Quality

6.4.4.1 Water Quality

The North-west Marine Region's surface waters are considered nutrient-poor due to the Indonesian Throughflow dominating the surface waters of the entire region. These waters contain high freshwater run-off from its passage through the Indonesian Islands and also suppress the upwelling of deeper more nutrient-rich waters. Being a warm, fresh current running southward along the shelf break, the Leeuwin Current also contributes to the nutrient-poor status. However, seasonal changes such as the weakening of these two key currents can result in episodic upwelling events (DEWHA 2008). Water clarity in the region varies according to water movement and the seabed sediment type (DEC 2007). In offshore waters, fine sediments are often resuspended by ground swell and these deeper areas can be turbid near the seabed (Chevron Australia 2005).

State Waters surrounding Barrow Island are well-mixed with seabed topography, strong currents, tidal ranges and winds driving the mixing process (RPS 2009). On average, two cyclones pass through the Barrow Island area each year, resulting in periods of high suspended sediment loads. Waters on the west coast are considered to have the highest clarity (<5 mg/L of total suspended sediment solids), which progressively decreases towards the south-eastern side of Barrow Island (DEC 2007).

Marine baseline surveys completed in 2006 in the vicinity of the Fourth Train Proposal horizontal directional drilling exit points off the west coast of Barrow Island recorded background levels of total suspended solids ranging between 3 and 4 mg/L (average 3.66 mg/L) (RPS BBG 2007). Off the east coast, in the vicinity of Town Point, background levels of total suspended solids ranged between 1.0 and 8.8 mg/L (average 3.8 mg/L) (RPS 2009).

Water quality in the vicinity of Barrow Island is characterised by high concentrations of nutrients (RPS BBG 2007). The analysis by RPS BBG (2007) recorded concentrations of nitrate and nitrite and Total Phosphorus (TP) above the Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) (2000) guidelines, with values ranging from 16 to 32 µg.N/L (west coast) and 80 to 210 µg.P/L (east coast), but this appears to be characteristic of the area based on their generally wide distribution (RPS BBG 2007).

Marine baseline surveys of seawater samples from the east and west coast of Barrow Island for hydrocarbons, benzene, toluene, ethylbenzene, and xylene (BTEX), oils and grease, phenols, and organotins showed that most analytes were below the laboratory reporting limits at the majority of sampling sites (RPS BBG 2007). Relatively high cadmium concentrations indicated that this is likely to be normal background concentrations rather than contamination, as it is consistent with results from other independent research in the Pilbara Region (RPS BBG 2007).

6.4.4.2 Salinity

The North-west Marine Region surface waters are of low salinity due to the presence of equatorial waters predominantly from the Indonesian Throughflow and Leeuwin Current. The regions subsurface currents (waters originating from southern Australia travelling towards the equator) are characterised by cooler waters with greater salinity levels.

Inshore waters off the west and east coasts of Barrow Island range in salinity between 35.08 and 37.75 ppt, with an average of 35.4 ppt (RPS BBG 2007). Salinity stratification between the surface and bottom waters is uncommon due to the waters being well-mixed (Chevron Australia 2005).

The salinity levels in the vicinity of Town Point have remained within ambient levels during Foundation Project discharge to date. No breaches of the established water quality criteria concentration (set at 36.1 ppt) have occurred as a result of the Foundation Project temporary reverse osmosis facilities brine discharge outfall to date. However, natural fluctuations in ambient salinity may at times result in salinity levels above 36.1 ppt in this area while maintaining a 40-fold dilution of the reverse osmosis brine discharge.

6.4.4.3 Bedform and Sediment Quality

Seabed sediment on the North-west Shelf is predominantly carbonate derived from the breakdown of marine material. It becomes finer (in sediment size) with increasing water depth with sands and gravels dominating the shelf changing to mud on the continental slope (DEWHA 2008). The steep scarp face feature is composed of over-consolidated silt materials (GUFT 2009). West of the scarp, sediments are likely to comprise of soft sediments of varying grain size. The thickness of sediment layers range from more than 5 m thick to a very thin patchy veneer, or absence, over large areas of sea floor (Chevron Australia 2005).

Sea floor sediments directly off the west coast of Barrow Island are dominated by a cemented calcarenite substrate, more commonly referred to as a limestone pavement feature. A veneer of sand of varying thickness covers the limestone pavement in some areas (Chevron Australia 2005). Seabed sediment on the east coast of Barrow Island in the vicinity of the Materials Offloading Facility are generally finer (displaying a greater clay, silt, and fine sand fractions) than those sediments observed off the west coast, but still contain a considerable sand component (typically more than 60%). Existing sediment quality data (nutrient and metal concentrations) are below the established Interim Sediment Quality Guideline trigger values (ANZECC/ARMCANZ 2000). Marine baseline surveys conducted on the east and west coast of Barrow Island found that the levels of hydrocarbons and BTEX in sediment samples were below laboratory reporting limits. Tributyltin (TBT) was detected, but at levels below the ANZECC/ARMCANZ (2000) guidelines. This was expected because of the historical and continued use of the area by significant numbers of large vessels (RPS BBG 2007). Oil and grease concentrations from less than 100 to 490 mg/kg were recorded in sediment samples taken during from the east coast during baseline surveys in November 2009 (Chevron Australia 2013). These concentrations are comparable to results from preliminary sediment quality data collected during sediment sampling surveys undertaken in 2006 (RPS BBG 2007).

6.4.5 Landforms and Topography

Barrow Island has a relatively low elevation (up to 60 m above sea level) (Figure 6-4) and is characterised by gentle undulations, eroded ridges, valley floor flood plains, and some incised creek channels. Five landscape units have been identified on Barrow Island (Chevron Australia 2008), specifically:

- West Coast Complex: The west coast of Barrow Island is exposed to direct wind and wave action from the Indian Ocean. The coastline topography varies from rocky weathered sheer cliffs to less steep, traversable inclines. Typically, narrow sandy beaches occur between weathered rocky headlands. This coastline is a significant feature of Barrow Island.

- East Coast Complex: The east coast is protected from wave action and has a slight land gradient to the ocean. This coastline is characterised by vegetated sand dunes and expansive tidal flats.
- Valley Slopes and Escarpments: The western half of Barrow Island is characterised by steep formed valleys, escarpments, and exposed limestone ridges.
- Limestone Ridges: This landscape unit generally occurs throughout the central upland plateaus of Barrow Island. The terrain ranges from steeper slopes in the west to flatter, more gentle, undulations as the ridges continue east.
- Creek and Seasonal Drainage: This landscape unit generally occurs in the broad valleys and flats of limestone ridges, and is located adjacent to the coastal fringes. This landscape has deeper alluvial soil structure.

The topography of Barrow Island in relation to the approved Foundation Project and the Fourth Train Proposal is shown in Figure 6-4 and Figure 6-5.

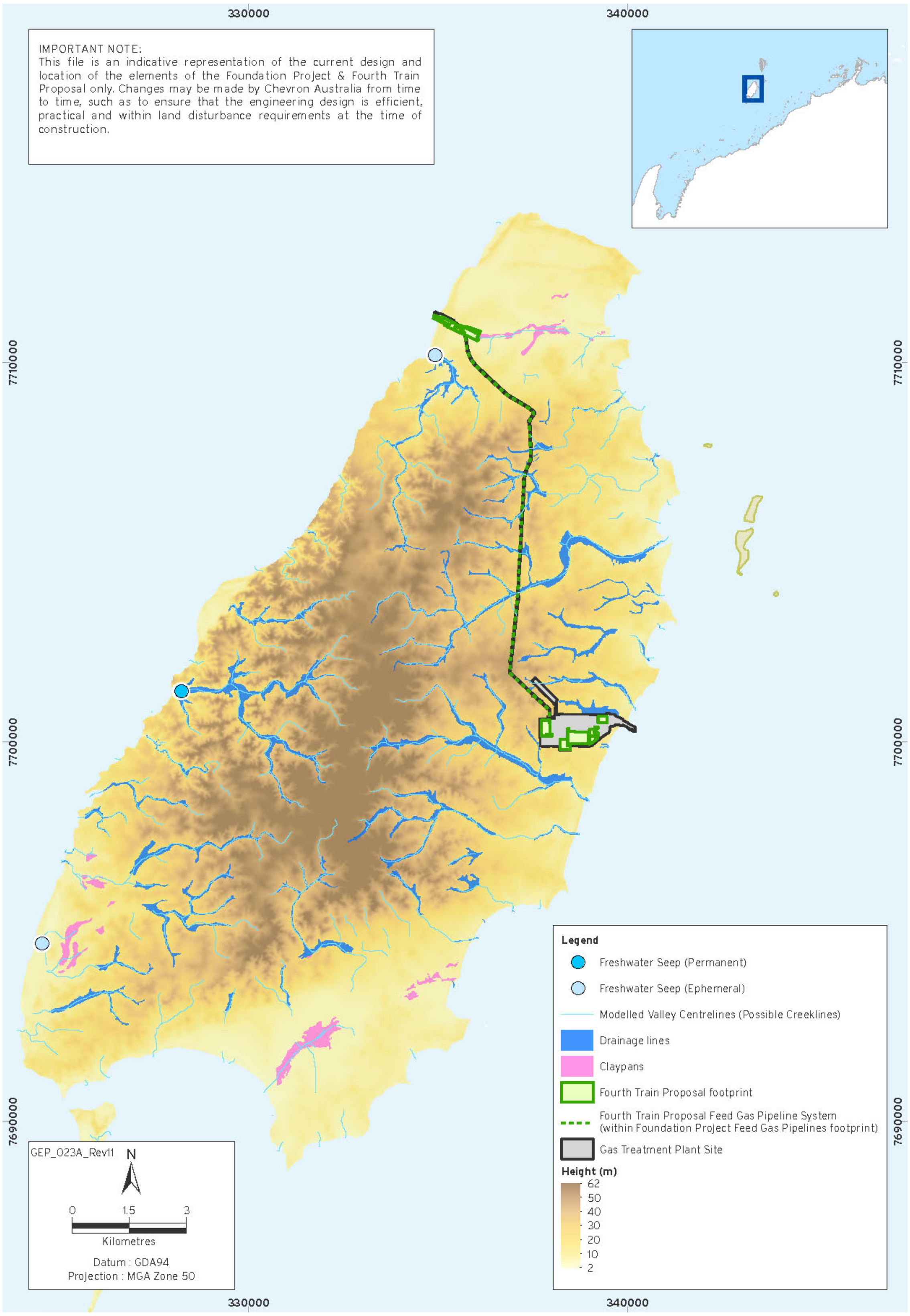


Figure 6-4: Surface Hydrology and Topography of Barrow Island

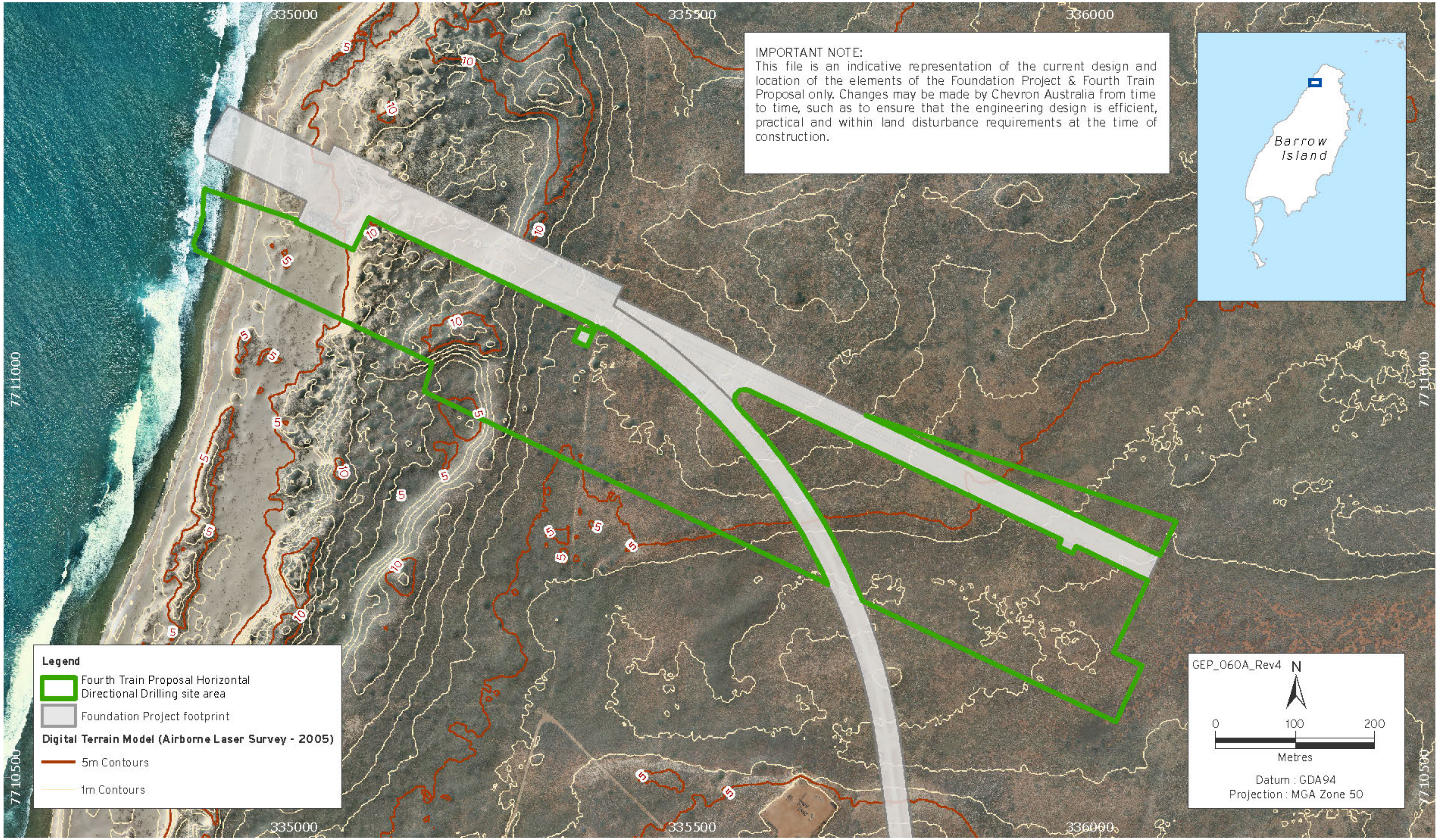


Figure 6-5: Topography of the Horizontal Directional Drilling Site

6.4.6 Geology and Soils

Barrow Island is a geological extension of the Cape Range Peninsula, which became separated from mainland Australia between 8000 and 10 000 years ago as a result of rising sea levels. Barrow Island is composed of coastal deposits overlaying tectonically folded limestone (Chevron Australia 2008).

Three broad geomorphic units have been identified on Barrow Island:

- limestone uplands
- near-coastal lowlands
- coastal fringe (Chevron Australia 2008).

The surface geology at the Gas Treatment Plant site consists of limestone (Tamala limestone), floodplain deposits, dune sands, and gravels. Geotechnical investigations near the Gas Treatment Plant site encountered up to 10 m of sands and clays overlaying limestone (Chevron Australia 2008).

Over the Fourth Train Proposal Feed Gas Pipeline System route between the shore crossing and the Gas Treatment Plant, the surface geology consists of outcrops of variably weathered Trealla limestone, interspaced with alluvial and colluvial deposits. These deposits are associated with the intermittent dendritic drainage system present on Barrow Island and primarily consist of calcarenitic sands and gravels (Chevron Australia 2005).

North Whites Beach—the location of the Fourth Train Proposal Feed Gas Pipeline System shore crossing—comprises coastal sands overlaying shoreline limestone platforms. An outcrop of limestone forms an extensive rock platform between the water and the sand, and runs parallel to the sandy beach. The primary dunes are steep and comprise coastal sand (Chevron Australia 2011a).

6.4.7 Seismic Activity

North-western Australia is a seismic area of low frequency and magnitude events in comparison with the rest of the Australian continent (University of Western Australia [UWA] 2011).

Barrow Island is located within a linear zone of seismicity known as the North West Shelf Zone, and occurs in an area of relatively low seismic activity (Chevron Australia 2008). The Barrow Fault, located at the southern end of Barrow Island, is represented topographically by a low, east–west trending escarpment.

6.4.8 Surface Hydrology

Surface hydrology on Barrow Island is characterised by:

- significant run-off in some areas and short-term ponding, both caused by unpredictable, but sometimes very intense, rainfall (Section 6.4.1)
- consistently high rates of evaporation resulting in extremely low soil moisture content
- high infiltration capacities of the surface sands and limestones, which is conducive to recharge of relatively deep groundwater aquifers (Chevron Australia 2008).

There are no wetlands listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or catchments listed under the *Country Areas Water Supply Act 1947* (WA) on Barrow Island (Chevron Australia 2014a).

A water divide running north to south along a central, elevated ridge divides the hydrological regime of Barrow Island (Chevron Australia 2008) (Figure 6-4). Creeks flow along a largely east–west orientation on either side of this divide; these creeks are highly ephemeral, usually dry, and generally flow in response to short intense rainfall rather than long duration rainfall events (Chevron Australia 2014a).

The Fourth Train Proposal Feed Gas Pipeline System crosses 14 ephemeral creeks (Figure 6-4); in many locations, these creeks are only discernible by the increased presence of vegetation (Golder Associates 2008).). Flow velocities in the ephemeral creeks are low (Golder Associates 2008).

The only permanent surface water features on Barrow Island are seeps that discharge into near-coastal (brackish to saline) pools of water (WAPET 1989). These seeps occur on the west coast of Barrow Island, remote from the Gas Treatment Plant and more than 5 km away from the Fourth Train Proposal Feed Gas Pipeline System Footprint. Other seeps are ephemeral and generally only appear after rain events. An ephemeral freshwater seep is situated approximately 500 m south of the shore crossing.

There are 22 claypans on Barrow Island covering a total of 193 ha. Claypans are areas where standing water typically accumulates for more than a few days after rainfall events. Two claypans are currently intersected by the existing road between the approved Butler Park (Construction Village) and the airport. This road is used as part of the approved Foundation Project and will be used by the Fourth Train Proposal. One claypan lies approximately 100 m north of the Fourth Train Proposal horizontal directional drilling site (Figure 6-9).

6.4.9 Hydrogeology

There is one shallow unconfined aquifer on Barrow Island, which contains a fresher water lens (at depths typically between 9 and 53 m) floating upon denser, saline groundwater (Chevron Australia 2008). The aquifer is located predominantly within the Tertiary limestone and is hydraulically separated by a thick sequence of low permeability material (Chevron Australia 2005). The aquifer provides habitat for significant subterranean stygofauna (Chevron Australia 2014a) (Section 6.5.3.5). The Combined Gorgon Gas Development Footprint overlies only a very small portion of the shallow unconfined aquifer.

The freshwater lens extends across Barrow Island to within 200 to 500 m of the coast (Groundwater Consulting Services 2005) where tidal influences prevent the formation of a stable low salinity lens (Chevron Australia 2007). The thickness of the freshwater lens increases from zero metres at its edge up to 25 m at around one to two kilometres from the coast. Whether the thickening is abrupt or gradual varies depending upon local groundwater flow, lithology, and recharge (Groundwater Consulting Services 2005). The freshwater lens is 20 m thick, on average (Groundwater Consulting Services 2005), but in most areas where groundwater abstraction has occurred, it appears to occur as a relatively thin lens up to six metres deep (WAPET 1989). The boundary between the fresh and saline water is not a sharp boundary line, but a transition zone of brackish water, caused by seasonal fluctuations in rainfall, tidal action, and amount of water extraction and discharge (Chevron Australia 2005).

Recharge to the aquifer is principally from direct infiltration of rainfall and, to a lesser extent, by indirect enhanced recharge in drainage lines (Groundwater Consulting Services 2005). Based on similar areas of Trealla Limestone in the Cape Range, a conservative estimate is that 10% of rainfall enters the groundwater regime (Groundwater Consulting Services 2005).There are several saline groundwater systems on Barrow Island (Chevron Australia 2008):

- Tertiary Limestone, extending from the mean sea level down to approximately 300 m below mean sea level
- Windalia Sand Member of the Muderong Shale, generally at depths between 650 m and 700 m below mean sea level
- the Barrow Group comprising the Flacourt and Malouet Formations, generally at depths between 1000 m and 2000 m below mean sea level
- the Dupuy Formation, generally at depths between 2000 m and 2300 m below mean sea level
- the Biggada Formation, generally at depths greater than 3000 m below mean sea level.

6.4.9.1 Air Quality, Light, and Noise

Air quality, light, and noise at both regional and Barrow Island scales are influenced by natural and artificial sources. For details, refer to Sections 5.2.2, 5.3.2, and 5.4.2.

6.4.10 Climate Change Projections

There is intrinsic uncertainty in making accurate climate change projections. Simulation of 20th and 21st century climate was conducted using 23 global climate models (Commonwealth Scientific and Industrial Research Organisation [CSIRO] and BOM 2007). The global climate models were used to determine large-scale effects on global climate, typically with a horizontal resolution of between 150 and 300 km. Using the global climate models, the CSIRO and BOM published comprehensive data on climate change predictions for Australia (CSIRO and BOM 2007; CSIRO and Department of Environment [DOE] 2007), to provide probabilistic information across various emissions scenarios.

Short-term climate change projections demonstrate little variation between different emissions scenarios, as changes are strongly affected by greenhouse gases that have already been emitted. However, climate change projections within the anticipated production life of the Fourth Train Proposal (i.e. to approximately 2070) have greater variation as they are more dependent on future greenhouse gas emissions. As these future greenhouse gas emissions are currently unknown, greater variation exists due to the numerous emission scenarios modelled.

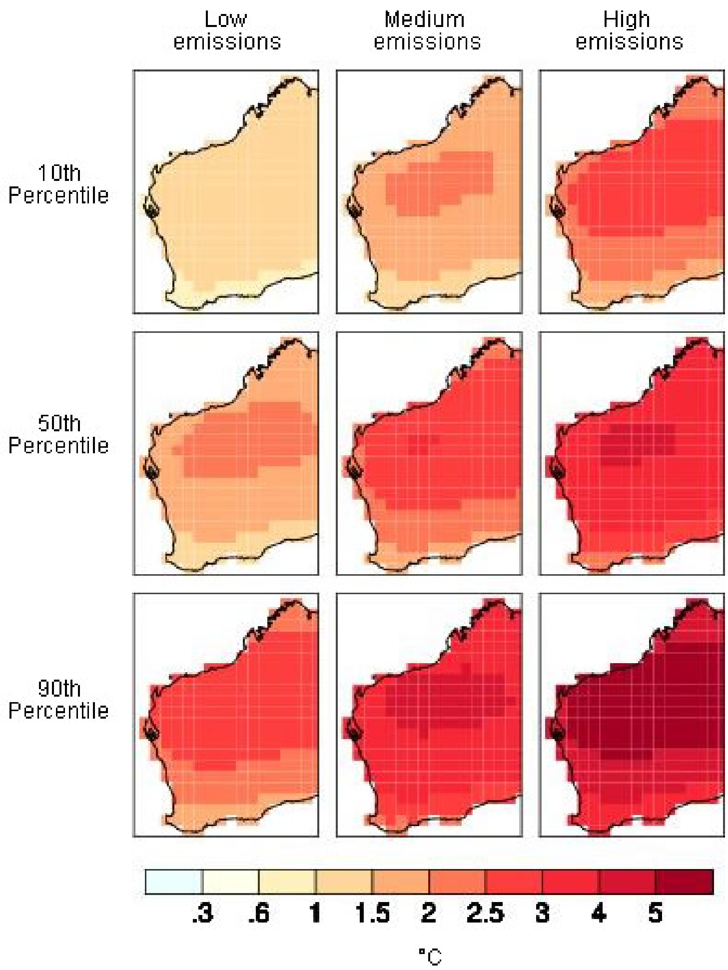
Of the 23 global climate models used, the 50th percentile (the mid-point of the spread of model results) provides a 'best estimate' result. The 10th and 90th percentiles (lowest 10% and highest 10% of the spread of model results) provide a range of uncertainty.

Since then, the Indian Ocean Climate Initiative (IOCI; a research partnership between the Government of Western Australia, CSIRO, and BOM) conducted a subsequent study from 2008 to 2012. This study was conducted using a regional climate model built upon previous studies. Different from the global climate models, regional climate models work to increase the resolution of the global climate model in a small area of interest, down to scales of 50 or 25 km. The IOCI aimed to analyse both rainfall and temperature variability and change across the whole of Western Australia and, in particular, to improve understanding of the north-west Western Australia's climate and weather systems (IOCI 2012).

6.4.10.1 Temperature Change

Allowing for model-to-model variations, the annual warming for Australia by 2070 is predicted to increase by 1.0 to 2.5 °C (low-emissions scenario) and between 2.2 and 5.0 °C (high emissions scenario) from that currently experienced. However, coastal regions experience less warming than inland areas (Figure 6-6) and projected temperate change can vary significantly at fine spatial scales, particularly in coastal and mountainous areas (CSIRO and BOM 2007, 2007a).

The IOCI 2012 study found that across the Pilbara, maximum temperatures are expected to increase by a total range of 3.8 to 4.6 °C by the end of the century (defined as 2082 to 2099). Although these temperature projections are suitable for impact, vulnerability, and risk assessments, they should be viewed as plausible future climates, not as predictions or weather forecasts (IOCI 2012).



Source: CSIRO and BOM (2007)

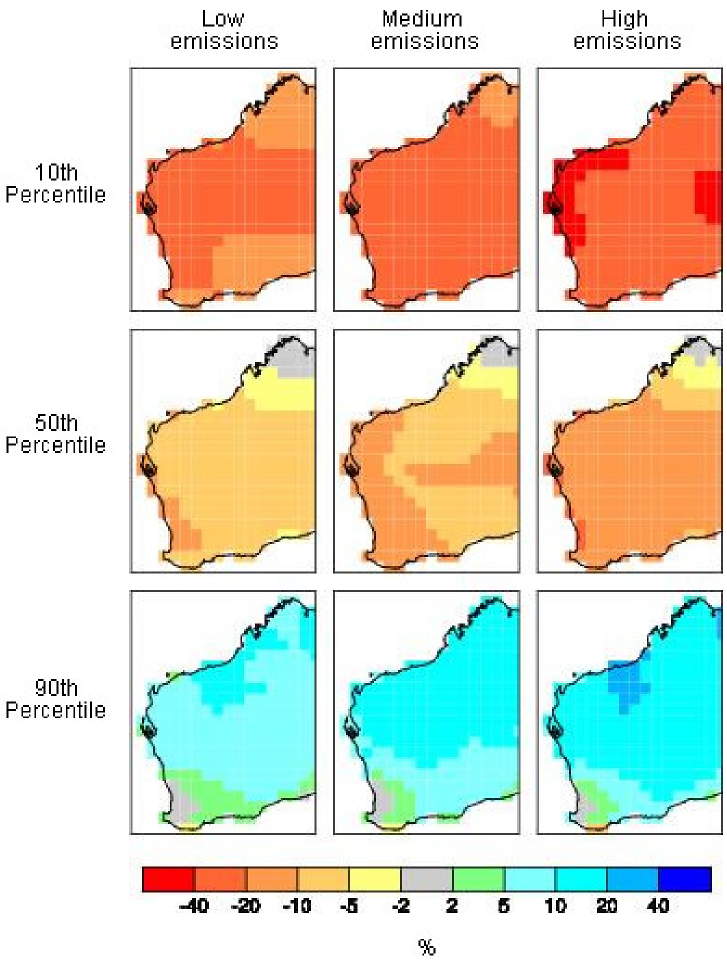
Figure 6-6: Western Australia Temperature Change 2070

6.4.10.2 Precipitation Change

Predicted precipitation changes for 2070 under the low-emissions scenario range from -20% to +10% in central, eastern, and northern regions of Western Australia. The 'best estimate' shows a grading to around a 7.5% decrease in other areas (Figure 6-7). Under the high emissions scenario, the range of annual precipitation change is -30% to +20% in central, eastern, and northern areas, with a 'best estimate' of little change in the far north, grading to around -10% in the south (CSIRO and BOM 2007, 2007b).

As for temperature, statistical downscaling studies have shown that projected precipitation change can vary significantly at fine spatial scales, particularly in coastal and mountainous areas. Regional precipitation variations can be quite sensitive to small differences in the wind patterns and other processes (CSIRO and BOM 2007; 2007b).

The IOCI 2012 study found that across the Pilbara, projections indicate a trend of drying by mid-century that will continue through to the end of the century. Projected rainfall reductions range from 9 to 24% for the end of the century. Although these projections may be used to inform climate change adaptation measures, including impact, vulnerability and risk assessments, there is a source of uncertainty given that observed rainfall records indicate a current increasing rainfall trend in east Pilbara whereas the majority of downscaled projections indicate future decreases (IOCI 2012).



Source: CSIRO and BOM (2007)

Figure 6-7: Western Australia Rainfall Change 2070

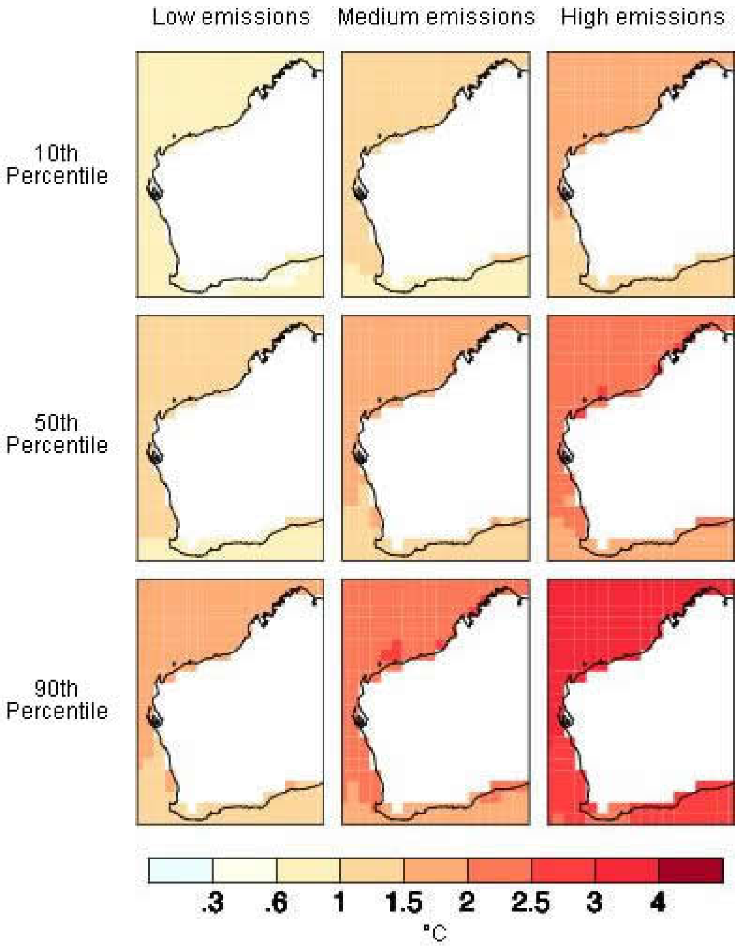
6.4.10.3 Sea Level Rise and Storm Surge

Global warming is predicted to cause the sea level to rise as increasing temperatures result in the melting of glaciers and land ice and in the thermal expansion of oceans. Global sea level rise is projected by the Intergovernmental Panel on Climate Change (IPCC) to be between 18 and 59 cm by 2100, with a possible additional contribution from ice sheets of 10 to 20 cm (CSIRO and BOM 2007). However, further ice sheet contributions, which cannot currently be quantified, may increase substantially the upper limit of sea level rise (CSIRO and BOM 2007).

Storm surges occurring on higher mean sea levels will result in coastal inundation and the penetration of damaging waves further inland. This would increase the potential for flooding, erosion, and damage to built infrastructure and natural ecosystems (CSIRO and BOM 2007).

6.4.10.4 Sea Surface Temperature Change

Sea surface temperature projections were available for 11 of the IPCC Fourth Assessment Report climate models (IPCC 2007). Under the low-emissions scenario for 2070, sea surface temperature increase is predicted to rise by 1.2 to 1.5 °C around Australia's west coast (Figure 6-8). Under the high emissions scenario, the regions of warming are predicted to be approximately 1.0 °C higher than the low-emissions scenario (CSIRO and BOM 2007, 2007c).



Source: CSIRO and BOM (2007)

Figure 6-8: Western Australia Sea Surface Temperature Change 2070

6.4.10.5 High-intensity Rainfall Events and Cyclones

Projected changes in tropical cyclone behaviour conditions are difficult to predict as tropical cyclones are not well resolved by global or regional climate models (Pittock *et al*. 1996; Walsh and Pittock 1998; CSIRO and BOM 2007, 2007b). Australian region studies indicate a likely increase in the proportion of tropical cyclones in the more intense categories, but a possible decrease in the total number of cyclones (CSIRO and BOM 2007). Peak intensity may increase by 5 to 10% and precipitation rates may increase by 20 to 30% (IPCC 2001, cited in CSIRO and BOM 2007; Walsh 2004).

A study based on the CSIRO simulations (Abbs *et al*. 2006), shows a 44% decrease in tropical cyclone numbers by 2070 for the coastline of Western Australia. However, severe Category 3 to Category 5 storms may increase—an increase of 60% and 140% in the intensity of the most extreme storms for 2030 and 2070, respectively, was found using a model with a 15 km grid spacing (Abbs *et al*. 2006). Walsh (2004) found an increase of 56% by 2050 using a 30 km model. Leslie *et al*. (2007) used a 50 km model and reported an increase of 22% by 2050 (CSIRO and BOM 2007).

The IOCI projects an increase in the proportion of tropical cyclones with a higher wind speed and intensity for the north-west of Western Australia (IOCI 2012). This research also projects a decrease in extreme rainfall events for the Pilbara Region, although these projections should be regarded as initial estimates and not used as part of impact assessment processes.

6.4.10.6 Ocean Acidification

Projected worldwide increases in carbon dioxide (CO_2) emissions may cause global changes in the carbon chemistry of the surface waters of the ocean. Ocean acidification is predicted to lower current global oceans' pH by 0.5 units by 2100, equivalent to a 320% increase in acidity (SEWPaC 2012a).

6.5 Terrestrial Ecology

6.5.1 Vegetation and Flora

6.5.1.1 Regional

Barrow Island is located within the Fortescue Botanical District of the Eremaean Botanical Province (Beard 1980). More recently, the area has been categorised in the Cape Range subregion according to the Interim Biogeographic Regionalisation of Australia (Kendrick and Mau 2002).

In some respects the flora of Barrow Island is typical of the arid Pilbara Region, but it also exhibits floral affinities with the Cape Range area on the mainland (Trudgen 1989; Mattiske Consulting Pty Ltd 1997). The floral linkages reflect both the past linkages to the mainland and the relative diversity of flora on Barrow Island (RPS BBG and Mattiske 2005).

6.5.1.2 Vegetation

In previous Foundation Project approval documentation (Chevron Australia 2005, 2008), 34 broadscale vegetation units were identified on Barrow Island by Mattiske and Associates (1993). These were referred to as 'vegetation types', while smaller 'vegetation communities' were delineated within these types. The Mattiske classification system was difficult to extend due to the inconsistent scale of vegetation description and a number of habitat and location issues.

Subsequent survey work redefined the classification system for vegetation on Barrow Island to ensure consistent terms and classifications across regional areas. All classifications were reassessed and assigned new categories. In line with the National Vegetation Information System (NVIS), the 'vegetation types' can more accurately be described as 'broad floristic formations' (hierarchical level III) and the 'vegetation communities' as 'vegetation associations' (hierarchical level V) (Astron Environmental Services 2011). All vegetation described on Barrow Island has now been classified in order of:

- broad floristic formation
- subformation
- association.

A total of 825 vegetation associations are identified, not including habitats that have been classed as disturbed (e.g. from previous and existing activities such as petroleum exploration production, roads, airport, wells, and pads) (Table 6-1).

The 825 vegetation associations are grouped into 11 categories based on broad conservation significance (Astron Environmental Services 2011) (Section 6.5.1.3). Mapping of vegetation associations using geographic information systems (GIS) has been undertaken by Chevron Australia; this mapping covers some 2773 ha, which represents 11.6% of the total area of Barrow Island (approximately 23 500 ha).

The exact location, size, and dimensions of the Fourth Train Proposal horizontal directional drilling site have not yet been determined; however, the horizontal directional drilling site will be located within the area shown in Figure 6-9. Note that the Fourth Train Proposal clearing will be within the allocated uncleared land available for tenure on Barrow Island under the *Barrow Island Act 2003* (WA).

The 14 vegetation associations that characterise the (approximately) 20 ha horizontal directional drilling site area (of which up to 10 ha will comprise the horizontal directional drilling site) are described in Table 6-2.

Table 6-1: Classification of Vegetation on Barrow Island According to Habitat/Landform

Habitat	Broad Floristic Formations	Subformations	Associations
Limestone Slopes	15	100	407
Flats	11	60	220
Creeks/Drainage Lines	13	43	125
Coastal Complex	9	32	65
Claypan	4	5	6
Marine	1	1	1
Tidal	1	1	1
Disturbed	12	48	106
Total (incl. Disturbed)	**66**	**290**	**931**
Total (excl. Disturbed)	**54**	**242**	**825**

Source: Astron Environmental Services 2011

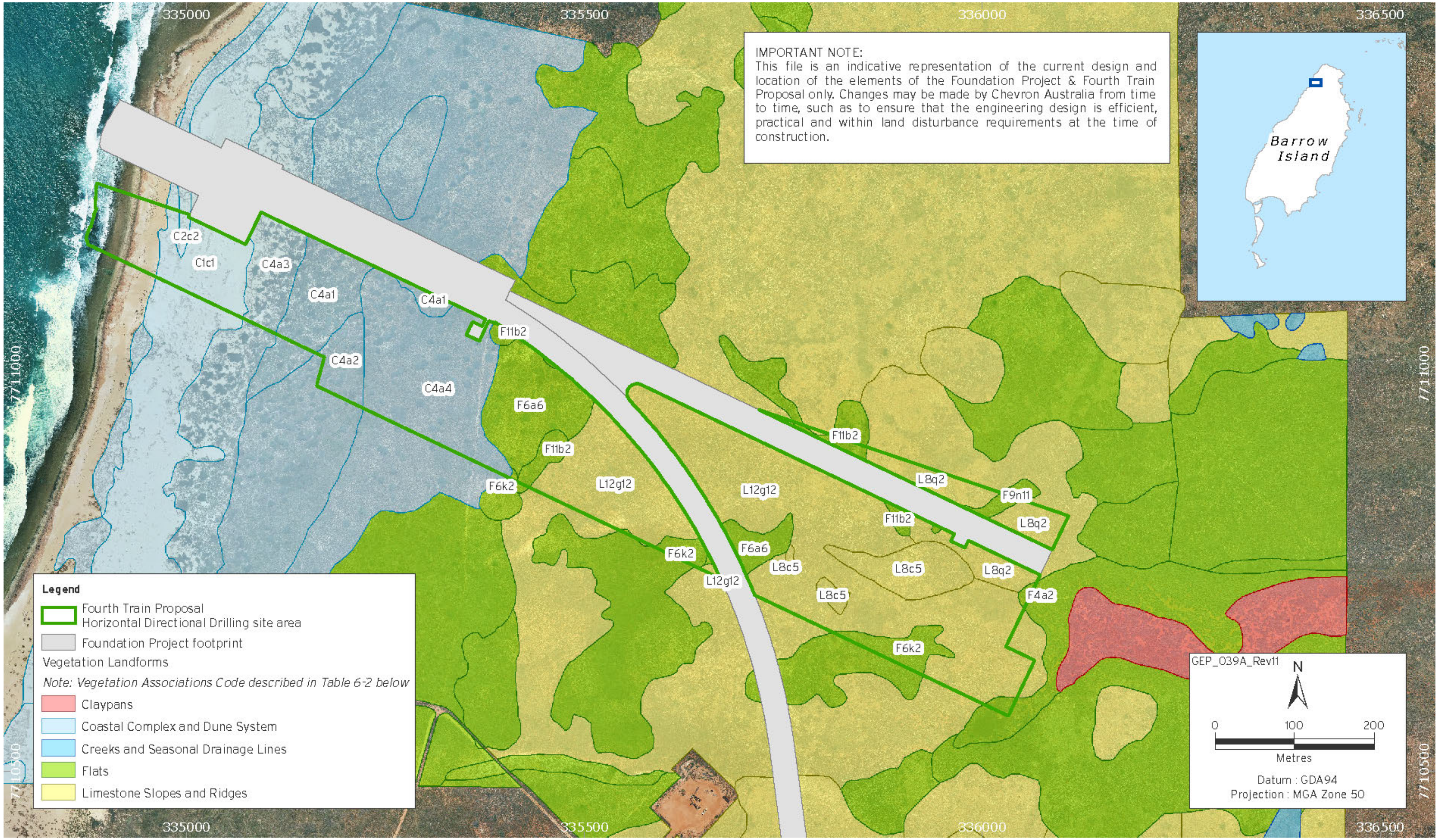


Figure 6-9: Vegetation Associations in the Vicinity of the Fourth Train Proposal Horizontal Directional Drilling Site Area

Table 6-2: Vegetation Associations at the Fourth Train Proposal Horizontal Directional Drilling Site

Code	Vegetation Description	Habitat Description	Description of Distribution on Barrow Island and Conservation Significance of Vegetation
C1c1[(1)]	Grassland of *Spinifex longifolius* over very open herbs of *Threlkeldia diffusa* with low scattered shrubs of *Rhagodia preissii* subsp. *obovata* and *Frankenia pauciflora* var. *pauciflora*.	Ridges and back slopes of white sandy foredunes	Vegetation restricted in distribution coverage on Barrow Island, based on total land area on Barrow Island
C2c2 [(1)]	Open grassland of *Spinifex longifolius* with low scattered *Atriplex isatidea*, *Myoporum montanum*, *Euphorbia myrtoides* and *Salsola tragus* shrubs and herbs.	Seaward face of white sandy foredunes	Vegetation restricted in distribution coverage on Barrow Island, based on total land area on Barrow Island
C4a1[(1)]	Low open shrubland to shrubland of *Acacia coriacea* subsp. *coriacea* with *Threlkeldia diffusa* over hummock grassland to closed hummock grassland of *Triodia epactia*.	Back slopes of secondary dune slopes and ridges	Vegetation restricted in distribution coverage on Barrow Island, based on total land area on Barrow Island
C4a2[(1)]	Shrubland of *Acacia coriacea* subsp. *coriacea* over low shrubland to shrubland of *Olearia dampieri* subsp. *dampieri*, *Stylobasium spathulatum* and *Acacia bivenosa* over hummock grassland of *Triodia epactia* over low scattered *Threlkeldia diffusa* herbs.	Swales between dunes	Vegetation restricted in distribution coverage on Barrow Island, based on total land area on Barrow Island
C4a3	Low shrubland of *Acacia coriacea* subsp. *coriacea* with *Rhagodia preissii* subsp. *obovata* over very open herbs of *Threlkeldia diffusa* over grassland to hummock grassland of *Triodia epactia* and *Spinifex longifolius*.	Secondary dune slopes and ridges	Not restricted in distribution coverage
C4a4	Open shrubland of *Acacia coriacea* subsp. *coriacea* over low open shrubland of *Olearia dampieri* subsp. *dampieri* and *Acacia bivenosa* with occasional *Stylobasium spathulatum* over hummock grassland of *Triodia epactia* (on dunes) over scattered *Heliotropium glanduliferum* and *Diplopeltis eriocarpa* (on back dunes and on red/brown sandy flats).	Sandy dune ridges and the back of dunes and red/brown sandy flats	Not restricted in distribution coverage
F11b2[(2)]	Low open woodland of *Erythrina vespertilio* over low open shrubland of *Pentalepis trichodesmoides*, *Solanum lasiophyllum* and *Trichodesma zeylanicum* over hummock grassland of *Triodia epactia* with patches of *T. wiseana*.	Red sandy flats with some limestone outcropping	Vegetation restricted in distribution coverage on Barrow Island, based on total land area on Barrow Island; and vegetation containing typically >2% cover of flora that are either Declared Rare, Priority, EPBC Act-listed or Specially Protected, and used to define the vegetation
F4a2[(1)]	Hummock grassland to closed hummock grassland of *Triodia angusta* with scattered *T. epactia* and *Eulalia aurea*.	Fringing claypan in shallow basin with loamy red silts	Not restricted in distribution coverage

Code	Vegetation Description	Habitat Description	Description of Distribution on Barrow Island and Conservation Significance of Vegetation
F6a6	Scattered shrubs of *Acacia coriacea* subsp. *coriacea* with low open shrubland of *Acacia bivenosa*, *Pentalepis trichodesmoides*, *Stylobasium spathulatum*, *Diplopeltis eriocarpa* and *Corchorus walcottii* over closed hummock grassland of *Triodia epactia*.	Red brown sandy flats with limestone cropping	Not restricted in distribution coverage
F6k2	Low open heath of *Stylobasium spathulatum* over *Diplopeltis eriocarpa* or scattered low shrubs of *Solanum lasiophyllum* over hummock grassland of *Triodia epactia* over scattered herbs of *Pterocaulon sphaeranthoides*, *Nicotiana occidentalis* subsp. *occidentalis*, *Swansonia pterostylis* and *Synaptantha tillaecea* var. *tillaecea*.	Red brown sandy flats with some limestone outcropping	Not restricted in distribution coverage
F9n11	Low shrubland of *Stylobasium spathulatum, Trichodesma zeylanicum* and scattered *Corchorus walcottii* over closed hummock grassland of *Triodia epactia* with some *T. wiseana* and *T. angusta*.	Red brown sandy slopes with some limestone outcropping	Not restricted in distribution coverage
L12g12	Scattered low trees of *Ficus brachypoda* over low open shrubland of *Pentalepis trichodesmoides* over hummock grassland of *Triodia epactia* and patches of *T. angusta*.	Red brown sandy slopes with limestone outcropping	Not restricted in distribution coverage
L8c5	Low open shrubland of *Acacia gregorii* with *Diplopeltis eriocarpa* over hummock grassland of *Triodia epactia* with *T. wiseana*. Sometimes with scattered *Pentalepis trichodesmoides*.	Gentle valley slopes and flats. Outcropping limestone on upper slope of hill.	Not restricted in distribution coverage
L8q2	Scattered low shrubs of *Trichodesma zeylanicum* over hummock grassland of *Triodia wiseana* with *T. epactia* and scattered *T. angusta*.	Red brown sandy slopes with limestone outcropping	Not restricted in distribution coverage

Notes:

1. *RD1: Conservation-significant vegetation: Vegetation restricted in areal coverage on Barrow Island, based on total land area on Barrow Island (Astron Environmental Services 2011)*
2. *RDF: Conservation-significant vegetation: Vegetation that satisfies one of the four categories of distribution restricted vegetation plus contains more than 2% cover of flora that are either Declared Rare, Priority, EPBC Act-listed, or Specially Protected (Astron Environmental Services 2011).*

6.5.1.3 *Vegetation of Conservation Significance*

No ecological communities listed under the EPBC Act are known to occur on Barrow Island (Astron Environmental Services 2011). Also, no Threatened Ecological Communities (TECs), as listed in the DPaW TEC Database (DPaW 2013), have been recorded or are known to occur on Barrow Island (Astron Environmental Services 2011).

Possible TECs that have not been adequately surveyed or defined are listed as Priority Ecological Communities (PECs) by DPaW. PECs are not protected by legislation, but are considered '*poorly known with apparently few, small occurrences, all or most of which are not actively managed for conservation (e.g. active mineral leases) and for which current threats exist; or if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, appear to be under immediate threat from known threatening processes across their range'* (DEC 2010).

DPaW has listed two vegetative Priority 1 Ecological Communities on Barrow Island (Astron Environmental Services 2011); these are:

- *Triodia angusta* dominated creekline vegetation (Barrow Island): General cover of *Triodia angusta* with shrubs principally *Hakea subarea, Petalostylis labicheoides, Acacia bivenosa*, and *Gossypium robinsonii*
- Coastal dune soft spinifex grassland: Tussock grassland of *Whiteochloa airoides* on hind dunes or remnant dunes with white or pinkish white medium sands with marine fragments. There may be occasional *Spinifex longifolius* tussock or *Triodia epactia* hummock grasses. There may be scattered low shrubs of *Olearia dampieri* subsp. *dampieri*, *Scaevola spinescens*, *S. cunninghamii*, *Trianthema turgidifolia*, and *Corchorus* species. Occurs on Barrow Island and possibly some unaffected littoral areas in the west Pilbara.

Vegetation associations are considered to be locally sensitive if the vegetation association:

- is part of a PEC
- is part of a broader community that has a restricted distribution on Barrow Island
- is part of a broadscale coastal community that is vulnerable to erosion due to the nature of the landform and/or soil
- typically contains more than 2% cover of a plant that has low regeneration rates or that is restricted on Barrow Island
- represents a relict vegetation unit within an uncharacteristic, isolated landscape position that has resulted from geological processes.

Further information on the categories of sensitive vegetation associations is given in Table 6-3. Based on these criteria, five of the 14 vegetation associations within the Fourth Train Proposal Footprint are considered sensitive, although they are not protected by legislation. Of these five sensitive associations, four (C1c1, C2c2, C4a1 and F4a2) are categorised as RD1 vegetation associations (Figure 6-9) highlighting their potentially restricted areal coverage on Barrow Island. One association (F11b2) is classed as RDF; it includes the deciduous tree species *Erythrina vespertilio*, which is restricted to five main populations on Barrow Island. *Erythrina vespertilio* is native to Western Australia, and is considered widespread on the Pilbara mainland; the species is not currently threatened (Astron Environmental Services 2011; DEC 2012).

Table 6-3: Categories of Vegetation on Barrow Island

Category		No. of Vegetation Associations
Restricted Vegetation (Distribution)		**197**
RD1	Vegetation restricted in distribution coverage on Barrow Island, based on total land area on Barrow Island	188
RD2	Vegetation with fragmented distribution on Barrow Island	0
RD3	Vegetation with a restricted areal coverage and fragmented distribution on Barrow Island	9
RD4	Vegetation with a distribution that is endemic to Barrow Island	0
Restricted Vegetation (Flora)		**104**
RF	Vegetation containing typically more than 2% cover of flora that are either Declared Rare, Priority, EPBC Act-listed, or Specially Protected, and that are used to define the vegetation	104
Restricted Vegetation (Distribution and Flora)		**38**
RDF	Vegetation that satisfies one of the four categories of distribution restricted vegetation plus contains more than 2% cover of flora that are either Declared Rare, Priority, EPBC Act-listed, or Specially Protected	38
Restricted Vegetation (Botanical Relicts)		**51**
RBR1	Relict vegetation not with Restricted Distribution or Restricted Flora	6
RBR2	Relict vegetation with Restricted Distribution	26
RBR3	Relict vegetation with Restricted Flora	5
RBR4	Relict vegetation with Restricted Distribution and Flora	14
Other Vegetation	All other vegetation not included in above categories	435
TOTAL (excluding Disturbed Vegetation)		**825**

Source: Astron Environmental Services 2011

6.5.1.4 Flora

The flora of Barrow Island is relatively diverse, representing approximately 23% of the flora records documented for the Pilbara and 26% of the records for the mainland Carnarvon Bioregion (Department of Conservation and Land Management [CALM] 2005). To be consistent with EPA Guidance Statement No. 51, *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004), the focus of the flora inventories taken from Barrow Island has been on vascular plants.

The Western Australian Herbarium has identified and confirmed 226 plant taxa from 131 genera and 68 families on Barrow Island (Chevron Australia 2014a). All plant taxa on Barrow Island occur on the mainland, except for *Cucumis* sp. Barrow Island (D.W. Goodall 1264) and *Amaranthus* sp. Barrow Island (R Buckley 6884). However, taxonomic identifications of the flora on Barrow Island show there is evidence that some flora show diversification to an insular environment (RPS BBG 2005). Approximately 20% to 30% of flora species are expected only to be visible after cyclonic events or fires (Chevron Australia 2005, 2008). More recently, Astron Environmental Services (2011) listed 376 plant taxa on Barrow Island (Table 6-4).

Thirty-three vascular plant taxa have been recorded as being introduced to Barrow Island, six of which are native introductions. None of the introduced species are listed as Weeds of National Significance (Department of Agriculture, Fisheries and Forestry [DAFF] and DotE

2014) or Declared Plants under the *Agricultural and Related Resources Protection Act 1976* (WA). Buffel Grass (*Cenchrus ciliaris*), first recorded on Barrow Island in 1980, is considered highly invasive but its distribution is currently restricted to disturbed sites and is currently considered under control (Chevron Australia 2014b). There is no evidence of Non-indigenous Terrestrial Species establishing on Barrow Island as a result of the approved Foundation Project.

Table 6-4: Categories of Flora on Barrow Island

Category	No. of Taxa Within Category
Declared Rare Flora	0
Priority Flora	3
EPBC Act-listed Flora	0
Specially Protected Flora	
SPF1 Restricted within Barrow Island	*16*
SPF2 At or near extent of their range	*9*
SPF3 Restricted within Barrow Island and at or near extent of their range	*12*
SPF4 Low regeneration capacity	*2*
Total	39
Poorly Known Flora	
PKF1 (Species rarely collected: specimens present in WA Herbarium)	*42*
PKF2 (Species rarely collected: no specimens present in WA Herbarium)	*52*
PKF3 (Species inadequately identified)	*73*
Total	167
Introduced Flora	
IF1 (*Environmental Weed Species)*	*22*
IF2 (Native Introduction)	*6*
Total	28
Other Flora	139
TOTAL (excluding Removed Flora)	**376**

Source: Astron Environmental Services 2011

6.5.1.5 Flora of Conservation Significance

No threatened flora listed under the EPBC Act, or Declared Rare Flora listed under the *Wildlife Conservation Act 1950* (WA) (Wildlife Conservation Act), have been recorded on Barrow Island (Chevron Australia 2014a).

Three Priority Flora species have been collected on Barrow Island. Priority Flora is a non-legislative category, which aims to manage those plant taxa listed by DPaW on the basis that they are known from only a few collections or a few sites, but which have not been adequately surveyed. Such flora may be rare or threatened, but cannot be considered for declaration as rare flora until further survey work has been undertaken. The three Priority species collected on Barrow Island are:

- the annual Priority 1 daisy species *Helichrysum oligochaetum*, which was recorded twice on Barrow Island by Mattiske and Associates (1993) but has not been recorded since
- the Priority 2 species *Cucumis* sp. Barrow Island (D.W. Goodall 1264) (identified in the Draft Environmental Impact Statement [EIS]/Environmental Review and Management Plan [ERMP] [Chevron Australia 2005] as *Mukia* sp. Barrow Island (D.W. Goodall 1264) but since renamed). The closest recording of this species to the Fourth Train Proposal is approximately 1 km outside the horizontal directional drilling site

- the Priority 3 species *Corchorus congener*, which was recorded at the Gas Treatment Plant site and the Foundation Project horizontal directional drilling site (Chevron Australia 2005), both of which have now been cleared as part of the approved Foundation Project. It has also been found in the vicinity of the Fourth Train Proposal horizontal directional drilling site. This spreading shrub is widely distributed on parts of Barrow Island, and is well recorded from the Cape Range on the mainland (Astron Environmental Services 2011). Therefore, it is not included as conservation-significant flora.

In addition to Priority Flora species, 39 individual flora species were assessed as having a restricted distribution on Barrow Island. A probability calculation was created using three main factors—abundance, habitat restrictedness, and habitat land area. These flora, which are not Declared Rare Flora under the Wildlife Conservation Act, Priority Flora, or EPBC Act-listed flora, are referred to as Specially Protected Flora (Table 6-4) (Astron Environmental Services 2011). Information on the restricted flora distribution species on Barrow Island is detailed in Appendix E3 [Restricted Distribution Flora Species on Barrow Island].

One species of restricted distribution flora, *Erythrina vespertilio*, occurs near North Whites Beach where the Fourth Train Proposal horizontal directional drilling site is located (Figure 6-10). On Barrow Island, this deciduous tree is restricted to five main populations (Mattiske and Associates 1993); on the mainland, it is widespread across northern Australia and has been collected across northern Western Australia, from Shark Bay to the Northern Territory border south of Halls Creek (Western Australian Herbarium 2008, cited in Chevron Australia 2014a).

Figure 6-10: Locations of Conservation-significant Flora Individuals Identified in the Vicinity of the Fourth Train Proposal Horizontal Directional Drilling Site Area

6.5.2 Terrestrial Fauna Habitat

The EPA defines habitat as *'[t]he natural environment of an organism or a community, including all biotic and abiotic elements; a suitable place for it to live'* (EPA 2004, 2004a).

Fauna habitat is considered significant for Barrow Island (Chevron Australia 2005, 2008) if it:

- supports an unusually high species-richness or abundance compared to other parts of Barrow Island
- contains faunal habitats not well-represented in other parts of Barrow Island
- contains habitat for site-restricted fauna of high conservation significance
- is in a location where development impacts may extend beyond the boundaries of the site and the impacts may lead to the disruption of ecological processes.

The Barrow Island terrestrial habitats identified as significant (Chevron Australia 2014a) are:

- Boodie warrens – habitat for Boodies, which are fauna of high conservation significance
- termite mounds that support high species-richness
- nests of raptors (birds of prey) which are not represented on Barrow Island in high numbers, and which provide habitat for fauna of high conservation significance.

Boodie warrens are the habitat for the conservation-significant Boodie. Boodies are dependent upon their warrens and are expected to have limited ability to disperse to surrounding areas (Chevron Australia 2005). The number of Boodie warrens on Barrow Island is estimated at 250 to 300 (Biota Environmental Services 2013). The distribution of active and inactive Boodie warrens recorded on Barrow Island since 2003 is shown in Figure 6-11. Active Boodie warrens are generally located on well-drained sites (often on or near the crests of ridges), usually located in cap rock, and often associated with the fig *Ficus platypoda* (Chevron Australia 2014a). No warrens have been found in dune habitats or drainage lines in the absence of rocks. Active Boodie warrens are dispersed widely and evenly across Barrow Island at low density (Chevron Australia 2014a). There are no Boodie warrens located in the Fourth Train Proposal horizontal directional drilling site.

Termite mounds are listed as a protected 'naturally occurring feature' on the conservation estate (of which Barrow Island is a part) under the Conservation and Land Management Regulations 2002 (WA). Termite mounds support high species- richness and the termites perform an important function in the organic matter cycle (Chevron Australia 2005). Termite mounds provide valuable shelter for reptiles, birds and mammals on Barrow Island; including the Golden Bandicoot. According to Perry (1972), termite mounds are not distributed uniformly across Barrow Island; they are most abundant on the flats south of the geological fault between Junction Beach and Eagles Nest Point, and at North Whites Beach on the west coast (Chevron Australia 2014a). Approximately 140 termite mounds are present within the Fourth Train Proposal horizontal directional drilling site area (Figure 6-11). These termite mounds represent a small proportion of termite mounds present on Barrow Island. Chevron Australia mapped termite mounds within 500 m of the Foundation Project. The mapping found a distribution of approximately 10 000 termite mounds over an area of approximately 5770 ha.

Raptors establish nests along the Barrow Island coastline (Chevron Australia 2014a). The observations of Pruett-Jones and O'Donnell (2004) were that:

- Brahminy Kite (*Haliastur indus*) nests are scattered along the coast
- Osprey (*Pandion haliaetus*) nests are regularly spaced along the coast
- White-bellied Sea-eagles (*Haliaeetus leucogaster*) are occasional visitors and nesting pairs are seen on the southern coast.

Two raptor nests are present within 2 km of the Fourth Train Proposal Footprint, as illustrated in Figure 6-11. One Osprey nest is located approximately 1.1 km north-east of the Gas Treatment Plant site and one Osprey nest is located on the communications tower located within the Foundation Project horizontal directional drilling site. There are no known active raptor nesting sites within the Fourth Train Proposal horizontal directional drilling site. It is possible that some of the raptor nests presented in Figure 6-11 are disused.

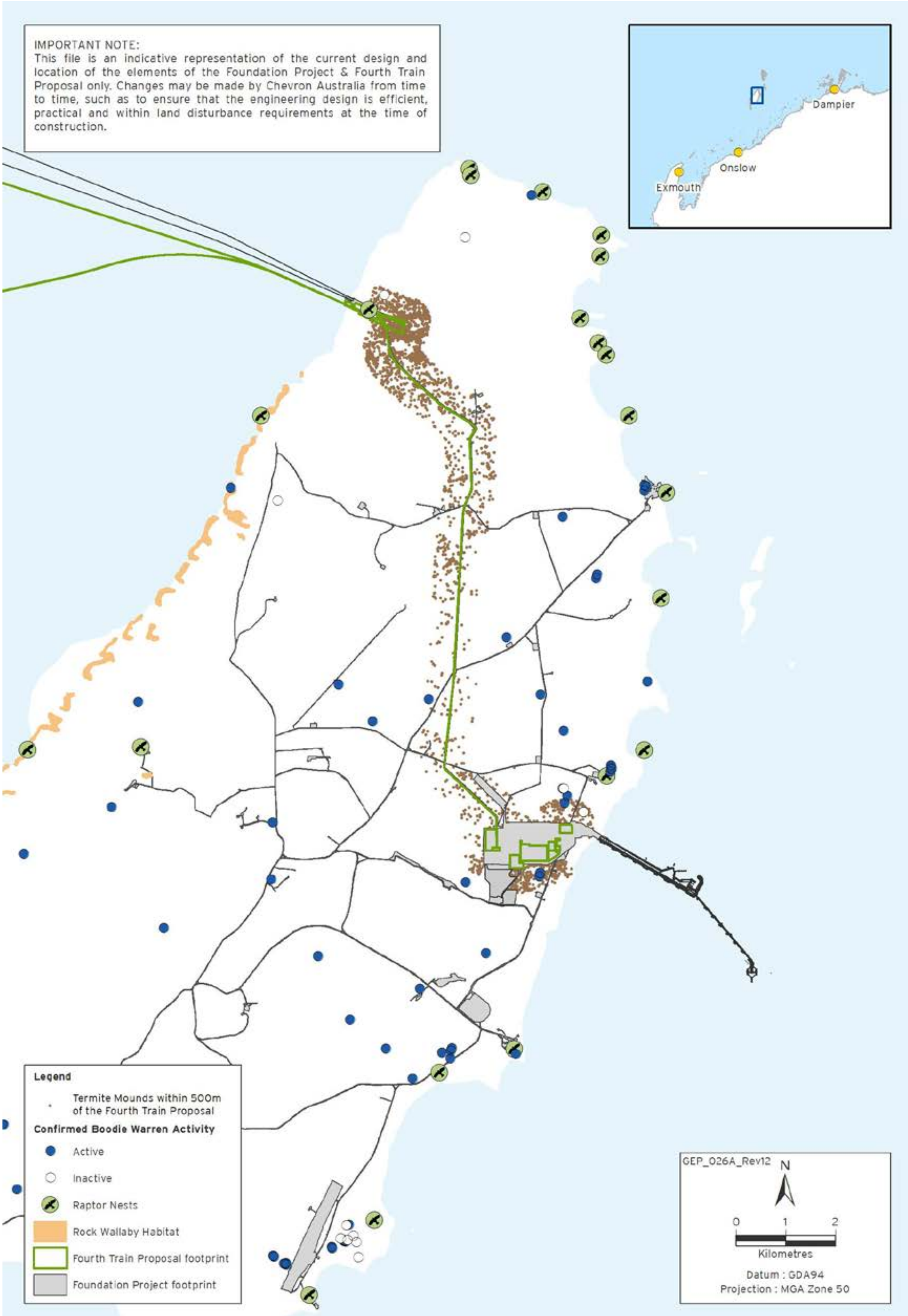


Figure 6-11: Locations of Significant Fauna Habitats on Barrow Island

6.5.3 Terrestrial Fauna Species

Barrow Island is an important refuge for some rare and threatened species, some of which are not found elsewhere. This is because Barrow Island has not been colonised by non-indigenous terrestrial mammals, such as cats and foxes, that could alter ecological processes, and because direct interactions between humans and the environment have been strictly controlled (Chevron Australia 2014a).

6.5.3.1 Terrestrial Birds

The birds of the Pilbara Region include transient species that move throughout the region, and resident or regular species that are more frequent at particular sites. Fifty-one species of terrestrial avifauna have been recorded on Barrow Island; however, only 16 of these species are residents or regular migrants to Barrow Island. The most common of these are the Spinifex-bird *Eremiornis carteri*, White-winged Fairy-wren (Barrow Island) *Malurus leucopterus edouardi*, Singing Honeyeater *Lichenostomus virescens*, White-breasted Wood Swallow *Artamus leucorhynchus*, and the Welcome Swallow *Hirundo neoxena* (Chevron Australia 2012).

Sixteen of the terrestrial bird species on Barrow Island were identified as potentially occurring in the vicinity of the approved Foundation Project (Chevron Australia 2008) and therefore these species may occur in the vicinity of the Fourth Train Proposal Area. Of these, one species—the White-winged Fairy-wren (Barrow Island)—is of conservation significance (Table 6-5). The remainder comprise terrestrial and shore-inhabiting species that are widely distributed around Barrow Island (Chevron Australia 2008).

The White-winged Fairy-wren (Barrow Island) is restricted/endemic to Barrow Island and is listed as Vulnerable under the EPBC Act and under Schedule 1 of the Wildlife Conservation Act. This species is abundant in most habitats on Barrow Island, especially those with complex vegetation structure. Island-wide population studies of the species found that the highest estimated numbers were recorded in 2009 with the lowest estimated numbers in 2010; numbers ranging from approximately 12 000 to 4900 (Biota Environmental Sciences 2011). Data from the 2011 Distance Sampling Program suggest that the population is now increasing, with an Island-wide population estimate of approximately 7000 birds, which is comparable to previous estimates (Biota Environmental Sciences 2012). Biota Environmental Sciences (2012) suggest the 2010 decline most likely resulted from low rainfall in the preceding 12 months. This view is supported by the increased encounter rates in 2011, which followed a wetter than average preceding 12 months (Biota Environmental Sciences 2012).

Shrubland of *Melaleuca. cardiophylla* has not been included as a significant habitat although it was indicated in the Draft EIS/ERMP that it may be critical habitat for the White-winged Fairy-wren (Barrow Island) (Chevron Australia 2005). More recent studies have suggested that White-winged Fairy-wrens (Barrow Island) have generalist nesting requirements; Bamford and Moro (2011) show that the species is not restricted or even largely restricted to *M. cardiophylla* for nest site selection, but are instead generalists on Barrow Island.

The Australian Bustard (*Ardeotis australis*), has also been highlighted as occurring on Barrow Island, inhabiting grasslands, spinifex, open scrublands and pastoral lands, although considered to be a vagrant visitor (Chevron Australia 2014a).

Table 6-5: Protected Terrestrial Birds that may occur in the Vicinity of the Fourth Train Proposal

Common Name	Scientific Name	Status		Presence in Vicinity of Fourth Train Proposal
		Cth[1]	WA[2, 3]	
White-winged Fairy-wren (Barrow Island)	*Malurus leucopterus edouardi*	V	Sch 1[2]	Likely
Australian Bustard	*Ardeotis australis*		P4[3]	Possible

Notes:

1 Status under the EPBC Act: V = Vulnerable; E = Endangered; CE = Critically Endangered; M = Migratory (matters of NES)

2 Status under the Wildlife Conservation Act: Sch 1 = Schedule 1: Fauna that is rare or is likely to become extinct

3 DPaW Current Threatened and Priority Fauna Ranking: P4 = Priority Four: Taxa in need of monitoring. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.

6.5.3.2 Mammals

Barrow Island is recognised as an important refuge for native terrestrial mammal species that have either declined in numbers or become extinct on the mainland (Chevron Australia 2008). Thirteen species of terrestrial mammal have been recorded as resident on Barrow Island, with a further two species of bat recorded as vagrants (Chevron Australia 2014a). Many of the mammal species are widespread and abundant. All mammal species have been recorded across Barrow Island; except for the Water Rat which is restricted to coastal habitats around Barrow Island (Chevron Australia 2005).

Five mammal species on Barrow Island are listed as threatened under the EPBC Act. Except for the Black-flanked Rock-wallaby (*Petrogale lateralis lateralis*), which inhabits the coastal cliffs along the west coast of Barrow Island (Figure 6-11), all other mammal species are likely to occur in or near the vicinity of the Fourth Train Proposal Footprint. These species are also protected under State legislation (Table 6-6).

Of these five species, three are restricted to islands in the region—the Barrow Island Euro (*Macropus robustus isabellinus*) to Barrow Island; the Spectacled Hare-wallaby (*Lagorchestes conspicillatus conspicillatus*) to Barrow Island; and the Barrow Island Golden Bandicoot (*Isoodon auratus barrowensis*) to Barrow Island and Middle Island. The Boodie occurs on Barrow Island and Boodie Island, as well as Bernier and Dorre Islands and a small area of mainland in Shark Bay. The Barrow Island Euro and the Spectacled Hare-wallaby are highly mobile and have a large home range (between 8 and 37 ha). The Golden Bandicoot is also a mobile mammal, with a home range between 4 and 10 ha.

The Black-flanked Rock-wallaby has scattered populations across Western Australia (DotE 2014a). Their population is remote from the Fourth Train Proposal Footprint. Black-flanked Rock-wallabies shelter in rocky cliffs along approximately 13 km of the west coast of Barrow Island and up to 3 km inland (Butler 1970). The total extent over which they range on Barrow Island has not been determined, but they have been recorded 1.4 km from cliff habitat on Barrow Island (Burbidge 2008).

Water Rats (*Hydromys chrysogaster*), which are a native species listed as a Priority 4 species by DPaW, generally inhabit rocky crevices and forage on adjacent sandy beaches and intertidal areas. Tracks have been observed on various Barrow Island beaches . Therefore, Water Rats may be present in or near the Fourth Train Proposal horizontal directional drilling site, but are not expected in the vicinity of the Fourth Train Proposal Feed Gas Pipeline System Footprint.

There are no terrestrial fauna habitats unique to the Fourth Train Proposal Footprint; therefore, it is considered unlikely that unusually high concentrations of mammals would be present in areas relating to the Fourth Train Proposal.

Table 6-6: Protected Terrestrial Mammals that may occur in the Vicinity of the Fourth Train Proposal

Common Name	Scientific Name	Status		Presence in Vicinity of Fourth Train Proposal
		Cth[1]	WA[2, 3]	
Black-flanked Rock-wallaby	*Petrogale lateralis lateralis*	V	Sch 1[2]	Unlikely
Boodie	*Bettongia lesueur*	V	Sch 1[2]	Likely
Water Rat	*Hydromys chrysogaster*	-	P4[3]	Likely
Barrow Island Golden Bandicoot	*Isoodon auratus barrowensis*	V	Sch 1[2]	Likely
Spectacled Hare-wallaby	*Lagorchestes conspicillatus conspicillatus*	V	Sch 1[2]	Likely
Barrow Island Euro	*Macropus robustus isabellinus*	V	Sch 1[2]	Likely

Notes:

1 *Status under the EPBC Act: V = Vulnerable; E = Endangered; CE = Critically Endangered; M = Migratory (matters of NES)*

2 *Status under the Wildlife Conservation Act: Sch 1 = Schedule 1: Fauna that is rare or is likely to become extinct*

3 *DPaW Current Threatened and Priority Fauna Ranking: P4 = Priority Four: Taxa in need of monitoring. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.*

6.5.3.3 Reptiles and Amphibians

There are 45 reptile species recorded on Barrow Island, with all reptile families represented, except for the snake family Colubridae (Chevron Australia 2014a). The reptile assemblage on Barrow Island includes fewer species than the mainland, but includes a range of species from small sand-dwelling skinks, dragons, and snakes, up to the large varanid lizards (including the Perentie (*Varanus giganteus*), which is considered to be a top-level predator (Chevron Australia 2005).

None of the terrestrial reptile species on Barrow Island are listed as Threatened Species under the EPBC Act or the Wildlife Conservation Act.

During studies for the Foundation Project, the most species-rich areas were habitats with a mixture of shrub species and *Triodia* on coastal primary and secondary dunes (Chevron Australia 2014a).

The troglobitic Subterranean Blind Snake (*Ramphotyphlops longissimus*) is listed by DPaW as a Priority 2 species, and is described in Section 6.5.3.5.2.

A single frog species, *Cyclorana maini*, is found on Barrow Island. This burrowing frog species breeds in seasonal watercourses in the vicinity of the Gas Treatment Plant site, in Airport Creek approximately 800 m south of the Gas Treatment Plant site, along the Feed Gas Pipeline System route, and in other areas across Barrow Island.

6.5.3.4 Terrestrial Invertebrates

More than 2200 terrestrial invertebrate species have been identified to date on Barrow Island, none of which are listed as requiring special protection under the EPBC Act, Wildlife Conservation Act, or are listed as Priority Species by DPaW. Most terrestrial invertebrate species appear to be more abundant on Barrow Island during the wet season when there is a flush of growth in dominant plant forms (Callan *et al.* 2011).

Several of these species have been identified as short-range endemics (SREs). SREs identified on Barrow Island include, but are not limited to, the pseudoscorpion *Synsphyronus* sp. nov. '*barrow*', the scorpion *Urodacus* '*linneai*'', the spider *Idiommata* sp. (trapdoor), and the snail *Rhagada* sp. 1 (the smaller of the two *Rhagada* species on Barrow Island) (Chevron Australia 2014a).

These species, except *Idiommata* sp., are widespread on Barrow Island (Chevron Australia 2014a). *Idiommata* sp. is the subject of further surveys under the Foundation Project to locate and confirm its distribution on Barrow Island. However, the genus is widespread on the Australian mainland, with one species formally named and several undescribed species found in Western Australia (M Harvey pers. comm. 2008 cited in Chevron Australia 2014c).

6.5.3.5 Subterranean Fauna

Barrow Island is recognised as being of high conservation significance for subterranean fauna communities (Chevron Australia 2014c). Barrow Island Subterranean Fauna are listed by the DPaW as Priority 1 PEC.

There are two broad categories of fauna that have adapted to subterranean conditions and that are generally considered to comprise true subterranean fauna:

- stygofauna – groundwater-dwelling aquatic fauna
- troglofauna – obligate cave- or karst-dwelling terrestrial fauna occurring above the watertable.

Typically, subterranean fauna are strongly adapted to the subterranean environment, with features such as lack of pigment, elongated appendages, and reduced or absent eyes (Chevron Australia 2008).

6.5.3.5.1 Subterranean Fauna Habitat

A number of investigations have been undertaken on Barrow Island that have helped characterise the subterranean habitat and subterranean communities (e.g. Biota Environmental Sciences 2007; UWA 2007; Campbell and Wedepohl 2005 all cited in Chevron 2008). These studies provide evidence that the subterranean geological habitat on Barrow Island does not present any large-scale barriers to the distribution of subterranean fauna across Barrow Island. While it is possible that certain subterranean taxa are restricted to discrete areas of karst habitat (Chevron Australia 2008), current hydrogeological data infers that these taxa are unlikely to be restricted to the Combined Gorgon Gas Development Footprint on Barrow Island.

The Fourth Train Proposal horizontal directional drilling site area overlaps with the approved Foundation Project Footprint (Figure 6-5) and falls within the same local geology where subterranean fauna surveys have been conducted. A geological review by Campbell and Wedepohl (2005, cited in Chevron Australia 2008) suggests that the karstic and shallow aquifer habitat is widespread both within and beyond the approved Foundation Project Footprint. This is further supported by morphological and genetic species distributional data (UWA 2007 cited in Chevron Australia 2008). There is no evidence of large caves or other large-scale geomorphological features that might create barriers to gene flow between the Combined Gorgon Gas Development Footprint and adjacent habitats on Barrow Island.

6.5.3.5.2 Subterranean Fauna

Nineteen troglofauna and 63 stygofauna species have been recorded on Barrow Island. Conservation-significant subterranean fauna taxa, along with their conservation status, are listed in Table 6-7.

Two stygal vertebrates have been recorded on Barrow Island—the Barrow Cave Gudgeon (*Milyeringa justitia)* and a blind eel (*Ophisternon* sp.). The Barrow Cave Gudgeon (*Milyeringa justitia)* was previously reported as the Blind Gudgeon (*Milyeringa veritas*), which is known extensively from Cape Range on the mainland, but was reclassified in 2013 (Larson *et al.* 2013). The Barrow Cave Gudgeon is a protected species under Schedule 1 of the Wildlife Conservation Act. Note that Section 13 assesses the Barrow Cave Gudgeon as *Milyeringa veritas*, as the Commonwealth Government has not yet formally accepted recognition of the reclassification of this species to *Milyeringa justitia*.

The blind eel (*Ophisternon* sp.) has not been identified to species level but, given the wide range of *Ophisternon candidum* in stygal ecosystems in the Pilbara, the single blind eel found on Barrow Island is taken to be *Ophisternon candidum* for the purposes of conservation status (Humphreys *et al.* 2013). *Ophisternon candidum* is listed as Vulnerable under the EPBC Act and as a Schedule 1 species under the Wildlife Conservation Act.

Nine individuals of the Barrow Cave Gudgeon have been collected on Barrow Island. Eight individuals were collected from a borehole in the centre of Barrow Island, located approximately 4 km west of Butler Park (Construction Village); and one individual was collected from a sampling bore on the Administration and Operations Complex site. One specimen of the blind eel has also been found on Barrow Island, approximately 2 km from the eastern edge of the Fourth Train Proposal horizontal directional drilling site.

The Subterranean Blind Snake (*Ramphotyphlops longissimus*) is listed by DPaW as a Priority 2 species and is likely to be endemic and restricted to Barrow Island since it is known from only one specimen collected on Barrow Island. It is not known to occur within the areas coinciding with the approved Foundation Project (Chevron Australia 2014a) and the Fourth Train Proposal Footprint.

Most of the troglofauna and stygofauna species that have been well-collected, that have a taxonomic frame of reference, and for which genetic or morphological work has been completed, have a wider distribution on Barrow Island (i.e. beyond the approved Foundation Project Footprint) (Biota Environmental Sciences 2007; Chevron Australia 2014a). However, there are four subterranean fauna species that have not been identified outside the Gas Treatment Plant site and Additional Support Area—two stygofaunal taxa (?*Bogidomma* sp. 1, *Melitidae* unknown sp. 1) have only been identified within the Gas Treatment Plant site, and one stygofaunal taxa and one troglofaunal taxa have only been identified in the vicinity of the Additional Support Area (*Pilbaracandona* sp. nov. 1 and *Symphyla* sp., respectively).

Table 6-7: Protected Subterranean Fauna on Barrow Island

Common Name	**Scientific Name**	**Status**		**Presence in Vicinity of Fourth Train Proposal**
		Cth[1]	**WA**[2, 3]	
-	**Amphipoda** *Nedsia fragilis*	-	Sch 1[2]	Possible
-	**Amphipoda** *Nedsia humphreysi*	-	Sch 1[2]	Possible
-	**Amphipoda** *Nedsia hurlberti*	-	Sch 1[2]	Likely
-	**Amphipoda** *Nedsia sculptilis/macrosculptilis*	-	Sch 1[2]	Possible
-	**Amphipoda** *Nedsia straskraba*	-	Sch 1[2]	Possible
-	**Amphipoda** *Nedsia urifimbriata*	-	Sch 1[2]	Possible
Barrow Cave Gudgeon[4]	**Eleotridae** *Milyeringa justitia*	V	Sch 1[2]	Likely
Blind eel[5]	**Synbranchidae** *Ophisternon* sp.	V	Sch 1[2]	Possible
Blind Snake	*Ramphotyphlops longissimus*	-	P2[3]	Possible

Common Name	Scientific Name	Status		Presence in Vicinity of Fourth Train Proposal
		Cth[1]	WA[2, 3]	
-	**Schizomida** *Draculoides bramstokeri*	-	Sch 1[2]	Likely
-	**Spirobolida** *Speleostrophus nesiotes*	-	Sch 1[2]	Likely

Notes:

1 *Status under the EPBC Act: V = Vulnerable; E = Endangered; CE = Critically Endangered; M = Migratory (matters of NES)*

2 *Status under the Wildlife Conservation Act: Sch 1 = Schedule 1: Fauna that is rare or is likely to become extinct*

3 *DPaW Current Threatened and Priority Fauna Ranking: P2 = Priority Two: Taxa with few, poorly known populations on conservation lands. Taxa that are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.*

4 *The Barrow Cave Gudgeon (*Milyeringa justitia*) was formerly reported as the Blind Gudgeon (*Milyeringa veritas*). The taxonomy of the Blind Gudgeon has recently been revised, with* M. veritas *no longer considered present on Barrow Island. The very similar* M. justitia*, or Barrow Cave Gudgeon, is described by Larson* et al. *(2013) as occurring within the groundwater on Barrow Island.*

5 *The record of the blind eel (Ophisternon sp.) from Barrow Island was not identified to species level. Given the wide range of the Blind Cave Eel (Ophisternon candidum) in stygal ecosystems in the Pilbara, the blind eel is taken to be the Blind Cave Eel for assessment purposes and is assigned the relevant conservation status.*

6.5.3.6 Introduced Fauna

There is no evidence of Non-indigenous Terrestrial Species establishing on Barrow Island as a result of the approved Foundation Project (Section 3.5.3). Chevron Australia confirmed the presence of 30 non-indigenous invertebrate species, which includes six putative non-indigenous invertebrate species (species for which the identification, or whether it is native to Barrow Island, is in question) on Barrow Island (Appendix E4 [Detected Non-indigenous Terrestrial Species Currently on Barrow Island]). There are no vertebrate non-indigenous species currently established on Barrow Island and historically, rats and mice have been eradicated (Chevron Australia 2014b).

Most non-indigenous invertebrates are known commensal species strongly associated with human habitation and food. Most non-indigenous species are presently restricted to previously disturbed areas (Chevron Australia 2014b).

Although most of the non-indigenous species on Barrow Island are not considered a threat to taxa native on Barrow Island, the Black Crazy Ant (*Paratrechina longicornis*) is potentially invasive and can become dominant in ecosystems where it lives. It is generally found at disturbed and rehabilitated sites (Chevron Australia 2014b) (Appendix E4 [Detected Non-Indigenous Terrestrial Species Currently on Barrow Island]). Management of non-indigenous species, including the Black Crazy Ant, is included in the Quarantine Management System.

6.6 Marine Ecology

The Fourth Train Proposal Area falls within the North-west Marine Region, which has been divided into six bioregions. The Northwest Shelf and Northwest Province bioregions (defined as part of the bioregional profiling and planning process by DEWHA [now DotE) fall within the Proposal boundaries and encompass both the Commonwealth Marine Area and State Waters adjacent to Barrow Island. The North-west Marine Region is made up of numerous habitats, biological communities and ecosystems and characterised by high species-richness due to the diversity of marine habitats available, although productivity of the area is generally considered low and associated with a boom and bust cycle driven by cyclones. Tropical species found in other parts of the Indian and western Pacific oceans characterise the area, with the southerly boundary of the region representing a temperate-tropical transition zone (DEWHA 2008).

6.6.1 Benthic Habitats

All habitats are important for the healthy functioning of the marine ecosystem. Benthic Primary Producer Habitats (BPPHs) provide important breeding/nursery grounds to a range of marine species and are also a source of food for a number of marine fauna. As defined by the EPA (2009), BPPH are ‘functional ecological communities that inhabit the seabed within which algae (e.g. macroalgae, turf, and benthic microalgae), seagrass, mangroves, corals, or mixtures of these groups are prominent components. BPPHs also include areas of seabed that can support these communities.

Non-BPPH are areas of sand or sediment habitats that are not capable of supporting benthic primary productivity and are likely to contain infaunal and/or epifaunal communities. Non-BPPH can be sediments which contain infaunal communities that include burrowing crustaceans and polychaete worms that live between the sediment particles, and epifaunal species, sessile benthic species such as sea fans and sea pens that live on the surface of the substrate as well as sea cucumbers and other non-photosynthesising marine fauna.

The following Section provides a regional setting and a description of the benthic habitats that are likely to be encountered in the Fourth Train Proposal Area.

6.6.1.1 Regional

6.6.1.1.1 Deepwater Marine Environment

The shelf of the North-west Marine Region contains several terraces and steps which provide a hard substrate in an area more widely dominated by softer sediments. The hard substrates of these escarpments may display areas of enhanced diversity in comparison with the more species depauperate soft sediments which are likely to be dominated (although at low densities) by scavengers, benthic filter feeders, epifauna and a patchy distribution of more mobile benthic fauna including sea cucumbers, echinoderms and polychaete worms. Areas of exposed hard substrate may support more diverse assemblages, including deepwater filter-feeding organisms such as hydroids, sponges, crinoids, molluscs, echinoderms and other benthic invertebrates associated with hard substrates (Chevron Australia 2014d; SEWPaC 2012).

6.6.1.1.2 Shallow Marine Environments

Much of the North-west Marine Region is shallow (with 50% of the area generally less than 500 m in depth) with surface currents the main driver of ecosystems in the region. The diversity of habitats also include abiotic habitats such as sand, mud, limestone pavement reef with variable coverage by a veneer of sand, and higher-profile rocky reefs (Chevron Australia 2005). Generally sandy substrates on the shelf are considered to be depauperate, with low densities of bryozoans, molluscs and echinoderms.

The Pilbara Region’s coastline includes a system of barrier islands and associated lagoons that support coastal and shallow water habitats such as mangroves, seagrass meadows, macroalgal beds, coral reefs, and shelf habitats dominated by complex sponge communities (CSIRO 2007). The predominant coastal habitats on the sheltered east coast of Barrow Island and the adjacent Pilbara mainland coast are unvegetated or bare sand flats, mud flats, sandy beaches, rocky pavements, and gently sloping limestone pavement (Chevron Australia 2012a).

Mangroves have developed on sheltered coasts off the Barrow/Montebello Islands and along the Pilbara mainland coast. Mangroves typically occur in relatively protected intertidal zones of brackish and marine shores with *Avicenna marina* and *Rhizophora stylosa* the most common mangrove species found (Government of Western Australia 2003). Seagrasses are widespread on soft sediments throughout the region, and corals are similarly widespread on hard substrates (Chevron Australia 2005).

Macroalgae are very common components of marine environments in the shallow waters and is estimated that macroalgae habitats make up 40% of the benthic habitats of the Montebello/Barrow Islands Marine Conservation Reserve (CALM 2004). Abundant macroalgae in the region include: Phaeophytes (brown macroalgae), such as *Sargassum*, *Dictyopteris*, *Turbinaria*, and *Padina*; Chlorophytes (green macroalgae), such as *Halimeda*, *Caulerpa*, and *Udotea*; and Rhodophytes (red macroalgae), such as *Hydrolithon* and *Laurencia* (BBG 2005; DEC 2007; Chevron Australia 2013a).

Fringing reefs occur in the relatively clear and high-energy conditions to the west and south-west of the Montebello Islands, as well as bomboras and patch reefs in the more turbid and lower energy waters along the eastern edge of the Montebello Islands. These reefs are believed to support the best-developed coral communities in the Montebello Islands/Barrow Island region (DEC 2007). These coral reefs occur and are protected within sanctuary zones of the Montebello/Barrow Islands Marine Conservation Reserves (Chevron Australia 2014d). A number of coral species are found in the Montebello/Barrow Islands, on habitats such as limestone pavements, reef patches, and bombora (Chevron Australia 2005; DEC 2007).

6.6.1.2 Fourth Train Proposal Area

6.6.1.2.1 Deepwater Marine Habitats

Deepwater marine surveys have been conducted along both the Northern and Southern pipeline route options of the Foundation Project infrastructure. These are in the vicinity or the same routes (Southern pipeline route option) as those currently being considered for the Fourth Train Proposal. It was found that the deepwater habitats of the Fourth Train Proposal Area are generally depauperate and were in low abundance, with low richness and diversity as observed in other deep areas of the North West Shelf.

Benthic surveys conducted in depths ranging from 212 m to more than 1300 m, recorded no epifauna (i.e. fauna living on the sea floor) for the majority of samples (63%) and infauna, where present, were in low abundance, with low richness and diversity (IRC Environment 2005). Benthic surveys for the Jansz Feed Gas Pipeline System identified no epifauna in the majority of samples and infauna only in low abundance with low species-richness and diversity (IRC Environment 2005). No benthic habitats of importance for conservation are expected to be present (IRC Environment 2005). Surveys conducted in the scarp region found that the soft sediment in the area was often marked by burrow holes made by unidentified organisms (thought to be small fish or crustaceans); these soft sediments supported some benthic life, including solitary sea pens, holothurians, and hydroids (RPS 2009a). Soft corals were present and were found to be most abundant at depths between approximately 550 and 700 m, with Alcyonian soft corals being the most common taxa identified. At these sites, the soft corals were found in mixed communities with bryozoans, sponges, and hydroids (RPS 2009a).

Sediments at depths of around 200 m are heavily bioturbated, indicating an active infauna assemblage. This assemblage type is typically dominated by polychaete worms and crustaceans that burrow into the sediment, together with larger demersal fish and crustaceans (Chevron Australia 2005). This assemblage is probably very widely distributed in similar depths along the edge of the continental shelf (Chevron Australia 2005).

6.6.1.2.2 Shallow Water Marine Habitats off the West Coast of Barrow Island

The local distribution of benthic habitats surrounding Barrow Island is affected by the frequent passage of tropical cyclones that shape sandy beaches; redistribute boulders and sand sheets over subtidal pavements; and, in extreme cases, cause widespread destruction of biotic habitats (Chevron Australia 2005). The predominant coastal habitats on the exposed west coasts of islands in the Montebello/Lowendal/Barrow Island region are sandy beaches, rocky shores, and cliffs.

Only small, sparse patches of seagrass occur on sand veneers at a few locations in shallow waters off the west coast of Barrow Island and at low levels of percentage cover, growing in mixed assemblages with macroalgae and occasionally benthic macroinvertebrates (Chevron Australia 2014d). The dominant seagrass species recorded in west coast Barrow Island waters was *S. Isoetifolium*, *Halophila ovalis*, and *Halophila spinulosa* regarded as coloniser species that are ephemeral in nature (Chevron Australia 2013a). Therefore, the cover and presence of these seagrasses is likely to experience natural fluctuations over time (Chevron Australia 2012b). Less common species include *Cymodocea angustatus*, *Halodule uninervis*, *Thalassia hemprichii*, and *Thalassodendron ciliatum* (RPS BBG 2007). No mangroves have been recorded on the west coast of Barrow Island within the Fourth Train Proposal Area (Chevron Australia 2005).

Macroalgae cover represents the dominant ecological element and the dominant habitat assemblage off the west coast of Barrow Island, with macroalgal taxa common to the wider Pilbara Region (Chevron Australia 2014d). The dominant (or most common) macroalgae in terms of percentage cover recorded in west coast Barrow Island waters are the brown algae (*Sargassum*, *Dictyopteris* spp., *Canistrocarpus cervicornis,* and *Padina* spp.) and the green algae (*Caulerpa* and *Halimeda* spp.) (Chevron Australia 2014d). Recent monitoring efforts post-horizontal directional drilling activities off the west coast of Barrow Island have identified an additional nine species of macroalgae not recorded during the baseline marine surveys (Chevron Australia 2012b). Natural seasonal variation in macroalgal recruitment and settlement and a lack of repetitive surveys in the region are considered the possible explanation for this increase (Chevron Australia 2012b).

Extensive coral reefs are limited to the southern and central parts of the west coast of Barrow Island. Biggada Reef on the central west coast of Barrow Island, approximately 7 km south of North Whites Beach, is a largely intertidal coral reef that extends to the subtidal zone (DEC 2007). In other areas, corals present are generally bomboras and sparsely scattered colonies of species such as the hard coral *Turbinaria* spp.; a widespread and common genus well-represented in the State Waters around Barrow Island. This species is found outside coral habitats in benthic macroinvertebrate-dominated assemblages (Chevron Australia 2011a).

The benthic habitats in the vicinity of the shore crossing are typical of the west coast of Barrow Island (refer to Figure 6-12 which provides a broadscale representation of classified habitats). 'Macroalgae with Sparse Sessile Taxa' represents the dominant ecological element which is described as habitats dominated by macroalgae with seagrass and non-coral benthic macroinvertebrates at subdominant levels of cover. Seagrass is present at a few locations and at low levels of percentage cover, growing in mixed assemblages with macroalgae and occasionally with benthic macroinvertebrates (Chevron Australia 2011a, 2013a).

Two rocky reef sections occur approximately 12 km and 25 km from the west coast of Barrow Island, in 40 m and 50–55 m water depths, respectively. The inner platform reef supports scattered corals and sponges, although the area is too deep to support well-developed benthic primary producer assemblages. The outer reef supports encrusting sponges and scattered deepwater coral (Chevron Australia 2005).

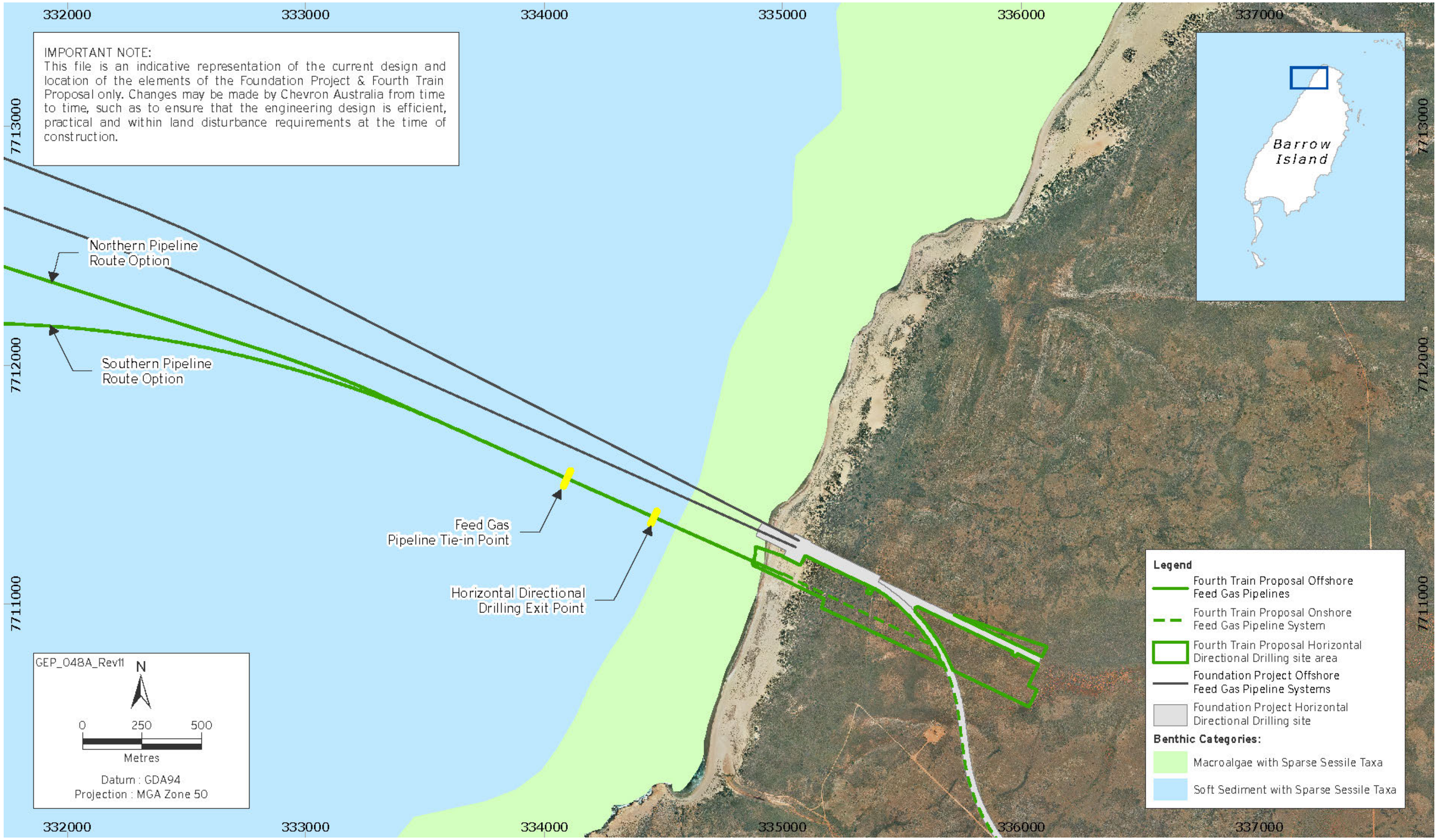


Figure 6-12: Benthic Primary Producer Habitat Communities Present off the West Coast of Barrow Island in the Vicinity of the Horizontal Directional Drilling Site and the Feed Gas Pipeline System

6.6.1.2.3 Shallow Water Marine Habitats off the East Coast of Barrow Island

Off the east coast of Barrow Island, the intertidal limestone reef flats and shallow pavement reef are variably covered by sand, gravel, and coral, with scattered pinnacles. Bare sands overlay limestone pavements in many areas, with exposed pavement and rubble present where water currents are stronger (Chevron Australia 2005).

Macroalgal assemblages are the most common ecological element off the east coast, which often co-occur in lower abundance with seagrass and non-coral benthic macroinvertebrates (Chevron Australia 2014) (Figure 6-13).

A number of coral reefs occur off the east coast of Barrow Island, including Ant Point Reef, Lone Reef, and Turtle Reef (Chevron Australia 2014). The most significant of these coral reefs are Dugong Reef and Batman Reef, approximately 3 km and 10 km south-east of Barrow Island respectively (DEC 2007) (Figure 6-13). The closest reef to WAPET Landing is Ant Point Reef, which is approximately 1.5 km north-east. The closest reefs to the Materials Offloading Facility and the LNG Jetty are Turtle Reef and Lone Reef, which are approximately 6 km south-west and 6 km south-east respectively.

The grey mangrove (*Avicennia marina*) is the only species of mangrove found around Barrow Island; it occurs in sheltered embayments on the southern and eastern coastlines from Bandicoot Bay to Shark Point (Chevron Australia 2005). Small communities also occur further north at Mattress Point and Ant Point (Figure 6-13). There are no mangrove stands in the vicinity of the Materials Offloading Facility, LNG Jetty, or WAPET Landing, with the closest stands occurring at the Mattress Point, approximately 5 km north of Town Point (Chevron Australia 2014).

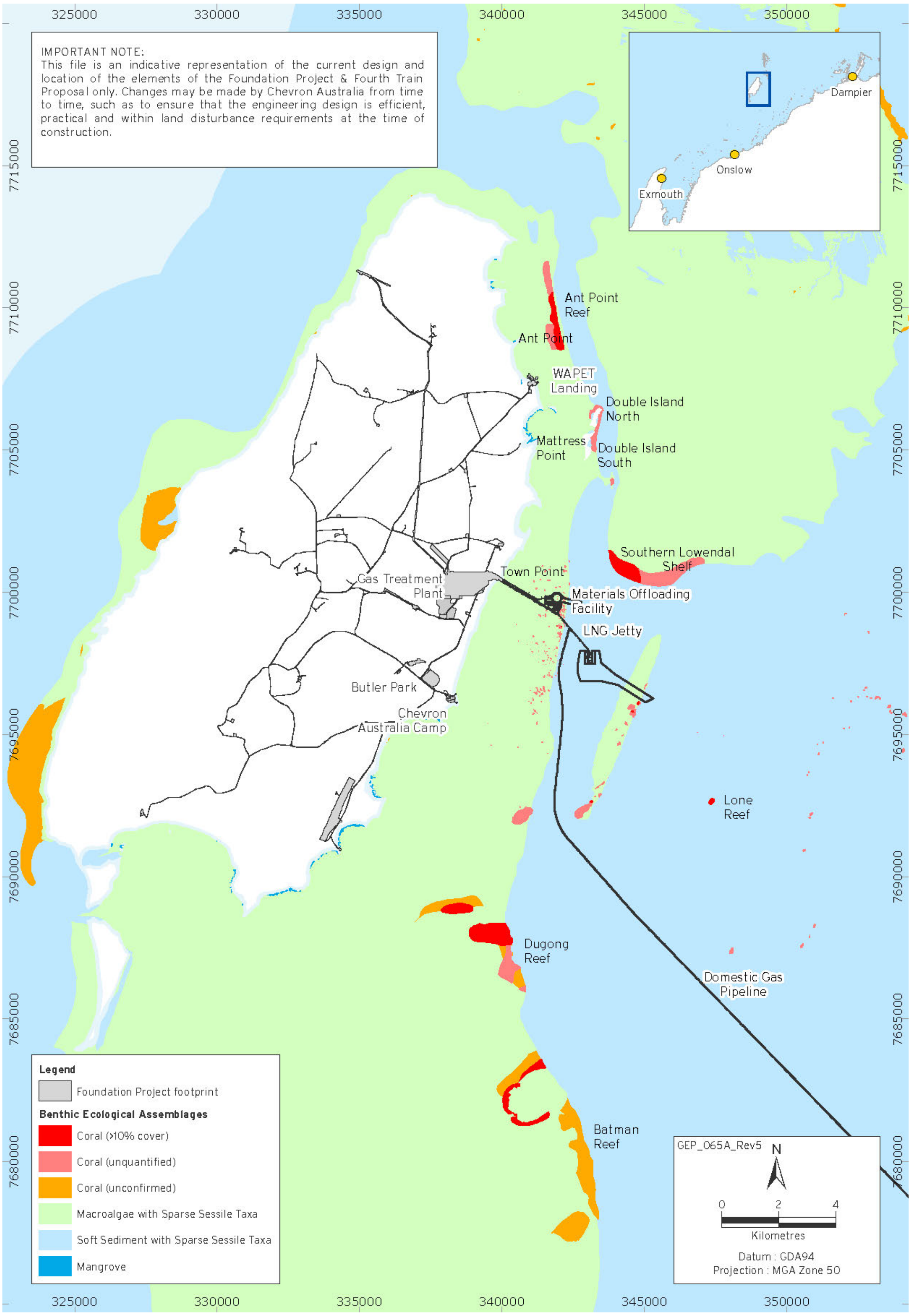


Figure 6-13: Benthic Primary Producer Habitat Communities Present off the East Coast of Barrow Island

6.6.1.2.3.1 Town Point

Benthic habitats off the east coast of Barrow Island in the vicinity of Town Point consist of limestone pavement reef overlain by a thin veneer of sediment and is dominated by *Sargassum* spp., with macroalgae such as *Cystoseira* spp. and *Dictyopteris* spp. also prominent. Low cover of seagrass is present, including the genus *Halodule* spp. (Chevron

Australia 2013). The benthic habitats in the vicinity of Town Point have been disturbed as a result of construction activities relating to the Foundation Project.

The limestone pavement in this area slopes gently into the lower intertidal and subtidal zones, with a large shallow lagoon surrounding Town Point. A narrow break in the platform opens the lagoon to the sea (RPS BBG 2005a). The lower intertidal zone has less sediment cover and supports the growth of macroalgae and seagrass as well as scleractinian corals (stony corals) and octocorals (soft corals). Benthic habitats containing coral communities on the subtidal pavement reef and the deeper offshore areas in the vicinity of the Materials Offloading Facility and LNG Jetty vary from almost exclusively coral-dominated assemblages, to areas dominated by macroalgae, but with scattered small hard corals such as *Acropora* spp. and soft corals such as *Rumphella* spp. (Chevron Australia 2008). The benthic macroinvertebrate assemblages present within the area are typical of the wider platform and similar to those in the vicinity of the Causeway footprint and comprise of ascidians, hydroids, sea whips, scattered small hard corals (e.g. *Turbinaria* spp., *Montipora* spp.), and sponges (Chevron Australia 2014). Much of the benthic habitats, such as the *Porites* spp. bombora, are either interspersed as isolated elements throughout the subtidal reef area or are grouped together to form bombora communities (Chevron Australia 2008).

6.6.1.2.3.2 WAPET Landing

The seabed in the vicinity of WAPET Landing, north of Town Point, comprises sand of various depths overlaying limestone pavement, with areas of exposed pavement reef dominated by macroalgae. The macroalgal assemblages found in the vicinity of WAPET Landing exhibit similar composition to those of the broader macroalgae community along the east coast of Barrow Island and predominantly include *Sargassum* spp., *Dictyopteris* spp., *Dictyota* spp., *Padina* spp. and *Halimeda* spp. All benthic macroinvertebrates recorded within the WAPET Landing area are well-represented elsewhere around Barrow Island. Low numbers of large *Xestospongia* spp., as well as the occasional sponge, have been recorded at WAPET Landing (Chevron Australia 2014). No coral assemblages have been observed at WAPET Landing, with only very sparse coral cover (less than 5% and comprising mainly of faviids, with some *Euphyllia* spp.) supported (Chevron Australia 2014).

The composition of seagrass assemblages surrounding WAPET Landing is similar to that of other parts of the shallow limestone pavement along the east coast of Barrow Island. Only scattered sparse patches of seagrass (e.g. *Halophila* and *Halodule* spp.) occur within the marine environment of WAPET Landing (Chevron Australia 2014).

WAPET Landing has been used since the 1960s and has been visited regularly by marine supply vessels. The Foundation Project upgraded WAPET Landing to allow it to handle all marine vessel and freight movement for import and export from Barrow Island. Benthic habitat in the immediate vicinity of WAPET Landing has been disturbed by previous activities, confirmed by the findings of the recent Post Development Environmental Impact Survey Report (Chevron Australia 2013a). The study states that the area has been disturbed by regular marine supply vessel activities. Although the WAPET Landing facility has expanded slightly, the area of disturbance is similar to the area of historical disturbance of the facility (Chevron Australia 2013a).

6.6.2 Marine Fauna

Marine fauna recorded in the North-west Marine Region are typically tropical or subtropical species. The North-west Marine Region is considered species-rich due to the diversity of habitats available, but has low endemicity as many of the species are also found in other parts of the Indian Ocean and the western Pacific Ocean (DEWHA 2008). The southern part of the North-west Marine Region (south of North West Cape) is considered a transition zone between tropical and temperate species.

A number of marine fauna species that may occur in the Fourth Train Proposal Area are protected under the EPBC Act and the Wildlife Conservation Act and a number of species are also listed as Threatened and/or Migratory and thus are considered to be matters of NES. These protected/listed fauna include a number of fish, mammals, reptile, and marine avifauna species.

A number of Biologically Important Areas (BIAs), identified by SEWPaC in 2012, are located within the North-west Marine Region. Through the marine bioregional planning program, SEWPaC have identified, described and mapped BIAs for protected species under the EPBC Act. BIAs spatially and temporally define areas where protected species may display biologically important behaviours including breeding, foraging, resting or migration. These areas are parts of the marine region that are particularly important for the conservation of protected species. These BIAs are described in the sections below.

6.6.2.1 Fish

6.6.2.1.1 Regional

Surveys of the fish fauna of North-western Australia has revealed a species-rich assemblage with species showing strong depth relationships which is thought to demonstrate a strong community-habitat link (e.g. Allen 2000; Hutchins 2004; Fox and Beckley 2005; Travers *et al*. 2006). Small pelagic fish are believed to comprise a significant proportion of the fish biomass throughout the region (approximately a third of total fish biomass), feeding on pelagic phytoplankton and zooplankton and providing a food source for a wide variety of predators including large pelagic fish, sharks, seabirds, and marine mammals. Fish species of the inner shelf include lizardfish, goatfish, trevally, angelfish, and tuskfish (DEWHA 2008). Large pelagic fish (such as tuna, deep lizardfish, deep goatfish, ponyfish, deep threadfin bream, adult trevally, billfish, mackerel, swordfish, and marlin) are also found in the region, mainly in water depths of 100 to 200 m, and occasionally on the continental shelf (DEWHA 2008). The region also contains a rich variety of chondrichthyan fish (sharks, skates and rays) with 157 species (both demersal and pelagic) believed to occur in these waters, occupying a broad range of shallow and deepwater habitats (DEWHA 2008).

The region is associated with important populations of demersal fish species, including commercial species such as snappers, emperors, and groupers, which are distributed across a number of distinct depth ranges, specifically areas of the upper slope (225–500 m water depth) and mid slope (750–1000 m water depth). More than 508 fish species have been identified on the slope in this area, of which 64 species are endemic (DEWHA 2008).

Seven fish species are listed as Vulnerable and/or Migratory under the EPBC Act and have been identified as potentially occurring within Fourth Train Proposal Area (Table 6-8). These species also have regional distributions. Grey Nurse Sharks (*Carcharias taurus*) have a broad inshore distribution around Australia (Environment Australia 2002). The Grey Nurse Shark has been recorded as far north as the North West Shelf in Western Australia; however, distribution is generally confined to the coastal waters of the south-west (Environment Australia 2002). No aggregation sites or other sites critical to the survival of Grey Nurse Sharks have been identified in Western Australia (Environment Australia 2002)

The Shortfin Mako Shark (*Isurus oxyrinchus)* inhabits Australian waters except for those offshore from the Northern Territory. They are rarely found in water below 16°C and are highly migratory. The Longfin Mako Shark (*Isurus paucus)* is an oceanic tropical shark found in Australian waters. Its range, which includes the Fourth Train Proposal Area, extends as far south as Geraldton on the western coast of Australia, and to at least Port Stephens in New South Wales on the eastern coast (DotE 2014a). Little information exists on this species, which is often confused with the Shortfin Mako.

The Giant Manta Ray (*Manta bostris*) inhabits Western Australian waters, ranging as far south as Geraldton, through the tropics and into the northern hemisphere. The Giant Manta Ray is commonly sighted along productive coastlines with regular upwelling, oceanic island groups and particularly offshore pinnacles and seamounts. They may be encountered on shallow reefs while being cleaned or feeding close to the surface inshore and offshore. They are occasionally observed in sandy bottom areas and seagrass beds. No BIAs for the Giant Manta Ray have been identified within this area.

The Dwarf Sawfish (*Pristis* sp.) has been recorded in Australia from Cairns, around the Cape York Peninsula, across northern Australian waters to the Pilbara coast in Western Australia (Last and Stevens 1994; Stevens *et al*. 2005, 2008; Threatened Species Scientific Committee 2008, 2009). This species is thought to inhabit shallow coastal waters and estuarine habitats in the Pilbara Region (DotE 2014a). They appear to rest within mangrove areas at high tide, and are more active on the moving tide when they tend to occupy mud and sand flats along the coastline, feeding on the benthos (Stevens *et al*. 2008; DotE 2014a). BIAs identified for the Dwarf Sawfish are along the northern Pilbara and Kimberley coastline (SEWPaC 2013). The Green Sawfish (*Pristis zijsron)* has been historically recorded in the coastal waters off Broome, Western Australia, around northern Australia and down the east cast as far as Jervis Bay, NSW (Stevens et al. 2005). The Green Sawfish habitat includes shallow bays, estuaries and lagoons (DotE 2014a).

Whale Sharks (*Rhincodon typus*) have a broad distribution in tropical and warm temperate seas (Chevron Australia 2005). An annual congregation occurs between March and April off Ningaloo Reef, approximately 150 km south-west of Barrow Island (Chevron Australia 2008) although sightings have also occurred in January (Wheeler 2013). Whale Sharks leave Ningaloo Reef between May and June, travelling north-east along the continental shelf (Wilson *et al.* 2006). BIAs for Whale Shark foraging have been identified along the Western Australian coast extending northward of Ningaloo Reef, including waters surrounding Barrow Island (SEWPaC 2013) (Figure 6-14).

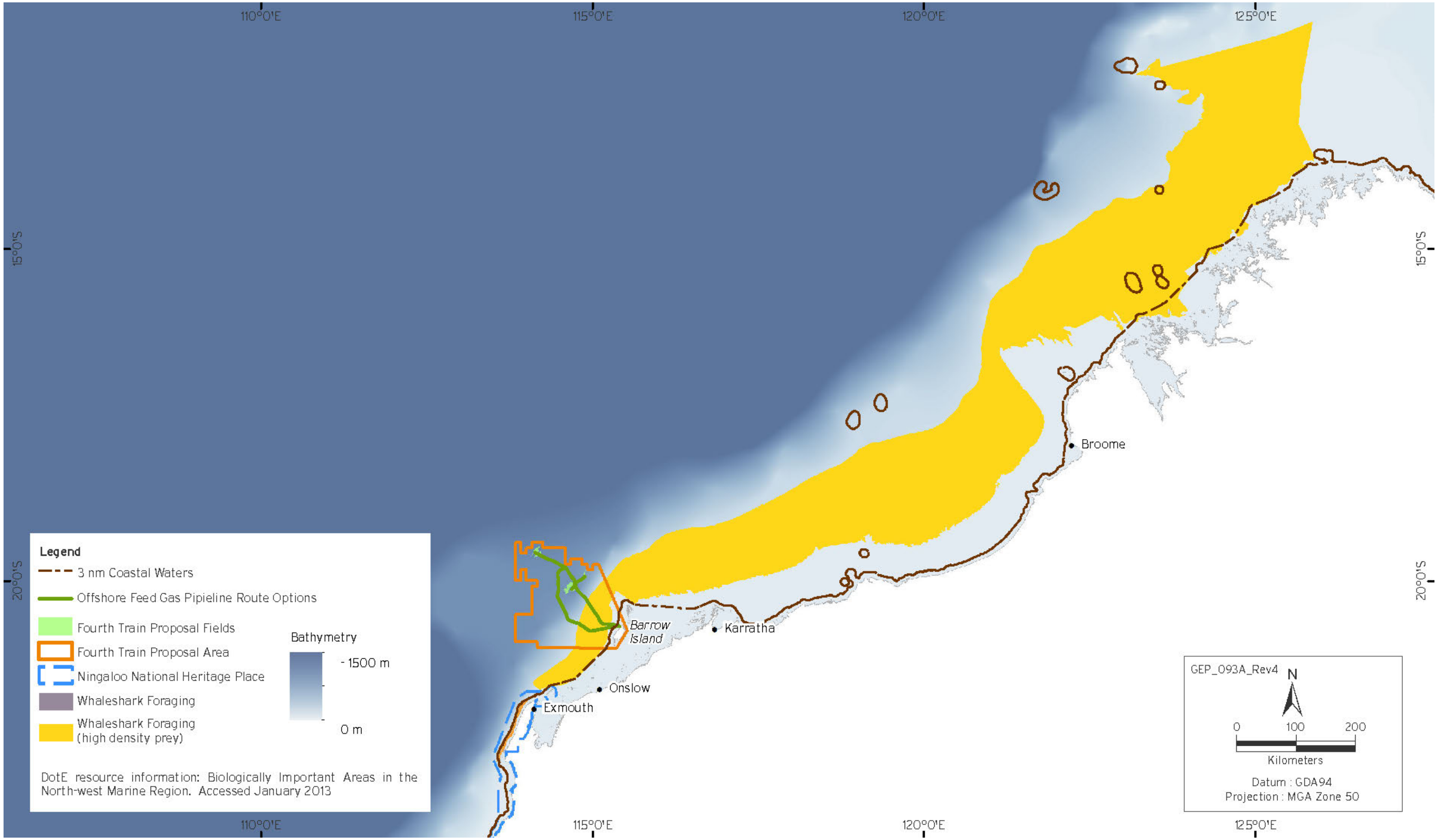


Figure 6-14: Biologically Important Areas in the North-west Marine Region for Whale Sharks

6.6.2.1.2 Fourth Train Proposal Area

The Montebello/Barrow Islands region supports a rich fish fauna with 456 species from 75 families recorded during a Western Australian Museum survey in 1993 (Allen 2000). Fish of the Montebello/Barrow Islands is considered to be closely related to that of the Dampier Archipelago, where 650 species were recorded during another survey by the Western Australian Museum (Hutchins 2004).

Demersal fish surveys were undertaken as part of the Foundation Project in the vicinity of the Offshore Feed Gas Pipeline System in State waters and the shore crossing, in macroalgal, soft sediments with sessile non-coral benthic macroinvertebrates, and unvegetated sand communities. These surveys were undertaken in water depths between 12 and 22 m. During the first survey in March 2009, a total of 698 individuals from 58 species and 28 families were recorded; in February/March 2010, 1266 individuals from 71 species and 31 families were recorded (Chevron Australia 2011). The results from surveys undertaken in 2008 and 2009 and reported by Chevron Australia (2011) indicated that different shallow water marine habitats surrounding Barrow Island were generally characterised by different species compositions and richness (Chevron Australia 2011):

- Coral habitats were the most species-rich, comprising high abundances of small-bodied pomacentrids (e.g. Six-banded Angelfish [*Pomacanthus sexstriatus*]), and the common occurrence of larger serranids (e.g. Barcheek Coral Trout [*Plectropomus maculatus*]), labrids (e.g. Blue Tuskfish [*Choerodon cyanodus*], lethrinids (e.g. Yellowtail Emperor [*Lethrinus atkinsoni*]) and lutjanids (e.g. Stripey Snapper [*Lutjanus carponotatus*]).
- Habitats dominated by macroalgae were characterised by high abundances of labrids (e.g. Bluespotted Tuskfish [*Choerodon cauteroma*]) and lethrinids (e.g. Threadfin Emperor [*Lethrinus genivittatus*]). These habitats may act as important nursery grounds for juveniles of numerous species of fish (in particular *Lethrinus* sp. and *Choerodon* spp.).
- Fish assemblages in soft sediments with sessile benthic invertebrate communities were less species-rich compared to habitats dominated by macroalgae or coral. High abundances of carangids (e.g. Gold-spotted Trevally [*Carangoides fulvoguttatus*]), lethrinids (e.g. Threadfin Emperor [*Lethrinus genivittatus*]), and nemipterids (e.g. Northwest Threadfin Bream [*Pentapodus porosus*]) were present within soft sediment environments.

Fish assemblages characteristic of hard and soft coral, macroalgae, soft sediments and sessile benthic macroinvertebrates, and bare sand communities occurred within the vicinity of Town Point. Separately, the marine area surrounding WAPET Landing has been classified as a macroalgal fish habitat and is expected to exhibit similar fish assemblages, including fish from the families Labridae, Lethrinidae, and Nemipteridae. The relative abundance or composition of the demersal fish assemblages recorded was common within the local area and region (Chevron Australia 2011).

Seven fish species listed as Vulnerable and/or Migratory under the EPBC Act have been identified as potentially occurring within Fourth Train Proposal Area (Table 6-8).

Table 6-8: Protected Fish that may occur in the Vicinity of the Fourth Train Proposal Area

Common Name	Scientific Name	Status		Presence in the vicinity of the Fourth Train Proposal Area
		Cth[1]	WA[2, 3]	
Grey Nurse Shark	*Carcharias taurus*	V		Possible
Shortfin Mako	*Isurus oxyrinchus*	M		Possible
Longfin Mako Shark	*Isurus paucus*	M		Possible
Giant Manta Ray	*Manta bostris*	M		Likely
Dwarf Sawfish	*Pristis clavata*	V	P1[3]	Possible
Green Sawfish	*Pristis zijsron*	V	Schedule 1, V	Possible
Whale Shark	*Rhincodon typus*	V, M		Likely

Notes:

1 *Status under the EPBC Act: V = Vulnerable; E = Endangered; CE = Critically Endangered; M = Migratory (matters of NES)*

2 *Status under the Wildlife Conservation Act 1950 [Wildlife Conservation (Specially Protected Fauna) Notice 2012 (2) dated 6th November 2012]*

3 *DPaW Current Threatened and Priority Fauna Ranking: P1 = Priority One: Taxa with few, poorly known populations on threatened lands. Taxa that are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.*

The coastal habitat surrounding Barrow Island may potentially be suitable for the Grey Nurse Shark but no records of its occurrence have been found to date. The Fourth Train Proposal Area is within the range for the Shortfin Mako Shark and the Longfin Mako Shark. However, no records or sightings have been documented for these species within the area. Suspected Giant Manta Ray sightings were recorded in Barrow Island's nearshore waters by Marine Fauna Observers (MFOs) for the Foundation Project.

The EPBC Protected Matters search and SEWPaC distribution maps suggest that the Dwarf Sawfish habitat may occur within the Fourth Train Proposal Area. The EPBC Protected Matters search and SEWPaC distribution map suggests that the Green Sawfish species does not occur within the Fourth Train Proposal Area. However, a single sawfish (*Pristis sp.*) sighting has been recorded at Bandicoot Bay, on the south coast of Barrow Island (Chevron Australia 2012c). Identification to species level was not possible, indicating a potential for either species to exist within the Fourth Train Proposal Area. Individual Whale Sharks may pass through the deeper waters off Barrow Island occasionally and sightings of individuals have been observed within the Fourth Train Proposal Area. Sygnathids, comprising pipefish, pipehorses and seahorses are widely distributed in marine waters off Western Australia, but the distribution of individual species within the region is little known (Chevron Australia 2005). Approximately 30 species of pipefish and seahorse occur in the Barrow Island area. These species may be widespread through the shallower benthic habitats of the Barrow Island area.

6.6.2.2 Marine Mammals

6.6.2.2.1 Region

The Pilbara Region supports migratory, transient, and resident marine mammals such as cetaceans (whales and dolphins) and Dugongs. The regional distribution of many cetacean species is not well understood; however, of the 45 cetacean species recorded in Australian waters, 27 are thought to regularly occur in the North-west Marine Region, with a further nine considered infrequent visitors (SEWPaC 2012b). Most cetacean species found in this region are pelagic, and predominantly found in the Commonwealth Marine Area (SEWPaC 2012b).

Bryde's Whales (*Balaenoptera edeni)* are generally more abundant in deeper waters and have been recorded in all Australian states except the Northern Territory (DotE 2014a). Bryde's Whale are known to occur off the north-western Australian coast (Chevron Australia 2008). Blue Whales (*Balaenoptera musculus*) can be found in waters off Australia's Antarctic Territory, and along the southern parts of the coast, including Western Australia (Department of Environment and Heritage [DEH] 2005). Known areas of significance to Blue Whales are feeding areas around the southern continental shelf, notably the Perth Canyon Commonwealth Marine Reserve, in Western Australia (DEH 2005). Fin Whales (*Balaenoptera physalus*) may travel through the North-west Marine Region on their way to breeding grounds, which are thought to be in deep oceanic waters around the Indonesian archipelago but have yet to be discovered (SEWPaC 2012b).

The North-west Marine Region is considered an important cetacean migratory pathway for a number of species, from the feeding areas of the Southern Ocean, to the warm tropical waters for breeding/calving. The migration pathway used by Blue Whales (*Balaenoptera musculus*) along the Western Australian coast is generally found along the shelf edge (500 to 1000 m depth contour), with the northern migration occurring during April to August and a southerly migration closer from October to late December, with animals noted to travel closer to the coastline.

The North-west Marine Region is particularly important for the Western Australian population of Humpback Whales *(Megaptera novaeangliae*). Humpback Whales migrate annually from their Southern Ocean feeding ground to nearshore waters of the Kimberley coast to calve and mate (Jenner *et al.* 2001). The exact timing of the migration is variable. Generally the northbound movement commences around May to July with the southerly migration from September to November, with most whales returning in water depths less than 75 m (Jenner *et al.*2008). The migratory paths of Humpback Whales along the Western Australian coast lie within the continental shelf boundary or 200 m water depth (Jenner *et al*. 2001). The Humpback Whales are likely to migrate closer to shore on their southerly migration, as this is when they travel with young and use sheltered bays and island areas to rest (Jenner *et al*. 2001).

Orcas (*Orcinus orca*) are migratory and are recorded from all Australian states (DotE 2014a). They are generally seen in relatively deeper waters; in Australian waters, they are most commonly seen along the continental slope and shelf (DotE 2014a). Sperm Whales (*Physeter macrocephalus*) tend to be found in offshore waters (Chevron Australia 2005; Reeves *et al*. 2002; DotE 2014a) and may occasionally visit the shelf waters to feed on cephalopods (Chevron Australia 2005). Sperm Whales (*Physeter macrocephalus)* may also be found in areas of upwelling and canyons on the continental shelf (SEWPaC 2012b).

Dusky Dolphins (*Lagenorhynchus obscurus*) are not well surveyed in Australian waters and occur mostly in temperate and sub-Antarctic waters, primarily inhabiting inshore waters (Ross 2006). Shallow water dolphin species include the Indo-Pacific Humpback Dolphin (*Sousa chinensis*), Australian Snubfin Dolphin (*Orcaella heinsohni*), and Indian Ocean Bottlenose Dolphin (*Tursiops aduncus*). These species can be found in association with mangrove systems in nearshore coastal waters within the North-west Marine Region and adjacent to it (SEWPaC 2012b). The Indo-Pacific Humpback Dolphin can typically be found in shallow waters (less than 20 m) in nearshore waters of Coral Bay and off the north-west coast, extending as far as Roebuck Bay in the western Kimberley (Hodgson 2007; Allen *et. al* 2012). They have resident populations within the shallow waters of the inner section of the Rowley Shelf, including Barrow Island (Chevron Australia 2005). The population of Indian Ocean Bottlenose Dolphins is thought to extend as far south as Exmouth. Australian Snubfin Dolphins (*Orcaella heinsohni*) are believed to be present within the coastal waters of north-west Australia, with resident populations along the Kimberley coast (DEWHA 2008). They mainly occur in shallow coastal or estuarine waters (Beasley *et al*. 2002) near rivers, tidal creeks and mangrove systems (DotE 2014a). Indian Ocean Bottlenose Dolphins (*Tursiops aduncus*) inhabit warmer coastal areas, in waters less than 10 m deep (Bannister *et al*. 1996). Spinner Dolphins

(*Stenella longirostris*) are not known to be migratory, but observations have indicated seasonal movement of the animals and substantial extensions of range (Secchi and Siciliano 1995). Limited data are available for this species in the North-west Marine Region; however, studies have recorded it at the shelf edge and shelf slope area of the Browse Basin and in nearshore areas of the Kimberley coast (RPS 2010; Woodside 2009). The presence of Spinner Dolphins in southern localities on the Australian west coast may be linked to movements of the Leeuwin Current (Bannister *et al*. 1996).

Dugong (*Dugong dugon*) are most abundant in the shallow, warm marine waters off the northern and the north-western coasts of Australia, where they typically feed on *Halodule* and *Halophila* seagrasses (Chevron Australia 2005a). Areas known to support Dugongs in Western Australia include: Shark Bay; Ningaloo Marine Park and Exmouth Gulf; Pilbara coastal and offshore regions (Exmouth Gulf to De Grey River); and Eighty Mile Beach and the Kimberley Coast Region (Marsh *et al.* 2002). Prince *et al*. (2001) conducted a study in the Pilbara Region and as a result, stated that the region was considered an integral part of the resource areas sustaining Dugong presence on the Western Australian coast. Within the Pilbara Region, Exmouth Gulf has been surveyed by DEC (now DPaW) for Dugongs four times since 1989 and a range of population estimates have been identified for this area. The Dugong population in Exmouth Gulf has varied over the last two decades, possibly as a result of Cyclone Vance destroying the seagrass beds in Exmouth Gulf in 1999 (Gales *et al.* 2004). However, the latest survey of Exmouth Gulf, conducted in 2007, showed that Dugong numbers had increased again (Hodgson 2007).

More recently, Dugong aerial surveys were conducted in 2010, 2012 and 2013 as part of the Wheatstone Project (Chevron Australia 2011b, Hodgson 2014 in prep.). The survey area extended from the Exmouth Gulf to the north-east tip of Barrow Island and out to the 20m contour. The surveys found both seasonal and annual changes in Dugong densities throughout the survey area. The highest densities of Dugongs were recorded in shallow waters near the coast or coastal islands, including the waters between Barrow Island and the mainland.

BIAs have been identified for several species of marine mammals within the North-west Region. These include the Humpback Whale; Australian Snubfin Dolphin, Indo-Pacific Humpback Dolphin, and the Indian Ocean Bottlenose Dolphin. Except for the Humpback Whale BIA, the BIAs for the three inshore dolphins are closer to the coast. The BIA for Humpback Whales includes a resting area at Exmouth Gulf, and the Humpback Whale migratory pathway, extending up to 100 km offshore (reducing to 50 km south of North West Cape) for much of the Western Australian coastline from their feeding area in the south, to their breeding and calving area off the Kimberley coast (Figure 6-15) (SEWPaC 2013). BIAs for the Australian Snubfin Dolphins and Indo-Pacific Humpback Dolphins are further north of Barrow Island, towards Port Hedland (SEWPaC 2013) and are not included in this PER/Draft EIS. BIAs for Dugong have been identified in Exmouth Gulf and Shark Bay for foraging and nursing of calves (SEWPaC 2013) and are not within the Fourth Train Proposal Area.

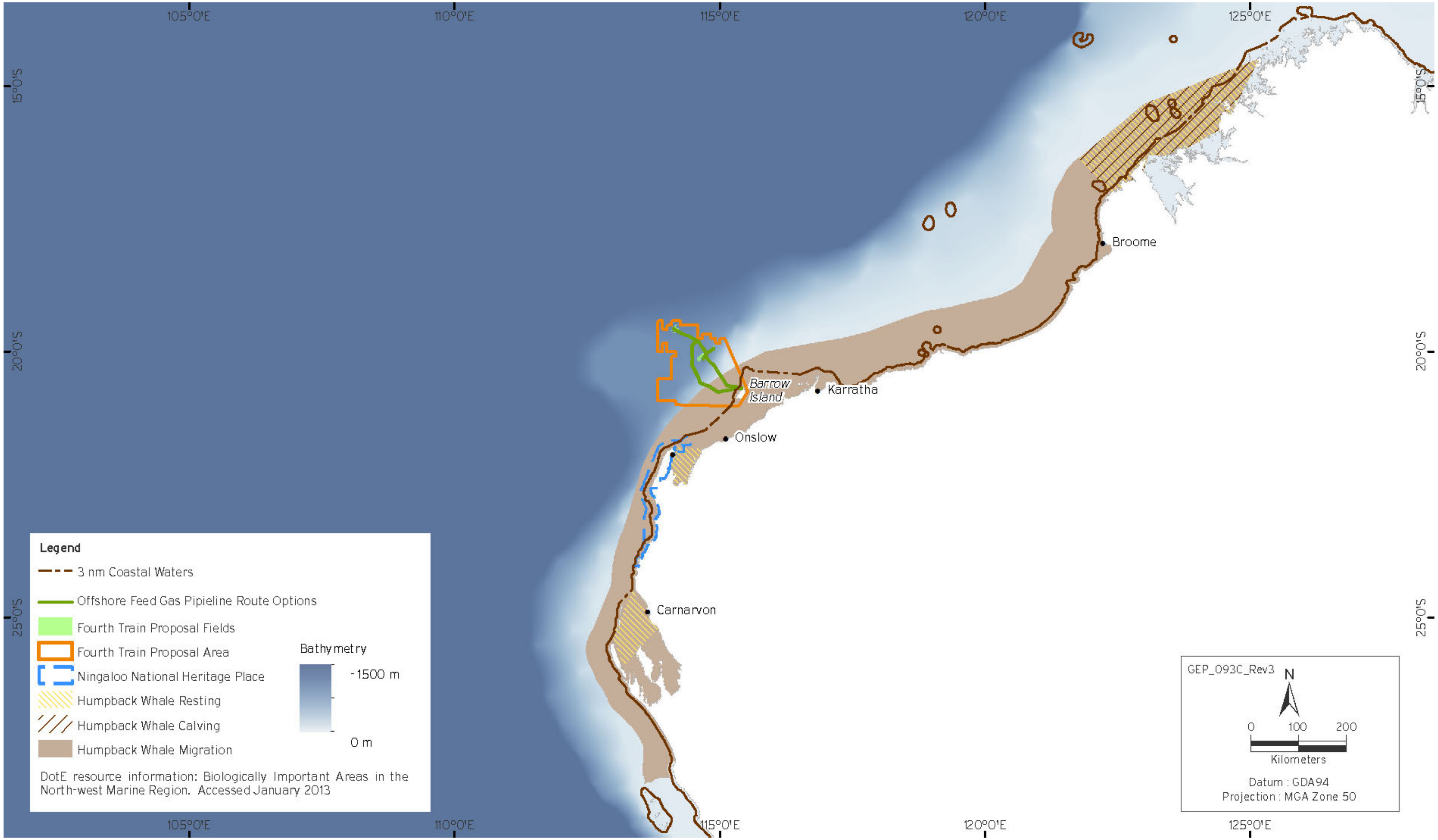


Figure 6-15: Biologically Important Areas in the North-west Marine Region for Humpback Whales

6.6.2.2.2 Fourth Train Proposal Area

Twelve species that may potentially be present in the vicinity of the Fourth Train Proposal (Appendix E2 [Conservation-significant Species Considered for Assessment in this PER/Draft EIS] and Table 6-9).

Table 6-9: Protected Marine Mammals that may occur in the Vicinity of the Fourth Train Proposal

Common Name	Scientific Name	Status		Presence in the vicinity of the Fourth Train Proposal
		Cth[1]	WA[2, 3]	
Bryde's Whale	*Balaenoptera edeni*	M, Cetacean		Likely
Blue Whale	*Balaenoptera musculus*	E, M, Cetacean	Sch 1[2]	Likely
Fin Whale	*Balaenoptera physalus*	V, M, Cetacean	Sch 1[2]	Possible
Humpback Whale	*Megaptera novaeangliae*	V, M, Cetacean	Sch 1[2]	Likely
Orca	*Orcinus orca*	M, Cetacean		Possible
Sperm Whale	*Physeter macrocephalus*	M, Cetacean	P4[3]	Possible
Dusky Dolphin	*Lagenorhynchus obscurus*	M, Cetacean		Possible
Australian Snubfin Dolphin	*Orcaella heinsohni*	M, Cetacean	P4[3]	Likely
Indo-Pacific Humpback Dolphin	*Sousa chinensis*	M, Cetacean	P4[3]	Likely
Indian Ocean Bottlenose Dolphin	*Tursiops aduncus*	M, Cetacean		Likely
Spinner Dolphin	*Stenella longirostris*	Cetacean	P4[3]	Likely
Dugong	*Dugong dugon*	M, Marine	Sch 4[2]	Likely

Notes:

1 *Status under the EPBC Act: V = Vulnerable; E = Endangered; CE = Critically Endangered; M = Migratory (matters of NES)*

2 *Status under the Wildlife Conservation Act 1950 [Wildlife Conservation (Specially Protected Fauna) Notice 2012 (2) dated 6th November 2012]: Sch 1 = Schedule 1: Fauna that is rare or is likely to become extinct; Sch 4 = Schedule 4: other specially protected fauna (for reasons other than those mentioned in Schedules 1, 2, and 3)*

3 *DPaW Current Threatened and Priority Fauna Ranking: P4 = Priority Four: Taxa in need of monitoring. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.*

The Sei Whale, Blue Whale, Bryde's Whale, Antarctic Minke Whale, and Sperm Whale may be present in the Fourth Train Proposal Area, although they are all deepwater species (DotE 2014a) and therefore are expected to be rare visitors to the shallow, nearshore waters in the vicinity of Barrow Island (Chevron Australia 2005).

Humpback Whales (*Megaptera novaeangliae*) are likely to be present in the offshore west coast of Barrow Island waters between June and October on their annual migration between their feeding grounds in Antarctic waters and their calving grounds in Pilbara/Kimberley waters (Chevron Australia 2005). They are more common in waters off the west coast of Barrow Island (Figure 6-16), but are also expected to occasionally visit the east coast (Chevron Australia 2005) (Figure 6-16). The strong currents and extensive shoals are thought to deter the majority of Humpback Whales from the area between Barrow Island and the mainland (Jenner *et al*. 2001). Foundation Project MFOs have recorded a number of whale sightings from vessels, including Humpback Whales.

It is possible that the Australian Snubfin Dolphin occasionally visits the Fourth Train Proposal Area. The Indo-Pacific Humpback Dolphin (*Sousa chinensis*) may occur in the shallow waters surrounding Barrow Island, and also between Barrow Island and the mainland. A number of dolphin observations have been recorded from MFOs for the Foundation Project; observations include expected sightings of the Indo-Pacific Humpback Dolphin.

As their distribution in Australia is uncertain, Dusky Dolphins may occur in the vicinity of the Fourth Train Proposal, although this is considered unlikely. Common Dolphins (*Delphinus delphis*), Spinner Dolphins (*Stenella longirostris*) and Striped Dolphins (*Stenella coeruleoalba*) are abundant in the waters around Barrow Island. They are generally oceanic species and therefore are more likely to occur on the west coast of Barrow Island than near the east coast (Chevron Australia 2005).

Marine fauna observations as part of the Foundation Project have regularly recorded Dugongs off both the east and west coasts of Barrow Island. The Wheatstone Project Dugong aerial surveys, which included the waters between Barrow Island and the Western Australian mainland, found that sightings were highest off the south-east coast of Barrow Island. The survey findings suggest that Dugongs move from habitats in the shallows between Barrow Island and the mainland, to habitats around Thevenard Island (approximately 70 km south-west of Barrow Island) and Serrurier Island (approximately 100 km south-west of Barrow Island) and the Exmouth Gulf (Chevron Australia in prep.).

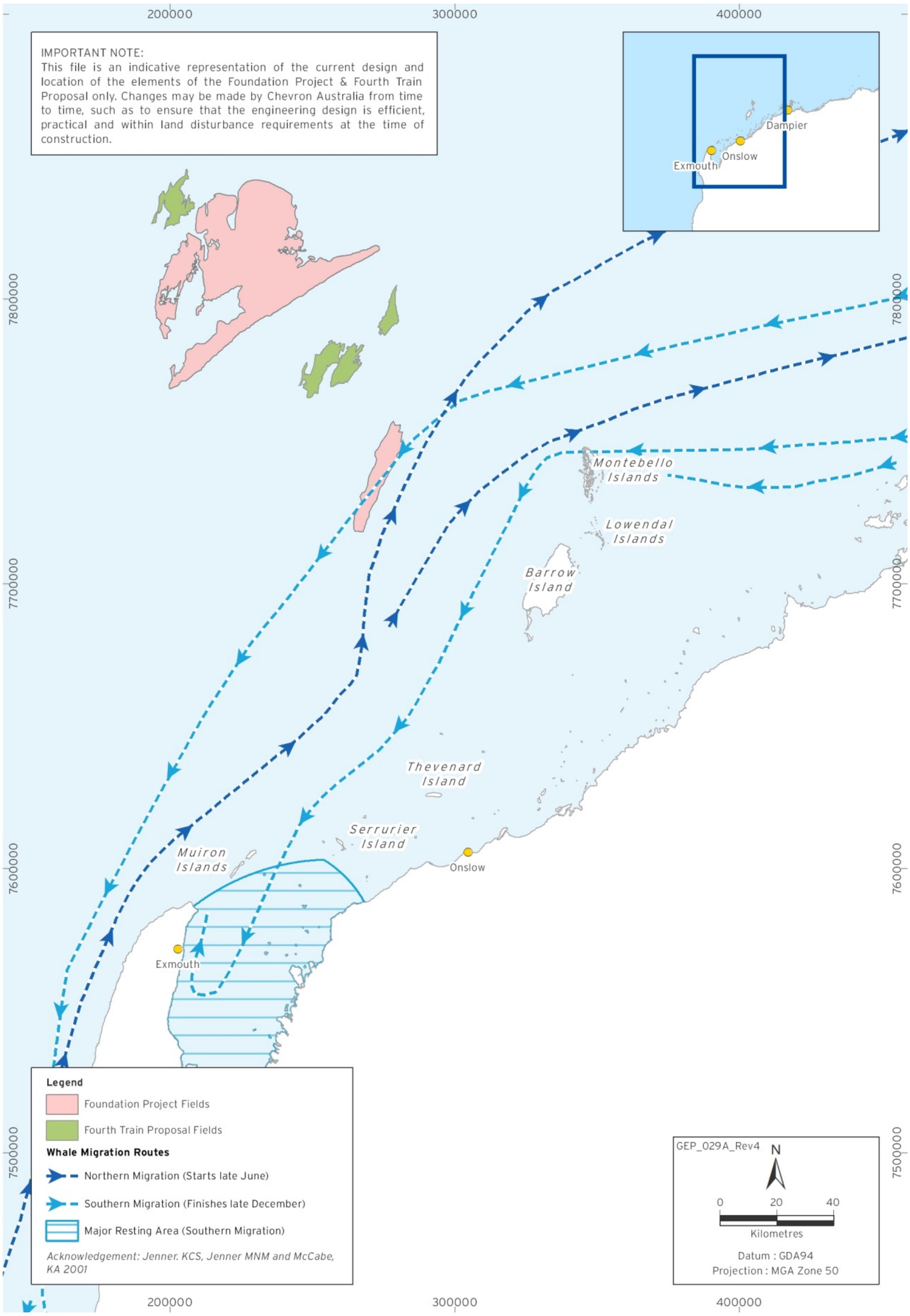


Figure 6-16: Humpback Whale Main Migration Route

6.6.2.3 Marine Reptiles

6.6.2.3.1 Regional

Six species of marine turtle occur in Australian waters and all six occur regularly in the North-west Marine Region (SEWPaC 2012c).

These are the Green Turtle (*Chelonia mydas*), Flatback Turtle (*Natator depressus*), Olive Ridley Turtle (*Lepidochelys olivacea*), Loggerhead Turtle (*Caretta caretta*), Hawksbill Turtle (*Eretmochelys imbricata*) and Leatherback Turtle (*Dermochelys coriacea*). In general, the coastal islands within the Pilbara Region have been recognised as important breeding sites for marine turtles (CALM 2002). Marine turtles in the region generally migrate over large distances and return to the same area to breed. The region also supports foraging grounds for turtles that nest elsewhere (Chevron Australia 2005).

Green Turtles are common in the North-west Region and breed extensively across northern Western Australia (Chevron Australia 2005b). Important breeding areas include Queensland, the Northern Territory and Western Australia, of which Barrow Island is an important rookery (Chevron Australia 2010). Flatback Turtles are endemic to Australian waters, and the Muiron Islands appear to be the southern limit of their distribution in Western Australia (Chevron Australia 2005b). Barrow Island and Mundabullangana are important rookeries for this species as well (Chevron Australia 2010). The Olive Ridley is the least common species and has been recorded off the coast of Exmouth and the Kimberley (Prince 1993) and is not known to nest in Western Australian waters (Chevron Australia 2008). The Loggerhead Turtle can be found along the eastern, northern, and western coastlines of Australia with Dampier Archipelago appearing to be the northern limit of their nesting (Chevron Australia 2010). The Hawksbill Turtle has been documented nesting as far south as North West Cape but the northward limit of their range has not been established for Western Australia (Chevron Australia 2010). Leatherback Turtles are uncommon throughout the Australian range (SEWPaC 2012c).

A number of BIAs have been identified for Green, Flatback, Hawksbill, and Loggerhead Turtles (Figure 6-17 to Figure 6-20). The BIAs are designed to include areas where foraging, mating, internesting (interval between individual nesting events when a new clutch of eggs is being formed inside the female), nesting and basking occur (SEWPaC 2012c).

The seas of tropical Australia support significant and diversified sea snake fauna, with a strong endemic component. Of the 55 species of sea snake recorded worldwide, 32 species are recorded from tropical Australia and nearly 50% of these are endemic (Cogger 2000). Cogger (1975) stated that most sea snakes have shallow benthic feeding patterns and are rarely found in water depths exceeding 30 m. However, very little is known about the distribution of the individual species of sea snakes in the region. The extensive mangrove system along the mainland coast of the Pilbara provides important habitat for these marine reptiles (Chevron Australia 2005).

The Short-nosed Sea Snake is known from Ashmore and Hibernia Reefs, off the north-west coast of Western Australia (Threatened Species Scientific Committee 2011). A small number of Short-nosed Sea Snake individuals collected have been recorded along the Western Australian coast from the Exmouth Gulf to Broome (Storr *et al*. 2002; Kangas *et al*. 2007). The origins of these specimens have not been determined, but they may have been vagrants or they may represent a population that has not yet been identified.

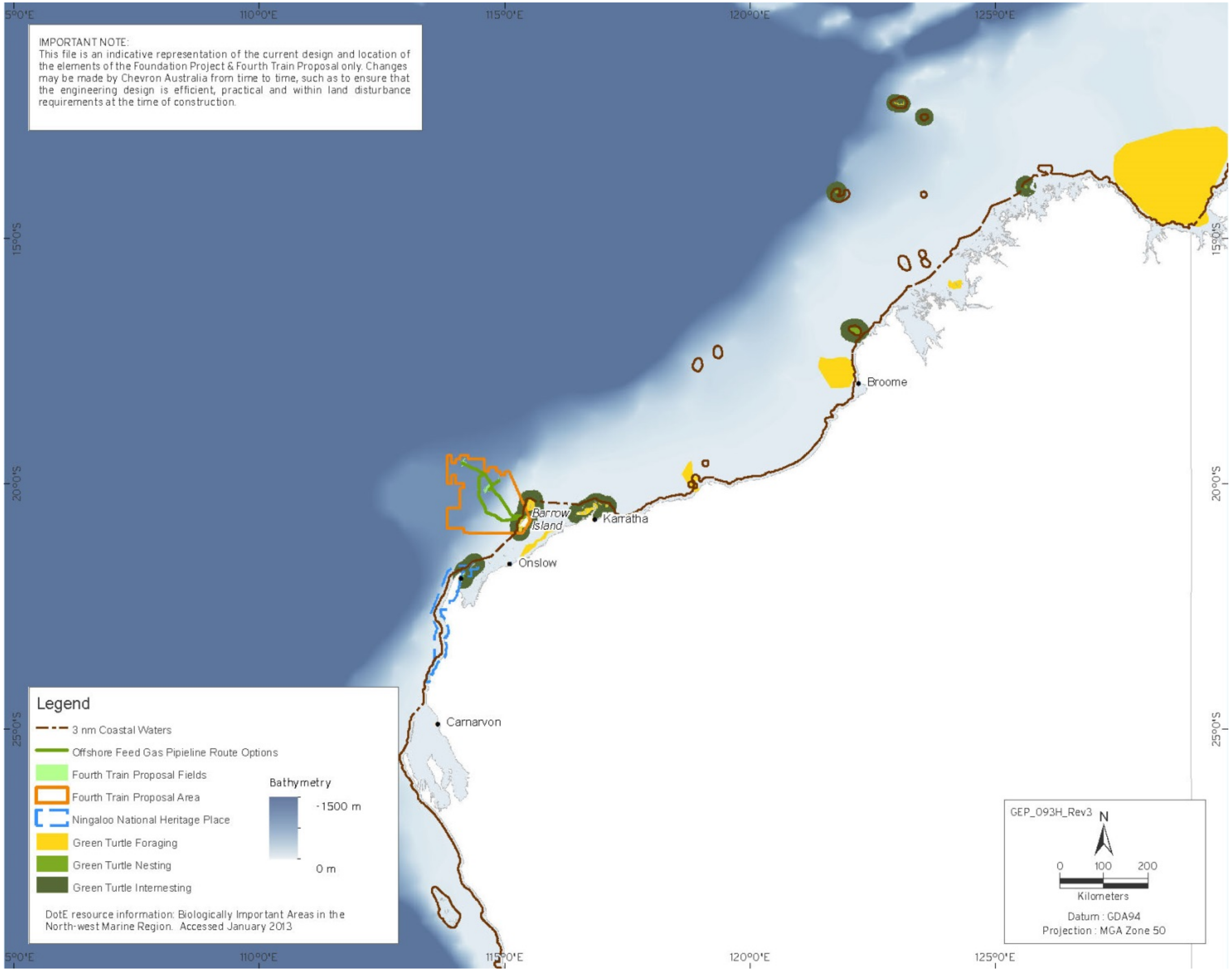


Figure 6-17: Biologically Important Areas for Green Turtles

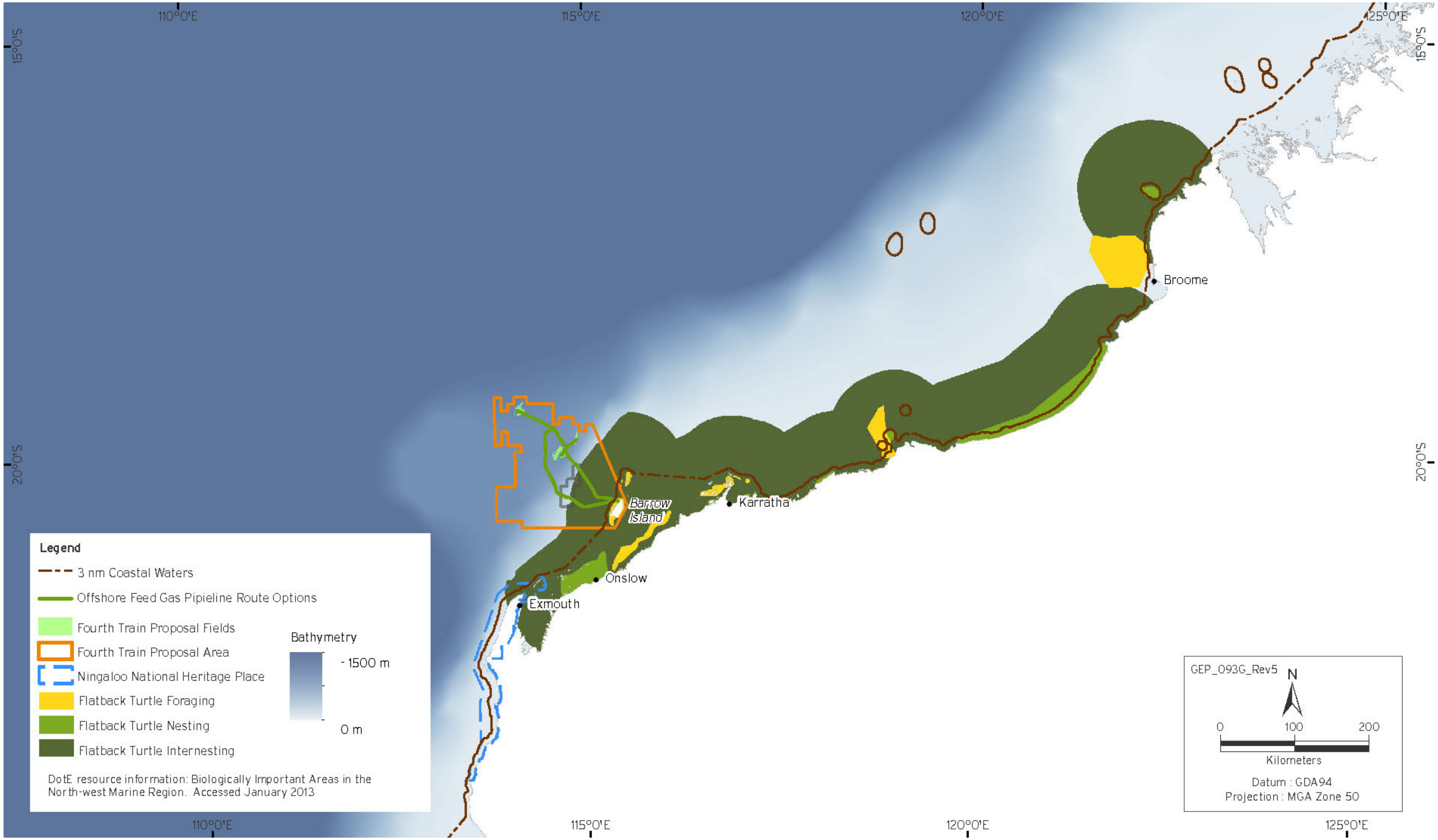


Figure 6-18: Biologically Important Areas for Flatback Turtles

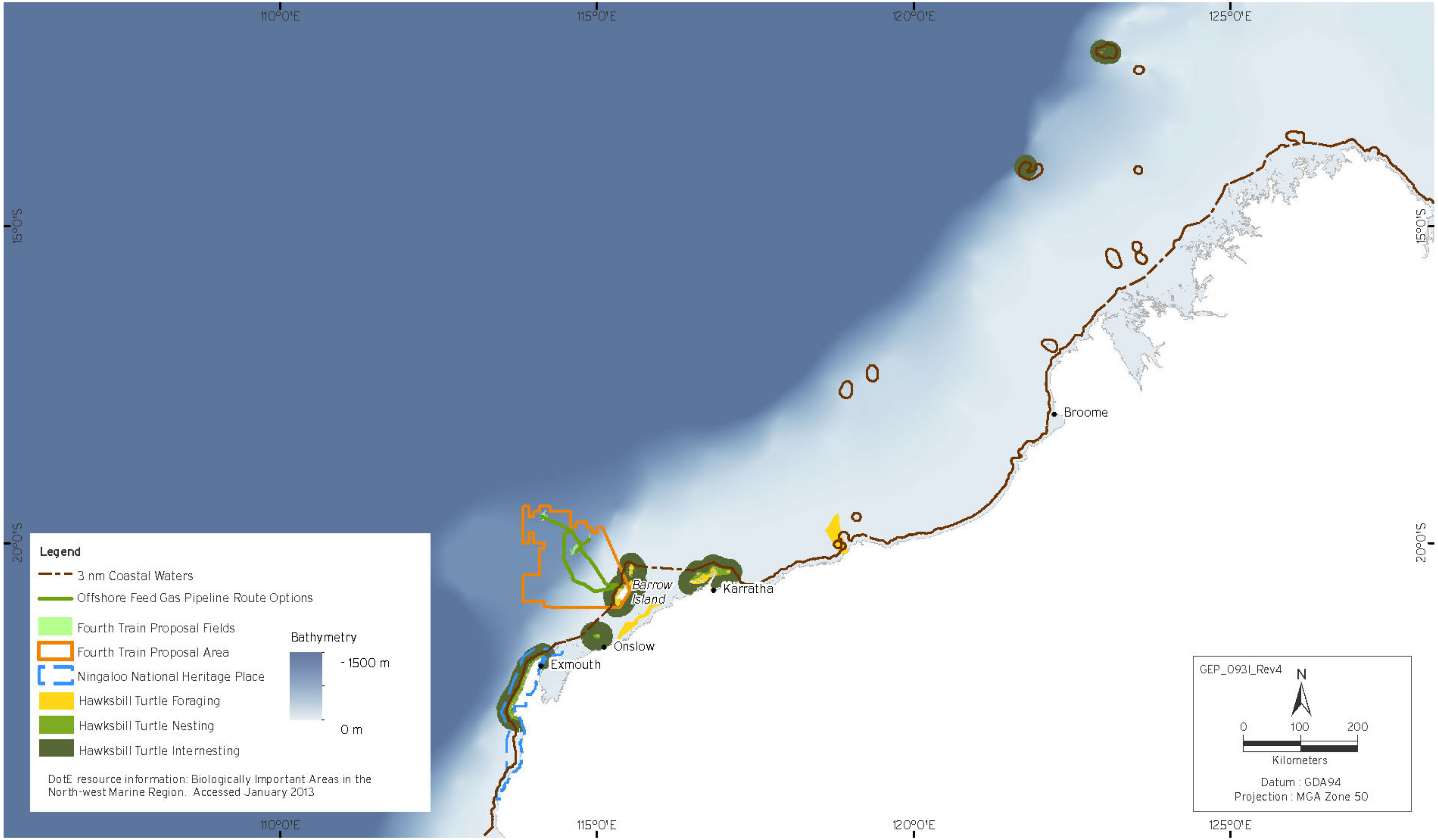


Figure 6-19: Biologically Important Areas for Hawksbill Turtles

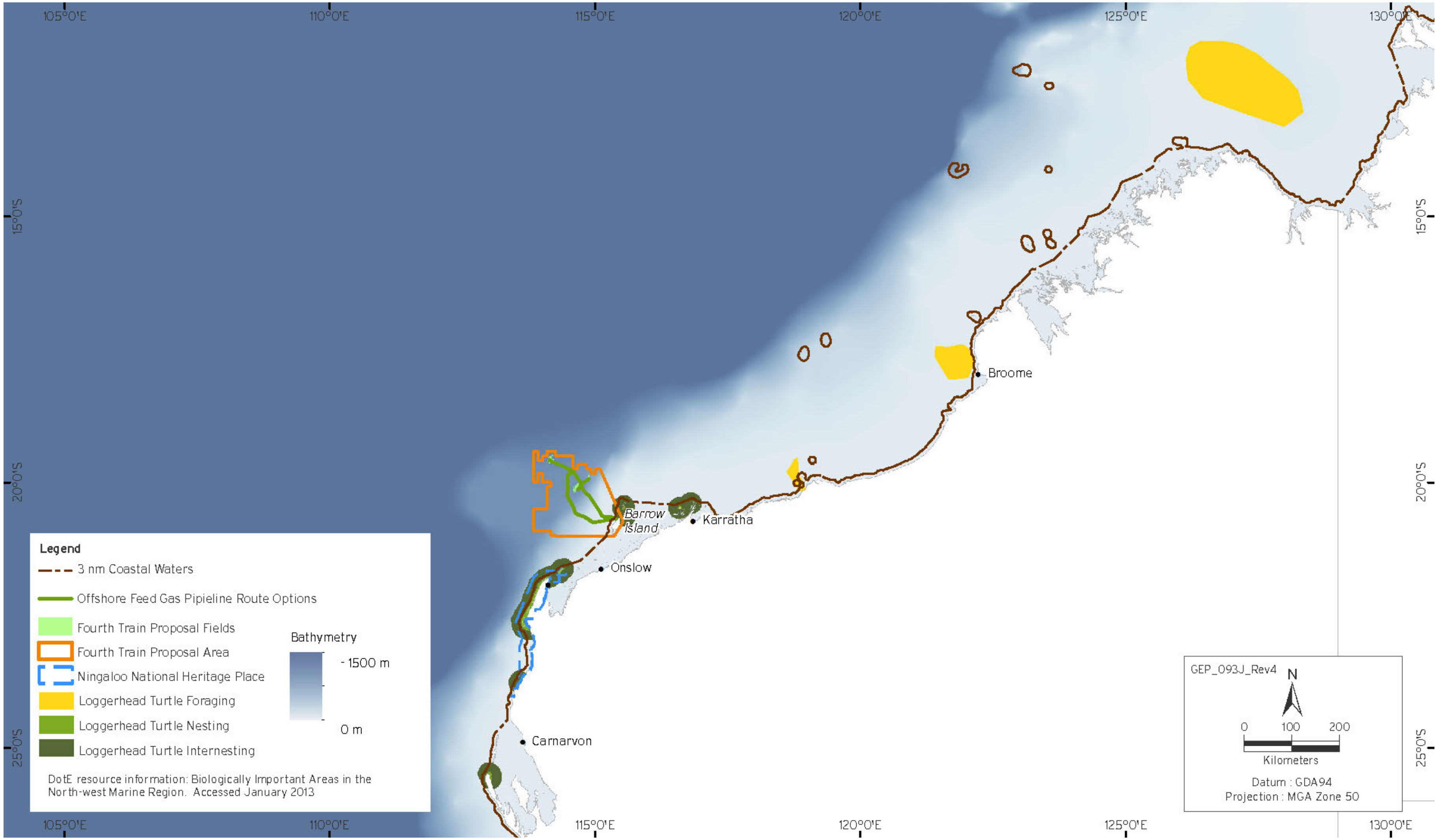


Figure 6-20: Biologically Important Areas for Loggerhead Turtles

6.6.2.3.2 Fourth Train Proposal Area

Barrow Island is a regionally important nesting area for Green Turtles and Flatback Turtles. Sea snakes are generally common in waters west of Barrow Island and in waters between Barrow Island and the mainland. (Chevron Australia 2005).

Flatback Turtle nesting on Barrow Island is concentrated on the mid-east coast on deep, sandy, low-sloped beaches with wide, shallow, intertidal zones (Pendoley 2005) (Figure 6-21). The nesting period for Flatback Turtles extends from October to March, with a peak nesting period in December and January (Pendoley Environmental 2011). Key nesting beaches for the Flatback Turtle occurs on the east coast of Barrow Island, adjacent to the Fourth Train Proposal. The hatching period occurs from January to April, with the peak hatching period in February and March (Chevron Australia 2014e; Figure 6-22). Internesting Flatback Turtles from Barrow Island are known to use the shallow waters between Barrow Island and the mainland (Pendoley Environmental 2010, 2010a).

The Green Turtle reproductive population at Barrow Island is estimated at around 20 000 females (Pendoley 2005), comprising an important proportion of the North West Shelf genetic stock (Prince 1994; Moritz *et al*. 2002). Mating aggregations occur off the west coast of Barrow Island from August to January, with the peak period from September to December (Chevron Australia 2014e). Green Turtles tend to nest on the west, north, and north-east coasts of Barrow Island (Figure 6-21) where beaches are high-energy, deep, steeply sloped, sandy, and have an unobstructed foreshore approach (Pendoley 2005; Chevron Australia 2014e). Turtle surveys have shown that Green Turtle nesting and track activity on North Whites Beach is significantly lower than on other beaches (Pendoley 2005; Pendoley Environmental 2008); an average of approximately five turtle tracks were recorded per night during the same period (Pendoley Environmental 2011).

The nesting period for Green Turtles on the west coast of Barrow Island occurs between October and April and peaks between December and February (Pendoley 2005; Chevron Australia 2012b, 2014e) (Figure 6-22). There are no nesting beaches for Green Turtles in the vicinity of Town Point; the closest nesting beach to WAPET Landing is Bed Beach (Chevron Australia 2014e), approximately 420 m to the north. The Green Turtle hatching period occurs between November and May and peaks in February and March (Chevron Australia 2014e).

Barrow Island is not considered a regionally important nesting site for Hawksbill Turtles. Hawksbill Turtles favour small, shallow beaches typically characterised by coarse-grained sand or coral grit interspersed with rocks and beach wrack for nesting (Chevron Australia 2014e). Records of Hawksbill Turtles nests on Barrow Island have been identified on beaches adjacent to Town Point and the WAPET Landing (Figure 6-21). They are also known to nest at Bobs Beach South, located approximately 30 m south-east of the WAPET Landing, as well as Terminal Beach and Bivalve Beach close to Town Point (Chevron Australia 2014e). The main nesting period for Hawksbill Turtles extends from July to February, with peak nesting time during October and November (Figure 6-22) (Chevron Australia 2014e). The hatching period for Hawksbill Turtles ranges from August to March, with peak hatching during November and December (Chevron Australia 2014e). The mating aggregation period occurs from June to January, with a peak during September and October (Chevron Australia 2014e).

Loggerhead Turtles have been observed feeding in the waters surrounding Barrow Island (Chevron Australia 2005). Occasional nesting on Barrow Island beaches occurs (Chevron Australia 2008), but Loggerhead Turtles typically breed from Dirk Hartog Island to the Muiron Islands. Although uncommon, Leatherback Turtles have been recorded in Barrow Island waters but the Olive Ridley Turtle has not been recorded in Barrow Island waters and on Barrow Island beaches (Chevron Australia 2014e).

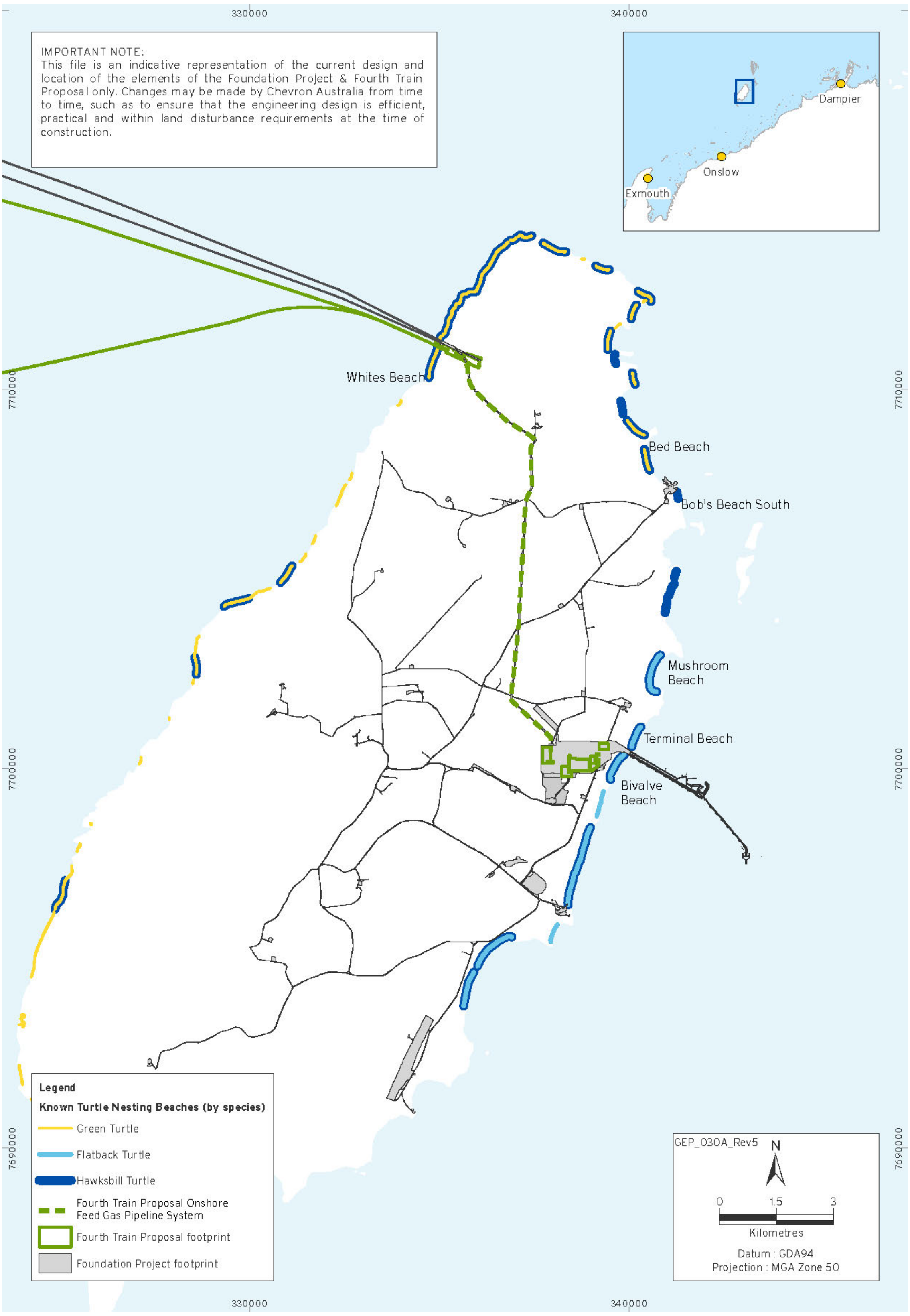
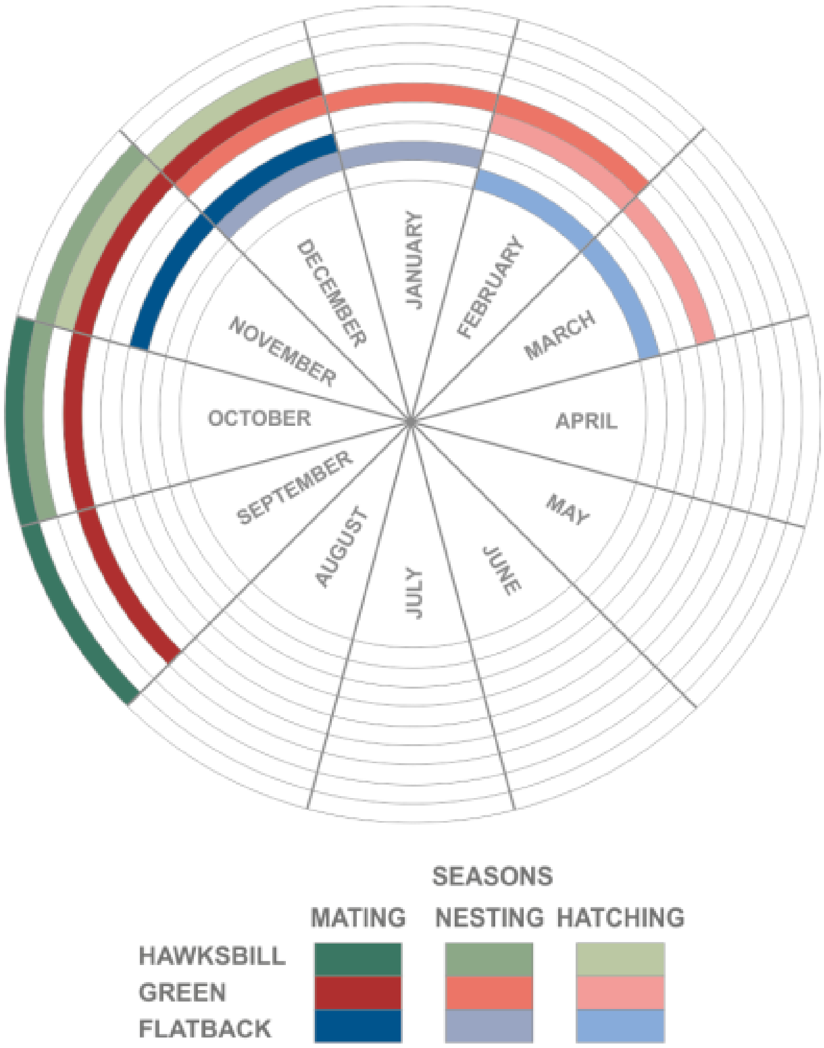


Figure 6-21: Marine Turtle Beach Usage



Source: Chevron Australia 2014e

Figure 6-22: Peak Marine Turtle Mating, Nesting and Hatching Seasons

Table 6-10: Protected Marine Reptiles that may occur in the Vicinity of the Fourth Train Proposal

Common Name	Scientific Name	Status		Presence in Fourth Train Proposal
		Cth[1]	WA[2, 3]	
Flatback Turtle	*Natator depressus*	V, M, Marine	Sch 1[2]	Likely
Green Turtle	*Chelonia mydas*	V, M, Marine	Sch 1[2]	Likely
Loggerhead Turtle	*Caretta caretta*	E, M, Marine	Sch 1[2]	Possible
Leatherback Turtle	*Dermochelys coriacea*	E, M, Marine	Sch 1[2]	Possible
Hawksbill Turtle	*Eretmochelys imbricata*	V, M, Marine	Sch 1[2]	Likely
Short-nosed Sea Snake	*Aipysurus apraefrontalis*	CE, Marine	P4[3]	Possible

Notes:

1 *Status under the EPBC Act: V = Vulnerable; E = Endangered; CE = Critically Endangered; M = Migratory (matters of NES)*

2 *Status under the Wildlife Conservation Act: Sch 1 = Schedule 1: Fauna that is rare or is likely to become extinct*

3 *DPaW Current Threatened and Priority Fauna Ranking: P4 = Priority Four: Taxa in need of monitoring. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.*

Sea snakes are generally common in waters around Barrow Island (Chevron Australia 2005). Although they are highly mobile and can cover large distances, many species are restricted to relatively shallow coastal waters. There are 14 species of sea snake listed as marine under the EPBC Act that may inhabit the Fourth Train Proposal Area (SEWPaC 2011). The Short-nosed Sea Snake may also be present in the vicinity of the Fourth Train Proposal as it has been identified as being present in the region (DEWHA 2008).

6.6.2.4 Marine Avifauna

6.6.2.4.1 Region

The seabird population of the Pilbara Region includes migratory and resident seabirds. Generally, migratory species visit the Pilbara Region from the northern hemisphere or close to the equator and pass through the area on their way southward, or they may stay in the Pilbara Region until ready to journey back to breed (Chevron Australia 2005). Resident species remain in the Pilbara Region throughout the year, but may move around within the region. Seabirds that occur in the North-west Marine Region include terns, noddies, petrels, shearwaters, tropicbirds, frigatebirds, and boobies (SEWPaC 2012d).

The North-west Marine Region is important at an international level, providing extensive non-breeding habitat for migratory shorebirds, predominantly mudflats, sandflats, and beaches (DEWHA 2005). The North-west Marine Region forms part of the East-Asian-Australasian Flyway, which sees the annual migration (during the northern hemisphere summer and autumn) of shorebirds to Australia where they may spend up to six months before returning north to Alaska (SEWPaC 2012d). Thirty-four species of seabird and 30 species of migratory shorebird are known to occur regularly in the North-west Marine Region (SEWPaC 2012d).

Double Island, 1.5 km off the east coast of Barrow Island, is a regionally significant rookery for Bridled Terns (*Onychoprion anaethetus* [previously *Sterna anaethetus*]) and a locally significant rookery site for the Wedge-tailed Shearwater (*Puffinus pacificus*) (Chevron Australia 2005). However, the Wedge-tailed Shearwater rookery is small compared to other rookeries in the immediate region (Chevron Australia 2005). Other species that may nest on Double Island from time to time include the Caspian Tern (*Sterna caspia*), Roseate Tern, and Lesser Crested Tern (*S. bengalensis*) (Burbidge pers. comm. 2008 [cited in Chevron Australia 2014a]).

The Montebello/Lowendal/Barrow Island region has significant rookeries for 15 seabird species (Chevron Australia 2005), including the largest breeding colony of Roseate Terns (*Sterna dougallii*) in WA located on the Montebello Islands. The Montebello Islands have been identified as an Important Bird Area (IBA) for the Roseate Tern and the Fairy Tern; both residents (found all year round) on the islands. The marine waters surrounding the Montebello Islands has been proposed as a candidate IBA through the International Birdlife program and represents a seaward extension to the breeding colonies for foraging activities (Birdlife International 2012).

The Australian Lesser Noddy (*Anous tenuirostris melanops*) is usually only found around its breeding islands in the Houtman Abrolhos Islands. It has a restricted distributional range and is heavily dependent on mangrove forests for nesting (DotE 2014a). The Yellow-nosed Albatross (*Diomedea chlororhynchos*) is rarely seen in Australian waters; it is common between 15°S and 50°S in the southern Atlantic Ocean (DotE 2014a). The Southern Giant Petrel (*Macronectes giganteus*) is widespread throughout the Southern Ocean and in Australia, and breeds on six sub-Antarctic and Antarctic islands in Australian territory (DotE 2014a). The Soft-plumaged Petrel's distribution includes the North-west Marine Region, although it is mainly found further south between 30° and 50°S off the WA coast (Marchant and Higgins 1990). Fairy Terns (*Sternula nereis nereis)* occur on the coast as far north as Dampier Archipelago (Blakers *et al*. 1984; Higgins and Davies 1996). They breed on islands off the north-west coast, in Shark Bay, on the mainland on the shores of Lake McLeod, and at Low Point (SEWPaC 2012d). The White-bellied Sea-Eagle is distributed along the coastline (including offshore islands) off mainland Australia and Tasmania (DotE 2014a).

BIAs (Section 6.6.2) have been identified for ten species of seabird in the North-west Marine Region: Brown Booby, Red-footed Booby, White-tailed Tropic Bird, Great Frigatebird, Lesser Frigatebird, Wedge-tailed Shearwater, Fairy Tern, Lesser Crested Tern, Little Tern, and Roseate Tern. These species use the North-west Marine Region for breeding with a foraging buffer (coastal tidal feeding areas above high tide, including vegetated areas) and for roosting. The Wedge-tailed Shearwater, Fairy Tern, Lesser Crested Tern, and Roseate Tern BIAs overlap the Fourth Train Proposal Area (Figure 6-23 to Figure 6-26) (SEWPaC 2012d).

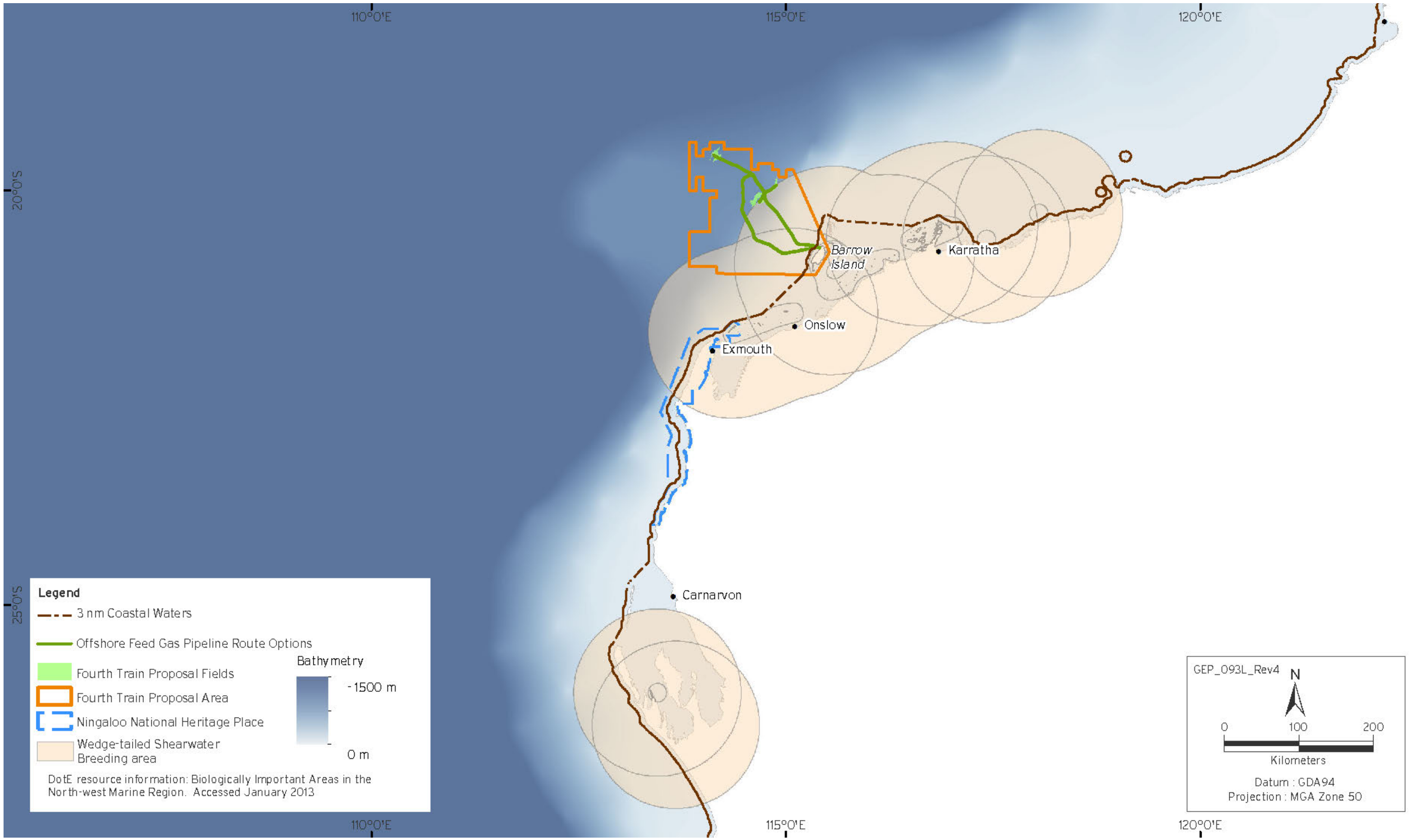


Figure 6-23: Biologically Important Areas for Wedge-tailed Shearwaters

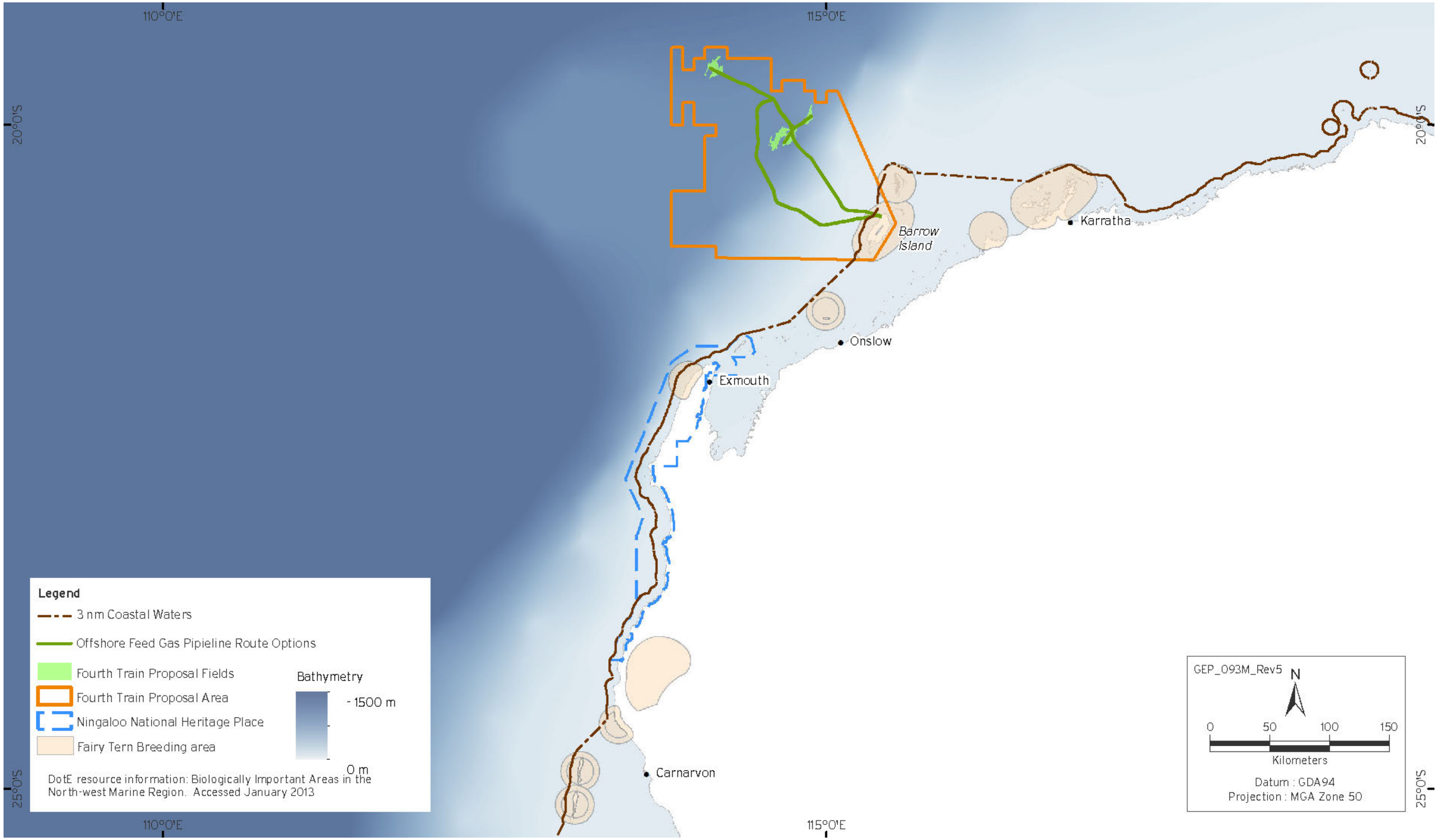


Figure 6-24: Biologically Important Areas for Fairy Terns

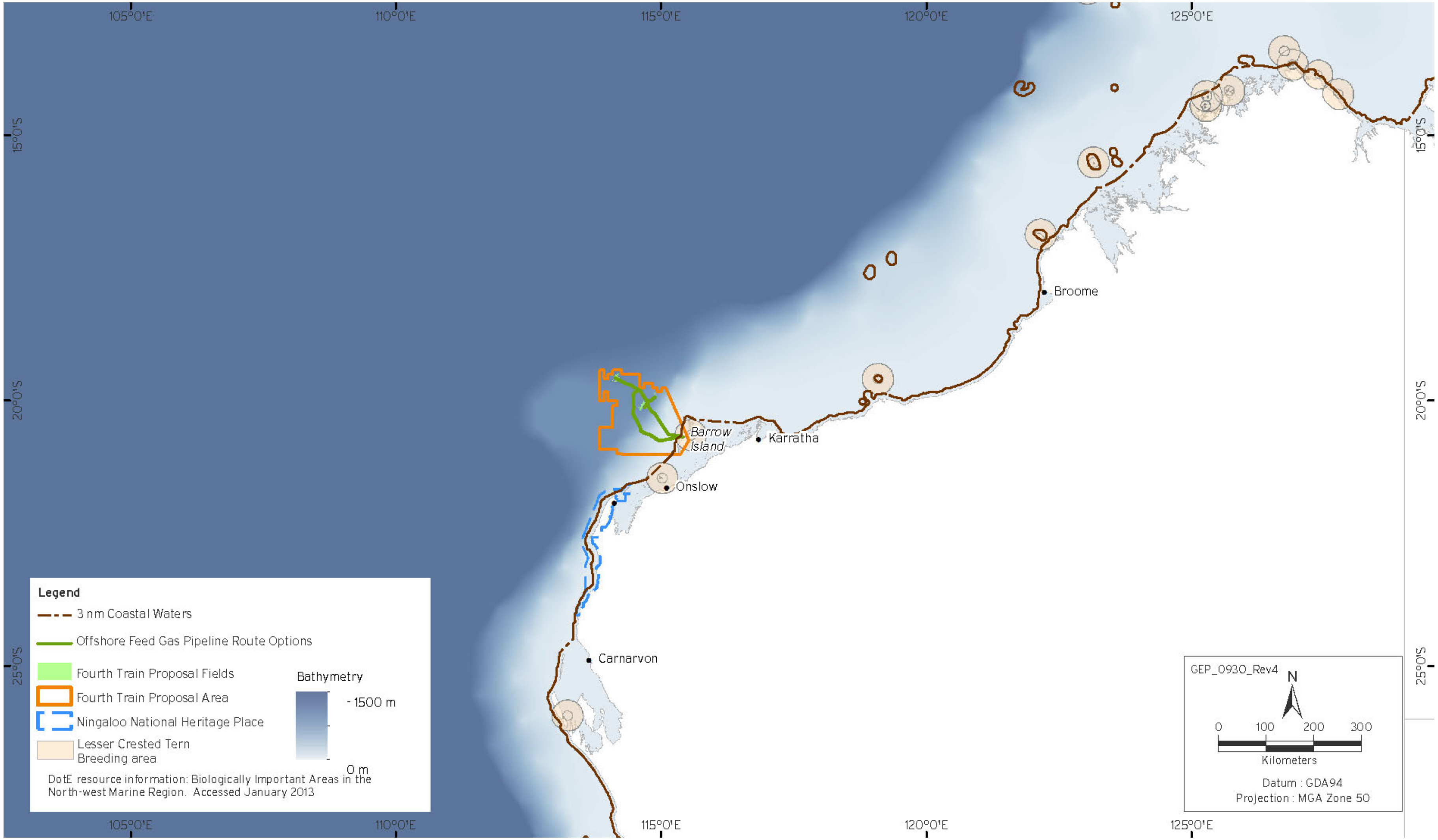


Figure 6-25: Biologically Important Areas for Lesser Crested Terns

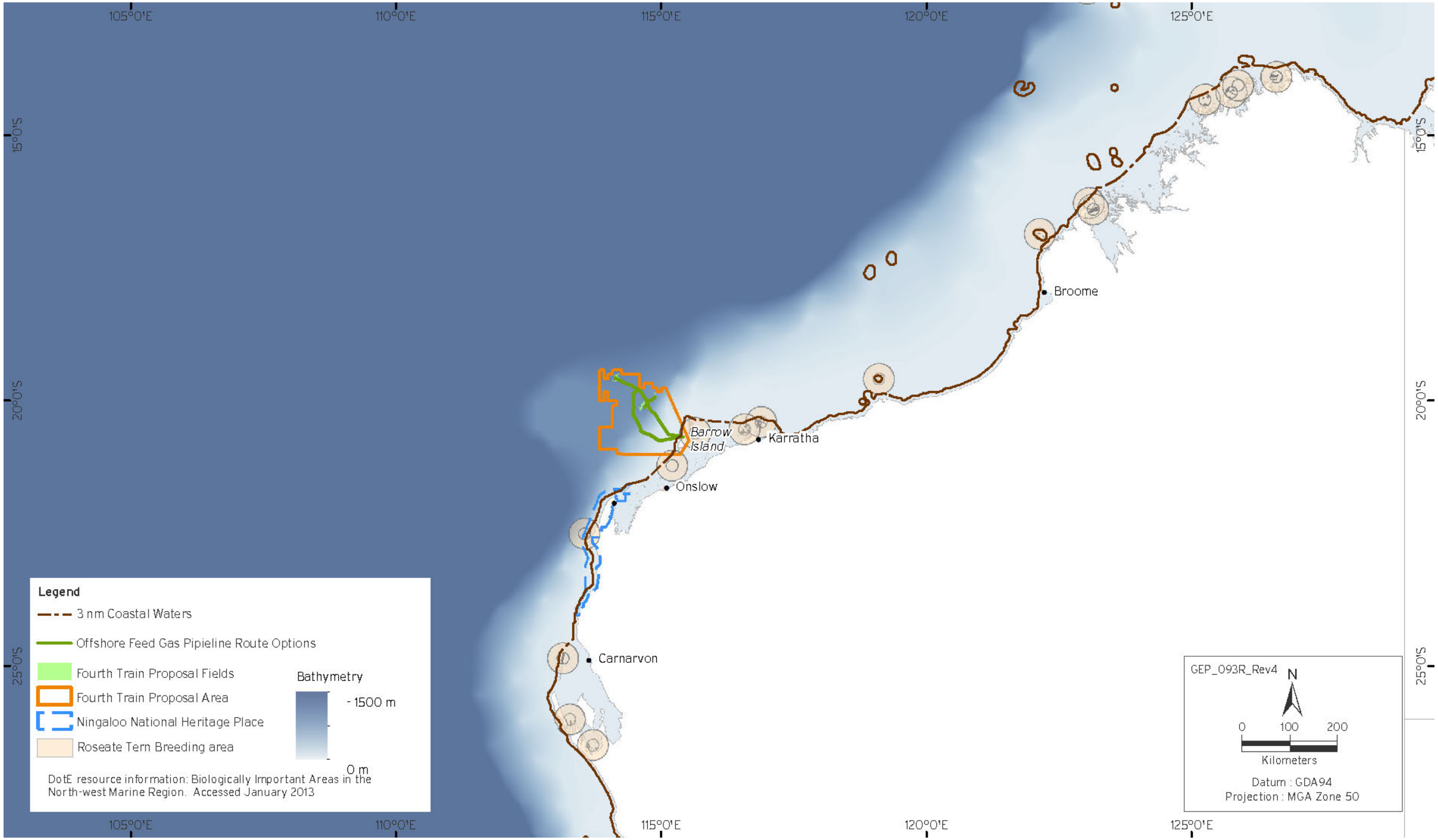


Figure 6-26: Biologically Important Areas for Roseate Terns

6.6.2.4.2 Fourth Train Proposal Area

Studies suggest that Barrow Island is both a staging site (an area where migrating birds gather to feed before continuing on their migration) and an important non-breeding site for migratory shorebirds (Bamford and Moro 2011a).

Barrow Island is an internationally significant site for six migratory species (Ruddy Turnstone [*Arenaria interpres*], Sanderling [*Calidris alba*], Red-necked Stint [*Calidris ruficollis*], Grey-tailed Tattler [*Tringa brevipes*], Greater Sand Plover [*Charadrius leschenaultia*], and Lesser Sand Plover [*Charadrius mongolus*]) and two non-migratory species (Fairy Tern [*Sternula nereis nereis*] and Sooty Oystercatcher [*Haematopus fuliginosus*]). Barrow Island is a designated IBA within the East Asian-Australasian Flyway as it supports the IBA criterion for congregations of Red-necked Stint and more than 1% of a biogeographic population of Red-necked Stint (2.4% of known population), Grey-tailed Tattler (6.6% of known population), Ruddy Turnstone (5.5% of known population) and Greater Sand Plover (Bamford and Moro 2011a; Chevron Australia 2005c). Barrow Island is a regionally significant site for Fairy Terns, with nesting sites identified at Cape Dupuy (north coast of Barrow Island) (Chevron Australia 2005c). Although Barrow Island is an internationally significant site for the Sooty Oystercatcher, this species is not listed under the EPBC Act or the Wildlife Conservation Act and therefore is not included in Table 6-11.

The highest abundances of shorebirds occur on the south-eastern and southern coasts of Barrow Island, from the existing Chevron Australia Camp to Bandicoot Bay (Chevron Australia 2005; Bamford and Moro 2011a). These areas contain an extensive intertidal sand/mudflat habitat and intertidal reef platform, thus providing a suitable foraging habitat (Chevron Australia 2005; Bamford and Moro 2011a).

North Whites Beach is a high-energy beach and does not provide significant shorebird habitat. The abundance of shorebirds is low in the vicinity of the Fourth Train Proposal horizontal directional drilling site, although birds are likely to use the area as seasonal roosts (Chevron Australia 2005). On the east coast, Town Point and the WAPET Landing do not provide significant shorebird habitat. A small portion of the shorebirds on Barrow Island forage on the reef platforms around Town Point (Chevron Australia 2005c). Nesting sites of Sooty Oystercatchers were observed in Cape Dupuy (north coast of Barrow Island) (Chevron Australia 2005c).

Due to its restricted distribution range and dependency on one type of habitat (mangrove forests) for nesting it is unlikely that the Australian Lesser Noddy will be present in the Fourth Train Proposal Area. The Yellow-nosed Albatross is rarely seen in Australian waters (DotE 2014a) and therefore, it is unlikely that they will be present in the Fourth Train Proposal Area. The Southern Giant Petrel occurs in Antarctic to subtropical waters (DotE 2014a), and may occur within the Fourth Train Proposal Area. The Soft-plumaged Petrel is common in West Australian waters and may occur within the Fourth Train Proposal Area (DotE 2014a). Fairy Terns will likely be present within the Fourth Train Proposal Area because Barrow Island is a regionally significant site (Chevron Australia 2005c). The White-bellied Sea-Eagle species is a breeding resident throughout much of its range in Australia and occurs and nests in a variety of locations around Barrow Island. No nests are currently present in areas to be cleared as part of the Fourth Train Proposal Footprint.

Silver Gulls are present on Barrow Island, with a higher number of gulls present on the west coast than on the east coast. Higher numbers of Silver Gulls present during the summer period coincides with the turtle egg-laying and hatchling period, gulls predate marine turtle hatchlings and scavenge eggs when nests are excavated by Perenties. There are no records of Silver Gulls breeding on Barrow Island, although breeding colonies of Silver Gulls are present on Middle Island and Lowendal Islands (Surman and Nicholson 2010).

Many of these species are protected under international treaties (e.g. Japan–Australia Migratory Bird Agreement [JAMBA], China–Australia Migratory Bird Agreement [CAMBA], Republic of Korea–Australia Migratory Bird Agreement [ROKAMBA]), and Commonwealth and State legislation, such as the EPBC Act and the Wildlife Conservation Act (Table 6-11).

Table 6-11: Protected Marine Avifauna that may occur in the Vicinity of the Fourth Train Proposal Area

Common Name	Scientific Name	Status		Presence in Vicinity of Fourth Train Proposal Area
		Cth[1]	WA[2, 3]	
Australian Lesser Noddy	*Anous tenuirostris melanops*	V, Marine	Sch 1[2]	Possible
Fork-tailed Swift	*Apus pacificus*	M, Marine	Sch 3[2]	Possible
Great Egret	*Ardea (Egretta) alba*	M, Marine		Possible
Eastern Reef Egret	*Ardea (Egretta) sacra*	M, Marine	Sch 3[2]	Likely
Ruddy Turnstone	*Arenaria interpres*	M, Marine	Sch 3[2]	Likely
Sharp-tailed Sandpiper	*Calidris acuminata*	M, Marine	Sch 3[2]	Likely
Sanderling	*Calidris alba*	M, Marine	Sch 3[2]	Likely
Red Knot	*Calidris canutus*	M, Marine	Sch 3[2]	Likely
Curlew Sandpiper	*Calidris ferruginea*	M, Marine	Sch 1[2]	Likely
Red-necked Stint	*Calidris ruficollis*	M, Marine	Sch 3[2]	Likely
Great Knot	*Calidris tenuirostris*	M, Marine	Sch 1[2]	Possible
Greater Sand Plover	*Charadrius leschenaultia*	M, Marine	Sch 3[2]	Likely
Lesser Sand Plover	*Charadrius mongolus*	M, Marine	Sch 1[2]	Likely
Oriental Plover	*Charadrius veredus*	M, Marine	Sch 3[2]	Possible
White-winged Black Tern	*Chlidonias leucoptera*	M, Marine	Sch 3[2]	Likely
Yellow-nosed Albatross	*Thalassarche chlororhynchos*	V, M, Marine		Possible
Lesser Frigatebird	*Fregata ariel*	M, Marine	Sch 3[2]	Possible
Oriental Pratincole	*Glareola maldivarum*	M, Marine	Sch 3[2]	Possible
White-throated Needletail	*Hirundapus caudacutus*	M, Marine	Sch 3[2]	Possible
Bar-tailed Godwit	*Limosa lapponica*	M, Marine	Sch 3[2]	Likely
Black-tailed Godwit	*Limosa limosa*	M, Marine	Sch 3[2]	Possible
Southern Giant Petrel	*Macronectes giganteus*	E, M, Marine	Sch 1[2]	Possible
Eastern Curlew	*Numenius madagascariensis*	M, Marine	Sch 3[2], P4[3]	Possible
Little Curlew	*Numenius minutus*	M, Marine	Sch 3[2]	Possible
Whimbrel	*Numenius phaeopus*	M, Marine	Sch 3[2]	Possible
Wilson's Storm Petrel	*Oceanites oceanicus*	M, Marine	Sch 3[2]	Possible
Bridled Tern	*Onychoprion anaethetus* (previously *Sterna anaethetus)*	M, Marine	Sch 3[2]	Likely
Osprey	*Pandion cristatus*	M, Marine		Likely

Common Name	Scientific Name	Status		Presence in Vicinity of Fourth Train Proposal Area
		Cth[1]	WA[2, 3]	
Pacific Golden Plover	*Pluvialis fulva*	M, Marine	Sch 3[2]	Likely
Grey Plover	*Pluvialis squatarola*	M, Marine	Sch 3[2]	Likely
Soft-plumaged Petrel	*Pterodroma mollis*	V, Marine		Possible
Wedge-tailed Shearwater	*Puffinus pacificus*	M, Marine	Sch 3[2]	Likely
White-bellied Sea-Eagle	*Haliaeetus leucogaster*		Sch 3	Likely
Little Tern	*Sterna albifrons*	M, Marine		Likely
Lesser Crested Tern	*Sterna bengalensis*	M, Marine	Sch 3[2]	Likely
Caspian Tern	*Sterna caspia*	M, Marine	Sch 3[2]	Likely
Roseate Tern	*Sterna dougallii*	M, Marine	Sch 3[2]	Likely
Common Tern	*Sterna hirundo*	M, Marine	Sch 3[2]	Likely
Fairy Tern (Australian)	*Sternula nereis nereis*	V		Likely
Oriental Pratincole	*Stiltia maldivarum*	M, Marine		Possible
Masked Booby	*Sula dactylatra*	M, Marine	Sch 1[2], Sch 3[2]	Possible
Brown Booby	*Sula leucogaster*	M, Marine	Sch 3[2]	Possible
Grey-tailed Tattler	*Tringa brevipes*	M, Marine		Likely
Wood Sandpiper	*Tringa glareola*	M, Marine	Sch 3[2]	Possible
Common Sandpiper	*Tringa hypoleucos*	M, Marine		Possible
Common Greenshank	*Tringa nebularia*	M, Marine	Sch 3[2]	Likely
Marsh Sandpiper	*Tringa stagnatalis*	M, Marine	Sch 3[2]	Possible
Terek Sandpiper	*Xenus cinerea (Tringa terek)*	M, Marine	Sch 3[2]	Possible

Notes:

1 Status under the EPBC Act: V = Vulnerable; E = Endangered; CE = Critically Endangered; M = Migratory (matters of NES)

2 Status under the Wildlife Conservation Act: Sch 1 = Schedule 1: Fauna that is rare or is likely to become extinct; Sch 3 = Schedule 3: Migratory birds protected under an international agreement

3 DPaW Current Threatened and Priority Fauna Ranking: P4 = Priority Four: Taxa in need of monitoring. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.

6.7 Protected Areas

6.7.1 Montebello/Barrow Islands Marine Conservation Reserves

The Montebello/Barrow Islands Marine Conservation Reserves comprises three separately vested reserves, namely the Montebello Islands Marine Park (58 331 ha), Barrow Island Marine Park (4169 ha) and Barrow Island Marine Management Area (114 693 ha), which were gazetted in 2004 (DEC 2007). The Montebello/Barrow Islands Marine Conservation Reserves also includes a number of islands that are vested in the Conservation Commission and managed by DPaW. These include the Barrow Island Nature Reserve; Montebello Islands Conservation Park; Boodie, Double and Middle Islands Nature Reserve; and the Lowendal Islands Nature Reserve (Figure 6-27).

Barrow Island has been reserved since 1910 under the Western Australian *Conservation and Land Management Act 1984* (CALM Act) as a Class A nature reserve. The Boodie, Double, and Middle Islands Nature Reserve was gazetted in 1984 (Reserve 38728, other than Class A) and covers an area of 586.7 ha. Both reserves extend to the low water mark and are set aside for the 'conservation of flora and fauna'. They are collectively known as the Barrow Group, and are zoned 'Conservation, Recreation and Nature Land' under the Shire of Ashburton Town Planning Scheme No. 7. The Barrow Island Marine Management Area is listed on the Western Australian Register of Heritage Places and these Conservation Reserves are also reserved under the CALM Act.

Approximately 49% of the Montebello Islands Marine Park and 100% of the Barrow Island Marine Park are zoned as 'sanctuary zones' which prohibits a range of activities occurring within the sites boundaries.

The Barrow Island Marine Park and Barrow Island Marine Management Area adjoin Barrow Island (Figure 6-27). The Barrow Island Marine Park is a significant rookery for marine turtles and also contains an extensive subtidal reef system, Biggada Reef. The Barrow Island Marine Management Area is largely an unzoned area, enabling a range of activities to occur within its boundaries, except for the Bandicoot Bay Conservation Area on the south coast of Barrow Island. This area contains extensive mudflats and is noted for its importance to benthic fauna and avifauna that use this area.

The Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves (2007–2017) sets out a vision and series of key ecological and social values to aid the management of the area. Ecological values are set out in Table 6-12 and cover a range of values associated with the complex geomorphology of the area, sediment and water quality, BPPH and the diversity of marine fauna which are resident or migrate to the islands (DEC 2007).

The social values of these conservation areas include hydrocarbon exploration and production, pearling, nature-based tourism, commercial fishing, recreational fishing, water sports, European history/maritime heritage, and scientific research (DEC 2007). Many of these social values are highly dependent upon the maintenance of these ecological values. Except for Barrow Island (which does not have public access on land), the conservation areas attract visitors who participate in activities such as fishing, diving, wildlife viewing, island exploration, and surfing. Visitor numbers to the conservation areas are low and are concentrated around the Montebello Islands, with activities around Barrow Island being rare (DEC 2007).

Table 6-12: Ecological Values of the Montebello/Barrow Islands Marine Conservation Reserves

Value	Description
Geomorphology	A complex seabed and island topography consisting of subtidal and intertidal reefs, sheltered lagoons, channels, beaches, and cliffs.
Sediment Quality	The sediments of the reserves are generally pristine, which is essential to the maintenance of healthy marine reserves.
Water Quality	The waters of the reserves are generally pristine, which is essential to the maintenance of healthy marine reserves.
Coral Reef Communities	Undisturbed intertidal and subtidal coral reefs and bombora, with a high diversity of hard corals.

Value	Description
Mangrove Communities	Six species of mangrove are found in the reserves, with the Montebello Islands mangrove communities considered globally unique as they occur in lagoons of offshore Islands.
Macroalgal and Seagrass Communities	Extensive subtidal macroalgal and seagrass communities are important primary producers and refuge areas for fishes and invertebrates.
Rocky shore/intertidal reef platform communities	Rocky shores predominate on most of the islands of the reserves and provide habitat for a variety of intertidal organisms, which in turn provide food for shorebirds.
Intertidal sand/mudflat communities	The intertidal sand/mudflat communities are primary producers with an abundant invertebrate fauna, which provides a valuable food source for shorebirds.
Subtidal soft-bottom communities	Subtidal sand and silt habitats support a variety of fauna including burrowing invertebrates and filter-feeding communities
Marine Mammals	Ten species of cetacean are recorded from the reserves, with the Humpback Whale passing through the area during its annual migration. Dugongs are found in the shallow warm waters.
Turtles	Green, Flatback, Hawksbill, Loggerhead, and Leatherback Turtles are found in the reserves, with the Western Australian Hawksbill Turtle population being the largest remaining in the Indian Ocean. Four species use sandy beaches in the reserves for nesting.
Seabirds	The reserves provide important feeding and resting areas for migrating shorebirds. Islands within the reserves are nesting areas for 15 species of seabird.
Finfish	A rich finfish fauna with at least 456 species.
Invertebrates	A diverse marine invertebrate fauna comprising mostly tropical species.

Source: DEC 2007

6.7.1.1 Montebello Commonwealth Marine Reserve

The Commonwealth has gazetted the Montebello Commonwealth Marine Reserve north-west of Barrow Island in 2012 (Figure 6-27); an area of approximately 3413 km^2, with depths ranging from approximately 15 m to 150 m (Figure 6-27).

The key ecological feature of the reserve is the ancient coastline, which is a unique seafloor feature that provides areas of enhanced biological productivity. The area may act as a foraging area for migratory seabirds and marine turtles, and also includes part of the migratory pathway of the Humpback Whale (SEWPaC 2012e).

The reserve includes shallow shelf environments and provides protection for shelf and slope habitats, as well as pinnacle and terrace seafloor features. The rocky reef occurring at approximately 12 km from Barrow Island (Section 6.6.1.2.2) is located within the reserve. It is a Multiple Use Zone – International Union for Conservation of Nature (IUCN) Category VI (SEWPaC 2012e).

6.7.2 Ningaloo Marine Park and Muiron Islands Marine Management Area

Further afield, the Ningaloo Marine Park (State Waters) and Muiron Islands Marine Management Area have also been established as reserves under the CALM Act. There is also an adjacent Commonwealth managed component to the Ningaloo Marine Park, established under the EPBC Act, and which extends the Ningaloo Marine Park into the Commonwealth Marine Area (Figure 6-27).

The Ningaloo Marine Park, a ‘Class A’ reserve, is located off the North West Cape of Western Australia (Figure 6-27). The Commonwealth component of the Park is assigned an IUCN Category II – National Park: Protected Area Managed Mainly for Ecosystem Conservation and

Recreation. The State component is classified as IUCN Category VI – Managed Resource Protected Areas: Protected Area Managed Mainly for the Sustainable Use of Natural Ecosystems. At its closest point, the northern boundary of the Ningaloo Marine Park is approximately 80 km south-west of the Fourth Train Proposal Area and 130 km south-west of Barrow Island. The Ningaloo Marine Park extends for about 300 km, north of the town of Exmouth and covers an area of approximately 263 300 ha. It is located within a 40 m strip above the high water mark in State Waters, and includes Ningaloo Reef, the largest fringing reef in Australia (CALM 2005). The Ningaloo Marine Park is characterised by a diverse range of habitats including coral reef and mangrove systems. The Ningaloo Marine Park is internationally recognised for its annual aggregations of Whale Sharks (CALM 2005), which number between 400 and 500 individuals and which occur from March to June each year. The Ningaloo Marine Park is also an important area of Aboriginal heritage and nature-based tourism (CALM 2005).

The Muiron Islands Marine Management Area, located adjacent to the north-east boundary of the Ningaloo Marine Park, covers an area of approximately 28 600 ha. Three conservation areas for flora and fauna protection have been established in the Muiron Islands Marine Management Area. These conservation areas cover approximately 7% of the Marine Management Area; the remaining 93% of the total area is unclassified (CALM 2005).

6.7.3 The Ningaloo Coast

At the time the referral decision was made for the Fourth Train Proposal, the Ningaloo Coast was National Heritage listed, and had not been World Heritage Listed. As a result, the Ningaloo Coast was included in the Tailored Guidelines for the Fourth Train Proposal (SEWPaC 2011a) as a National Heritage place and is addressed as such within this document.

The Ningaloo Coast (Figure 6-27) was included in the National Heritage List on 6 January 2010. Places listed in the National Heritage List are protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The Ningaloo Coast Heritage Place is noted for its exceptional natural qualities and Aboriginal significance (SEWPaC 2011b). The site includes the Ningaloo fringing reef, the associated limestone karst system and important archaeological sites within its boundaries.

The Ningaloo fringing reef forms an almost continuous barrier for 300 km, enclosing an offshore lagoon that varies from a couple of hundred metres to up to 7 km wide. It represents one of the largest and structurally complex fringing reefs in the world. The site is important for its biological diversity (SEWPaC 2011b).

The terrestrial features of the Ningaloo Coast include a limestone karst system and associated habitats and a high level of terrestrial species endemism, particularly for birds and reptiles (on the Cape Range Peninsula). Cape Range Peninsula supports the highest diversity of cave fauna in Australia and one of the highest in the world. Most of these species are rare, taxonomically diverse, and are not found elsewhere in the southern hemisphere (DEC 2012a).

The Ningaloo Coast also has important social and cultural values to society. Rock shelters on Cape Range have been sites for the discovery of Aboriginal archaeological deposits (shell beads dated at 32 000 years old), making it an important place for Aboriginal cultural reasons. Intrinsic value placed on the area relates to the aesthetics, recreation and ecosystem value. It is an important area for nature-based tourism in the region with activities including charter vessel tours for snorkelling, diving, recreational fishing, mud crabbing, island tours and a limited amount of surfing. Nearby coastal towns provide holiday accommodation and a variety of recreational activities including off-road driving, helicopter flying tours, chartered flights, hiking, snorkelling, surfing, diving, sailing and charter fishing (DEC 2012a).

In June 2011, the Ningaloo Coast was included on the World Heritage List as one of the outstanding natural places in the world (United Nations Educational, Scientific and Cultural Organization [UNESCO] 2011). The boundary of the Ningaloo Coast World Heritage Area extends over 604 500 ha (DEC 2012a) and is marginally different from the boundary of the

Ningaloo Coast inscribed under the National Heritage List. However, the values for which the Ningaloo Coast were inscribed are broadly similar, with the main geographic differences in the boundary determinations being inland.

The Ningaloo Coast World Heritage Area was selected for its mostly intact and large-scale marine, coastal, and terrestrial environments and the large aggregations of Whale Sharks. In addition, high marine diversity is supported in this World Heritage Area, which has important aggregations of reef fish species (700 reef fish species) and marine mammals, more than 300 coral species, 600 crustacean species, and 1000 marine algae species. Four marine turtle species nest in this World Heritage Area, with approximately 10 000 nests deposited annually (SEWPaC 2011b). The Dugong is found in the waters of the Ningaloo Coast. A large community of about 1000 Dugongs feeds in the waters of the inshore lagoon (SEWPaC 2010).

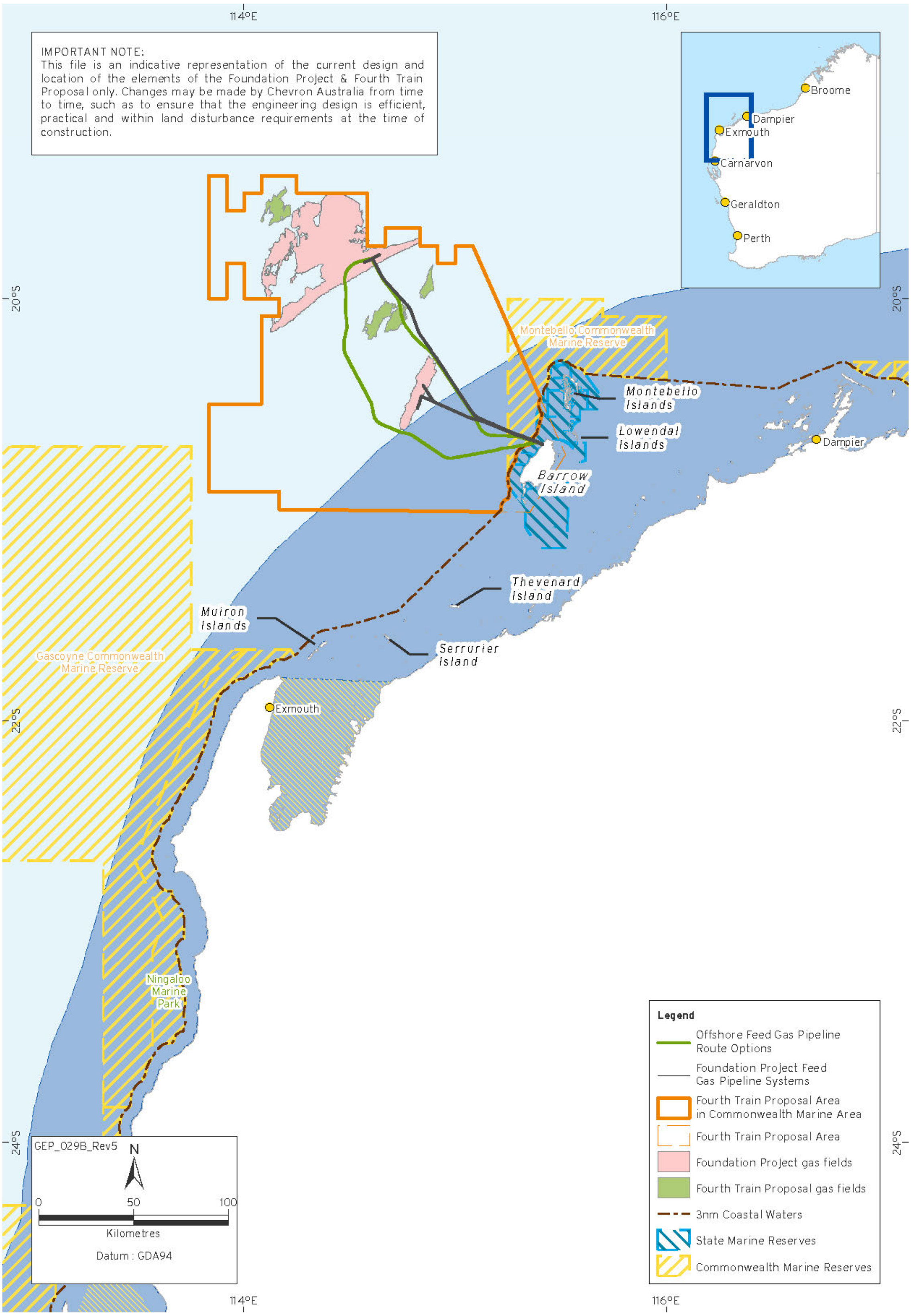


Figure 6-27: Marine Protected Areas in the Vicinity of the Fourth Train Proposal Area

6.8 Social, Cultural, and Economic Baseline

This Section describes the status of the social, cultural, and economic baseline (social baseline) to this PER/Draft EIS and describes the characteristics of each factor, particularly how it relates to the Fourth Train Proposal. The social baseline for the Fourth Train Proposal is the operational and approved Foundation Project and existing WA Oil operations. The approved

Foundation Project is currently under construction and is expected to be operational by the time construction of the Fourth Train Proposal begins.

6.8.1 Public Health and Safety

Barrow Island is located in a remote location, and its workforce (construction and operation) is accommodated on Barrow Island on a fly-in, fly-out basis from Perth and other regional centres, having minimal interaction with mainland communities in the Pilbara Region. The exception to this are the workers at the mainland supply base who reside in nearby communities and would ordinarily access local health facilities. There is no public access to Barrow Island.

6.8.2 Workforce Health and Safety

Chevron's Corporation's OEMS focuses on protecting the health and safety of people and the environment, with an emphasis on safe, reliable, efficient, and environmentally sound operations.

Workforce health and safety issues are managed through Chevron's OEMS and Health, Environment and Safety Policy (Policy 530) (Section 1.7). Chevron Australia's OEMS provides a systematic approach to safety, the environment, reliability and efficiency, and is fundamental to workforce health and safety.

Barrow Island is equipped with emergency response and basic medical services, which have been improved as a result of the approved Foundation Project construction activities. Most medical services for workers at the mainland supply bases are provided by their local community. The workforce on Barrow Island has access to other services and facilities to support their wellbeing and mental health, such as recreational, sport, and social activities (e.g. gymnasium, swimming pool, and private communication facilities).

6.8.3 Cultural Heritage

6.8.3.1 Aboriginal Cultural Heritage

Barrow Island occupies a potentially important position in the Aboriginal archaeology of north-western and continental Australia. It is located between the Cape Range Peninsula (mainland) and the Montebello Islands, both of which were initially occupied by Aboriginal people some 34 200 to 1050 years Before Present (BP) at Cape Range, and 27 220 to 650 years BP at the Montebello Islands. The presence of two areas on either side of Barrow Island with such long occupation records suggests that Barrow Island may also contain Aboriginal archaeological material in both rock shelters and possibly in stratified sites in sand dunes (Bowdler 1999, Morse 1988, Morse 1993; Przywolnik 2002; Quartermaine Consultants 1994, Veth 1994, Veth *et al.* in press cited in Chevron Australia 2005; Veitch and Warren 1992).

The Western Australian Department of Aboriginal Affairs' (DAA) Register of Aboriginal Sites (the Register) indicates 17 archaeological sites, all of which are artefact scatters except for one rock shelter, listed for Barrow Island (DAA 2014). No ethnographic sites are listed. Archaeologists, anthropologists, and Aboriginal stakeholders examined and surveyed areas associated with the approved Foundation Project and the Fourth Train Proposal from 2006 to 2010. A 2009 survey identified an archaeological site near the eastern end of the approved Foundation Project horizontal directional drilling site (Figure 6-28) (Archae-Aus 2009). This site is located outside the Fourth Train Proposal Footprint. To date, surveys conducted on Barrow Island have not identified any sites (including ethnographic and historical sites) within the approved Foundation Project Footprint or the Fourth Train Proposal Footprint on Barrow Island.

Traditional hunting of fauna by a person of Aboriginal descent is permitted in accordance with the Wildlife Conservation Act. Anecdotal evidence suggests that although turtles and Dugongs are occasionally caught for large family occasions, hunting in the region is minimal (DEC 2007).

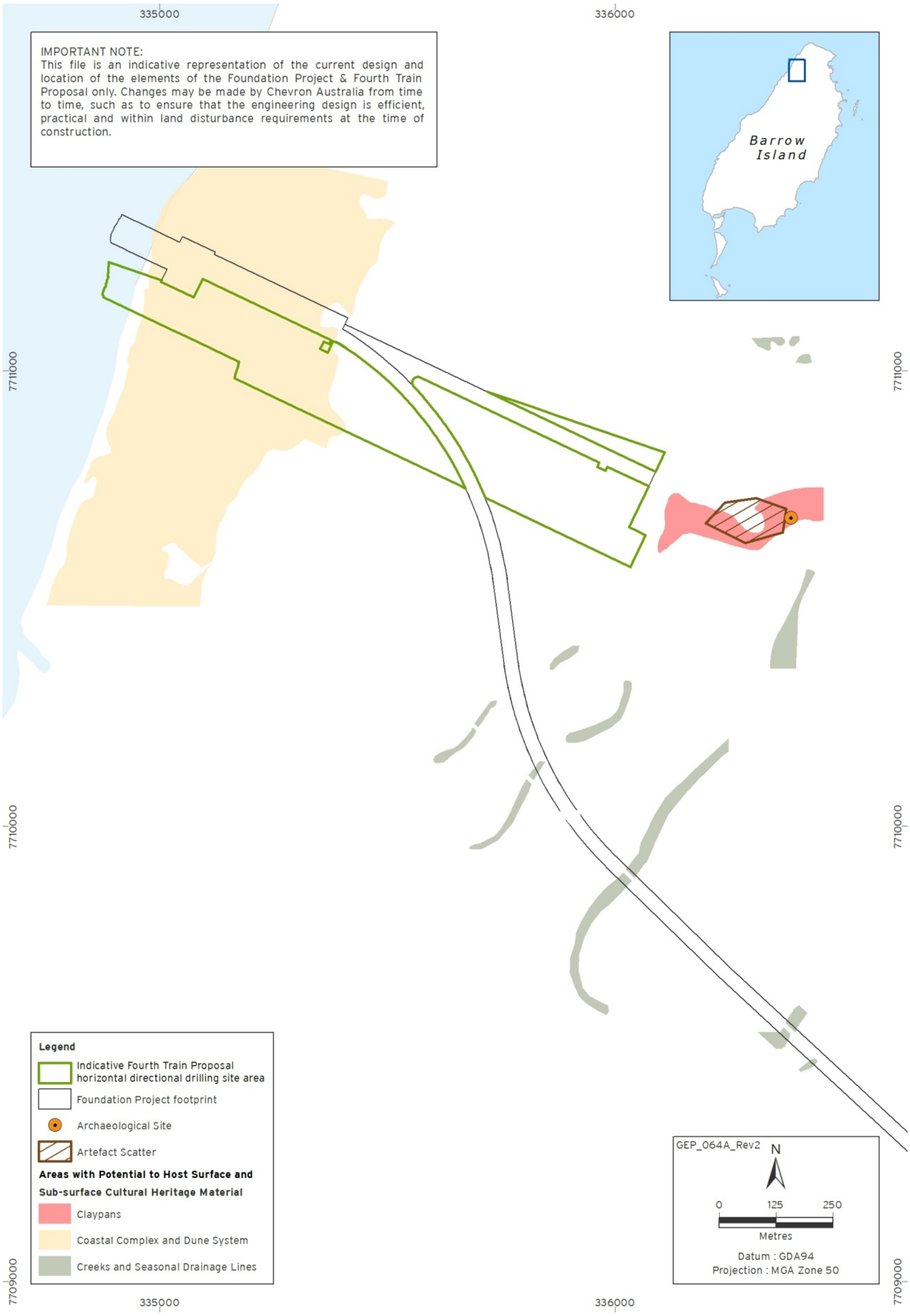


Figure 6-28: Identified Archaeological Site near the Fourth Train Proposal Horizontal Directional Drilling Site

6.8.3.2 Maritime Cultural Heritage

Archival sources suggest that a number of significant vessels have been lost in the Barrow Island region, with the potential for lugger shipwreck sites in the vicinity of Barrow Island. The Australian National Shipwreck Database listed seven shipwrecks within the Montebello/Barrow islands region and the Western Australia Museum identified a further three wrecks. The earliest known shipwreck of European origin within Australian waters (*The*

Trial, wrecked around 1622) is located approximately 45 km north of Barrow Island. The locations of known shipwrecks are shown in Figure 6-29.

The Materials Offloading Facility and shore areas adjacent to the approved Foundation Project Gas Treatment Plant site were examined by a marine heritage expert and no shipwreck sites were discovered (Chevron Australia 2005). Surveys conducted in 2007 and 2008 along the approved Foundation Project pipeline route for the Offshore Feed Gas Pipeline Installation Management Plan have not revealed the presence of any shipwreck material (Chevron Australia 2014d). Marine underwater video survey work and reviews of the side-scan sonar results support this (Chevron Australia 2005).

6.8.3.3 Native Title

The Western Australian High Court in the Ward Case (August 2002) held that vesting of Barrow Island reserves under the *Land Act 1933* (WA) (now the *Land Administration Act 1997* (WA)) and as a Class A nature reserve has extinguished Native Title. There are no lodged Native Title claims or anticipated claims over Barrow Island's surrounding waters.

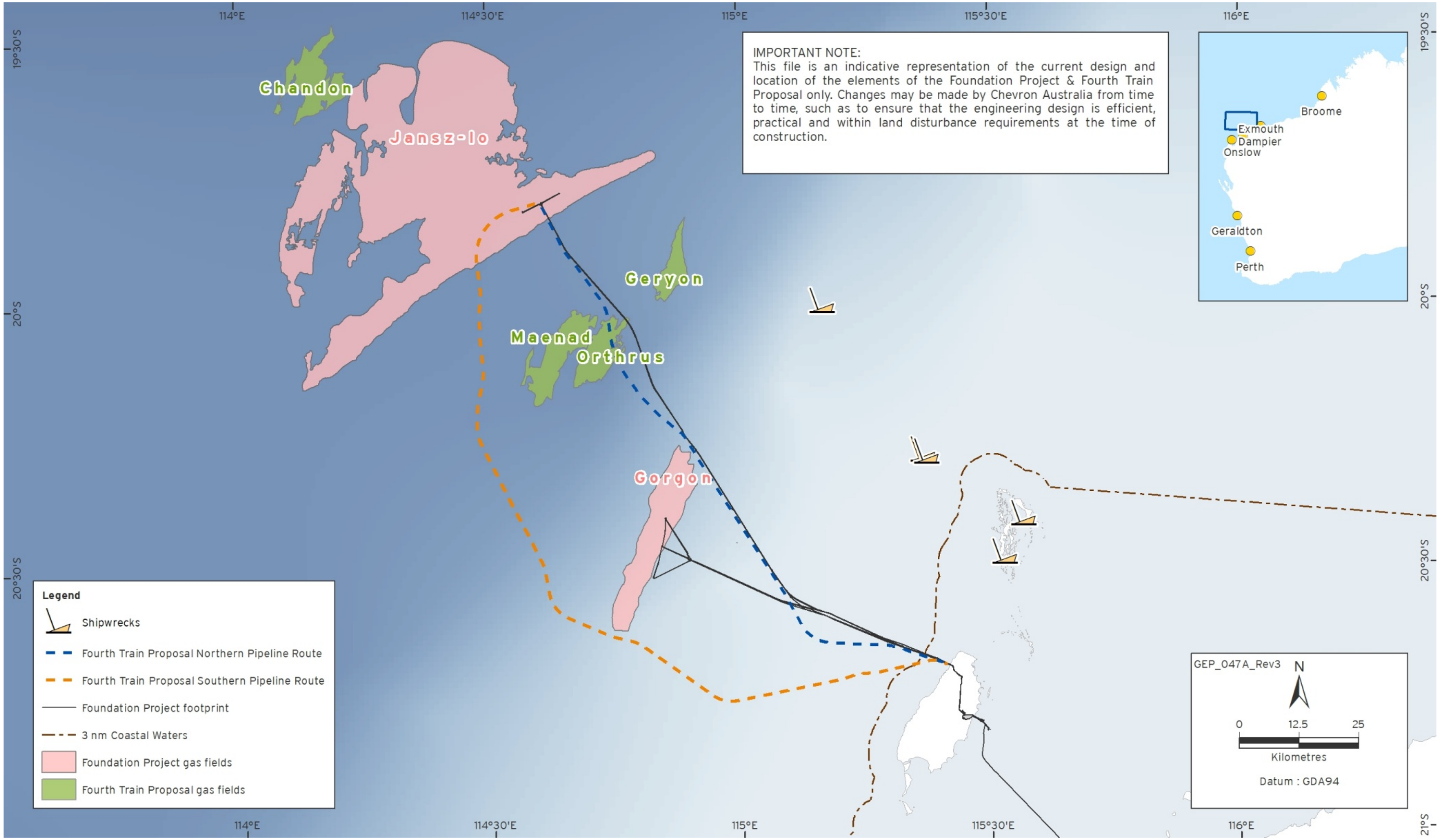


Figure 6-29: Identified Shipwrecks in the Waters Surrounding Barrow Island

6.8.4 Land and Sea Use

6.8.4.1 Barrow Island Tenure and Use

The Barrow Island Nature Reserve is listed on the Commonwealth Register of the National Estate. However, Barrow Island is located within the jurisdiction of the Government of Western Australia and management of the nature reserve is overseen by DPaW. Any onshore petroleum-related exploration or production within State jurisdiction is controlled by the Western Australian *Petroleum and Geothermal Energy Resources Act 1967*.

In addition to Barrow Island being declared as a Class A nature reserve, it is also reserved under section 41 (schedule 3, clause 2(3)) of the *Land Administration Act 1997* (WA). As a reserve for the purposes of 'Conservation of Flora and Fauna', Barrow Island is vested in the Conservation Commission of Western Australia and is managed on its behalf by DPaW. Further information about management of the Barrow Island and Montebello Islands reserves is provided in Section 6.7.1.

In 1967, the State Government granted a Petroleum Lease (L1H) to WAPET. In February 2000, Chevron Australia assumed ownership of WAPET and became the operator of the oilfield on behalf of the Barrow Island Joint Venture. The other non-operating Barrow Island Joint Venture partners are Santos Offshore Pty Ltd and Mobil Australia Resources Company Pty Ltd. Within Chevron Australia, the WA Oil Asset (WA Oil) manages the Barrow Island Joint Venture. WA Oil and the approved Foundation Project share a number of facilities on Barrow Island, including the Chevron Australia Camp, Old Airport, WAPET Landing, Barrow Island Airport, Communications Tower, and key roads. Most of these shared facilities are operated by the GJVs, except for the Airport and a large proportion of the road network.

Although Chevron Australia is the operator for the Barrow Island oilfield and the approved Foundation Project, different leases and land access requirements apply to the different joint ventures. Barrow Island Joint Venture is the lessee of the Barrow Island Petroleum Lease L1H, pursuant to the *Petroleum and Geothermal Energy Resources Act 1967* (WA), for the purposes of obtaining petroleum. Five Gorgon land tenure leases have been excised from the L1H lease area and are under the operational control of the GJVs for GJV activities.

Land use on Barrow Island is restricted due to its classification as a reserve for conservation purposes. Barrow Island has been actively used for petroleum exploration purposes by the Barrow Island Joint Venture (operated by WA Oil) since 1967, and is Australia's largest onshore oilfield. Access to Barrow Island is currently restricted to WA Oil personnel, Commonwealth and State Government staff, and, more recently, construction personnel associated with the approved Foundation Project. Access is not open to the public.

6.8.4.2 Sea Tenure and Use

6.8.4.2.1 Petroleum Activities

Offshore petroleum-related exploration or production within State jurisdiction is controlled by the *Petroleum (Submerged Lands) Act 1982* (WA). Onshore production is controlled by the *Petroleum and Geothermal Energy Resources Act 1967* (WA). Beyond the three nautical mile State Waters boundary west of Barrow Island, the sea falls under Commonwealth jurisdiction for a further 200 nm. Any petroleum-related exploration or production within the Commonwealth Marine Area is subject to the provisions of the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006*. The gas fields to be developed for the Fourth Train Proposal are located in the Commonwealth Marine Area.

There are several other sea tenures in and surrounding the Fourth Train Proposal Area:

- Barrow Island Port limit – pursuant to Section 10 of the *Shipping Pilotage Act 1967* (WA), this limit enables the Harbourmaster to restrict all shipping movements within the port limit

- Seabed Lease – seabed with operational infrastructure within the Barrow Island Port (i.e. Materials Offloading Facility, LNG jetty, shipping channel and WAPET Landing), has been granted a Seabed Lease under Section 12 of the *Marine and Harbours Act 1981* (WA) to ensure exclusive use during the Gorgon Project operations phase
- recommended shipping track – this is the recommended path for shipping movements according to surveyed conditions. As such, a high level of shipping traffic may be expected along this route
- prohibited entry areas – these exclusion zones around wells, platforms, and other oil and gas infrastructure vary between 4.5 and 9 nm (Figure 6-30)
- oil and gas activities – there are a number of subsea pipelines, wellhead platforms and other oil and gas infrastructure in the vicinity of the Fourth Train Proposal (Figure 6-30), including:
    - WA Oil export pipeline located within the Barrow Island Port boundary
    - East Spar manifold and pipeline and John Brookes unmanned platform and pipeline
    - Wonnich and Harriet pipelines (with their associated topside monopods and wellhead platforms)
    - Pluto LNG offshore platform
    - Woollybutt floating production, storage, and offloading vessel
    - approved Wheatstone platforms, pipelines and associated infrastructure
    - two export natural gas pipelines running between Varanus Island and the mainland.

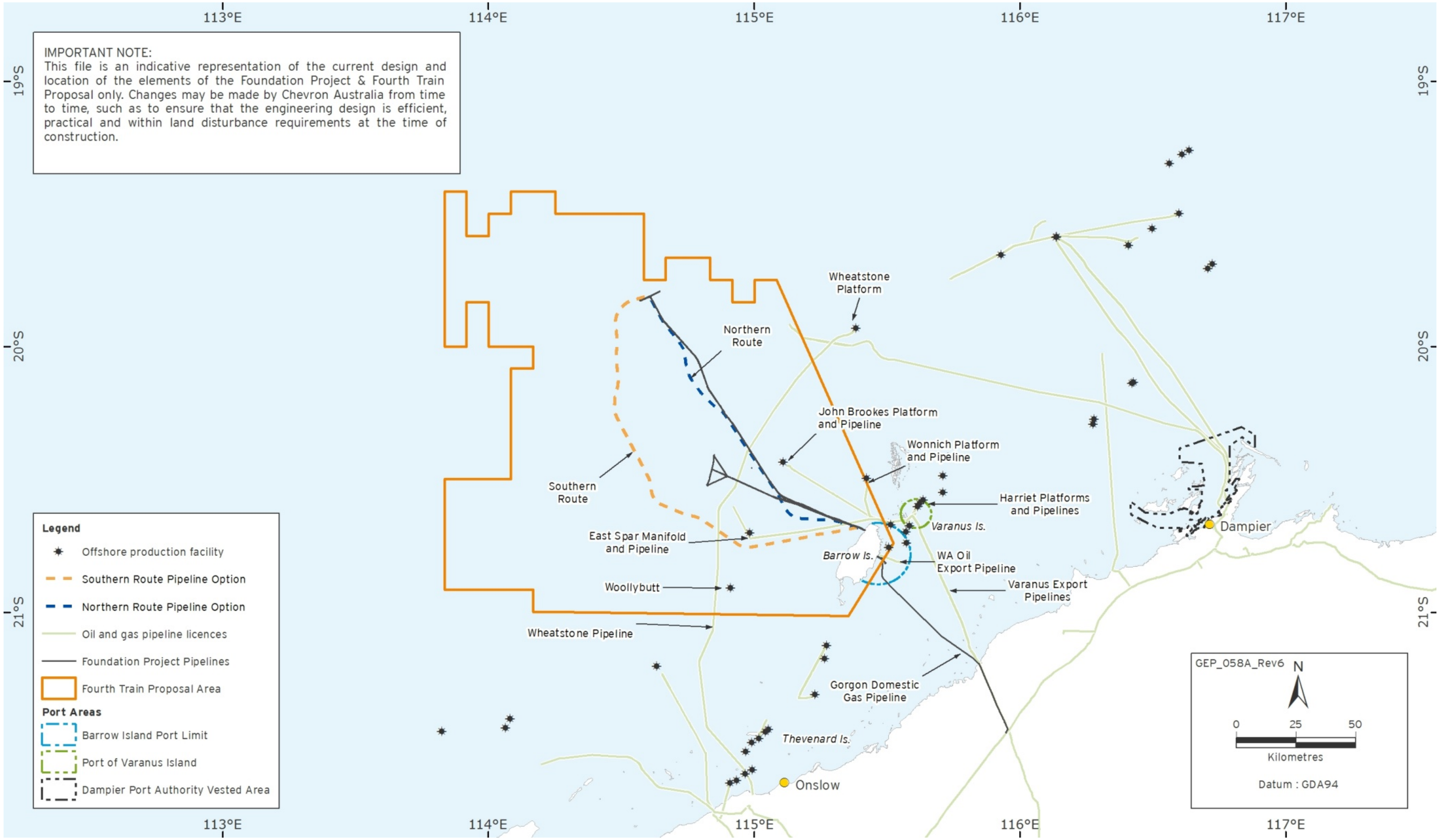


Figure 6-30: Petroleum Lease and Permit Area Surrounding Barrow Island

There are also gas and oil processing and storage facilities on Thevenard and Varanus islands. Additional oil and gas developments are located to the south (Griffin, Crest, Roller, Saladin, and Yammaderry) as well as to the north (Goodwin, North Rankin, Perseus, Cossack, Stag, and Wandoo), but these are a significant distance (more than 40 km) away from the Fourth Train Proposal Area.

6.8.4.2.2 Fisheries

Commercial fishing is limited in the Montebello/Barrow Islands Marine Conservation Reserves (DEC 2007) but does occur in the Pilbara Region. The Fourth Train Proposal Area overlaps with the fishing zones of Commonwealth and State Managed Fisheries.

The following Commonwealth Managed Fisheries may be active within the Fourth Train Proposal Area:

- North West Slope Trawl Fishery: The North West Slope Trawl Fishery encompasses the northern waters of Western Australia roughly between the edge of the continental shelf to the outer boundary of the Australian Fishing Zone (Woodhams *et al.* 2012). Northern Prawn trawlers predominately operate in this fishery on an opportunistic and part-time basis during seasonal closures in the Northern Prawn Fishery (Australian Fisheries Management Authority [AFMA] 2004). The fishing catch substantially reduced between the 2008–2009 season and the 2009–2010 season, reflecting the reduced fishing effort (Woodhams *et al*. 2011). Two vessels were active in the North West Slope Trawl Fishery in the 2009–2010 season and one vessel was active in the 2010–2011 season (Woodhams *et al.* 2012).
- Western Deepwater Trawl Fishery: The Western Deepwater Trawl Fishery is open all year but operators generally access the fishery on a part-time or opportunistic basis. Only the north-eastern boundary of the fishery overlaps with the Fourth Train Proposal Area. Fishing effort and the gross value of production is dramatically less than the peak numbers reached in 2002–2003 season (Woodhams *et al*. 2011). One fishing vessel was active in the 2008–2009 season (Woodhams *et al*. 2011), three were active in the 2009–2010 season and two were active in the 2010–2011 season (Woodhams *et al*. 2012).
- Western Tuna and Billfish Fishery: The Western Tuna and Billfish Fishery operates within the Australian Fishing Zone from Cape York Peninsula off Queensland around to the South Australia/Victoria boundary (AFMA 2011). However, the regions of greatest fishing intensity between 2005 and 2011 and the total area fished in 2011, were concentrated in the southwest, outside the Fourth Train Proposal Area (Woodhams *et al*. 2012). Since 2000, the number of vessels in the Western Tuna and Billfish Fishery has reduced from 45 to fewer than five vessels in 2007 (DEWHA 2009). In 2010 and 2011, four vessels were active in the fishery (Woodhams *et al*. 2012).

The following State Managed Fisheries may be active within the Fourth Train Proposal Area:

- Pilbara Demersal Scalefish Fisheries: The Pilbara Demersal Scalefish Fishery, situated in the Pilbara Region of Western Australia, collectively refers to the Pilbara Fish Trawl (Interim) Managed Fishery, the Pilbara Trap Managed Fishery and the Pilbara Line Fishery. The waters encompassing the Fourth Train Proposal Area are closed to trawl fishing. There are six licences in the Pilbara Trap Managed Fishery, which have been consolidated onto three vessels. The total annual catch taken by the Pilbara Trap Managed Fishery has remained relatively consistent since 2006 and within the target catch range. Similarly, in 2010 and 2011 the Pilbara Line Fishery experienced similar catch levels within the target range (Fletcher and Santoro 2012).
- West Coast Deep Sea Crab (Interim) Managed Fishery: The West Coast Deep Sea Crab (Interim) Managed Fishery encompasses all the waters lying north of Cape Leeuwin and west of the Northern Territory, between the extent of the Australian Fishing Zone and the 150 m isobath. Fishing effort in this fishery decreased by 17% from the 2009 season to the 2010 season (Fletcher and Santoro 2011) and a further 12% between 2010 and 2011

(Fletcher and Santoro 2012). There are currently seven permits operating in the fishery (Fletcher and Santoro 2012).

- Beche-de-mer Fishery: The Beche-de-mer Fishery is permitted to operate throughout Western Australian waters except for a number of specific closures. Of the six potential vessels that held endorsements to fish, only two licensed vessels fished in 2011. Only two licensed vessels have fished within the Beche-de-mer Fishery since 2007 (Fletcher and Santoro 2012). Beche-de-mer live on or in the benthic substrate and are caught by hand, primarily by diving, with a smaller amount caught by wading (Fletcher and Santoro 2012). This may limit the extent of the Beche-de-mere Fishery and therefore reduce the potential for interactions between the deeper waters of the Fourth Train Proposal Area and the fishery.
- North Coast Prawn Managed Fisheries: This fishery encompasses four small prawn fisheries, with the Onslow Prawn Managed Fishery relevant to the Fourth Train Proposal Area. Only one vessel was recorded as operating in the Onslow Prawn Managed Fishery in 2010 and trawling areas were confined to nearshore areas of the mainland coast (Fletcher and Santoro 2011). Fishing effort further decreased between 2010 and 2011, with one boat operating in 2011.
- Specimen Shell Managed Fishery: The Specimen Shell Managed Fishery encompasses all Western Australian waters between the high water mark and the edge of the continental shelf. Although there are 32 licences in the fishery, approximately 11 of these are regularly active (Fletcher and Santoro 2012). Interactions between this fishery and the Fourth Train Proposal Area, are not expected given operators predominately collect shellfish species in shallow coastal waters and along coastal beaches, with effort generally concentrated in areas adjacent to population centres (Fletcher and Santoro 2012).
- Mackerel Managed Fishery: Catches within the Mackerel Managed Fishery are reported separately for three areas, with Area Two and Area Three overlapping with the Fourth Train Proposal Area. The majority of the catch from the fishery is taken from Area One in the Kimberley area, which reflects the tropical distribution of the mackerel species. There are currently 21 permits each in Area Two and Area Three, with three and nine boats operational, respectively (Fletcher and Santoro 2012).

Additionally, the Southern Bluefin Tuna Fishery, Western Skipjack Tuna Fishery, Marine Aquarium Fish Managed Fishery, and Western Australian Roe’s Abalone Fishery have access to the waters around Barrow Island, but concentrate their fishing activities in areas outside the Fourth Train Proposal Area (Woodhams *et al*. 2012; Fletcher and Santoro 2012). Zone One of the Pearl Oyster Managed Fishery, which encompasses the Fourth Train Proposal Area, has not been fished since 2008 (Fletcher and Santoro 2012).

Cultured pearl farming activities are also undertaken in the region north of Barrow Island. Pearl farms may be floating or fixed structures with associated moorings, generally marked by buoys or beacons. The nearest active pearl farm is located near the Montebello Islands. As of November 2006, Morgan Pearls Limited held 14 lease areas, across 11 special purpose zones for pearling and a quarantine site in the Montebello Islands. Fantome Pearls also holds one pearl lease of approximately 1231 ha within the Lowendal Islands (DEC 2007).

6.8.4.2.3 Shipping and Ports

There are shipping channels in the waters surrounding Barrow Island and in the vicinity of the Fourth Train Proposal subsea infrastructure. These shipping channels are required for the existing WA Oil operation activities on Barrow Island, the approved Foundation Project, and shipping activities from Dampier and Port Hedland. Figure 6-31 shows the areas of greater commercial vessel activity in the Fourth Train Proposal Area. As described in Section 4.5.4, most of the required equipment, infrastructure, and materials for the Fourth Train Proposal will be transported to Barrow Island using the supply base network used for the approved Foundation Project.

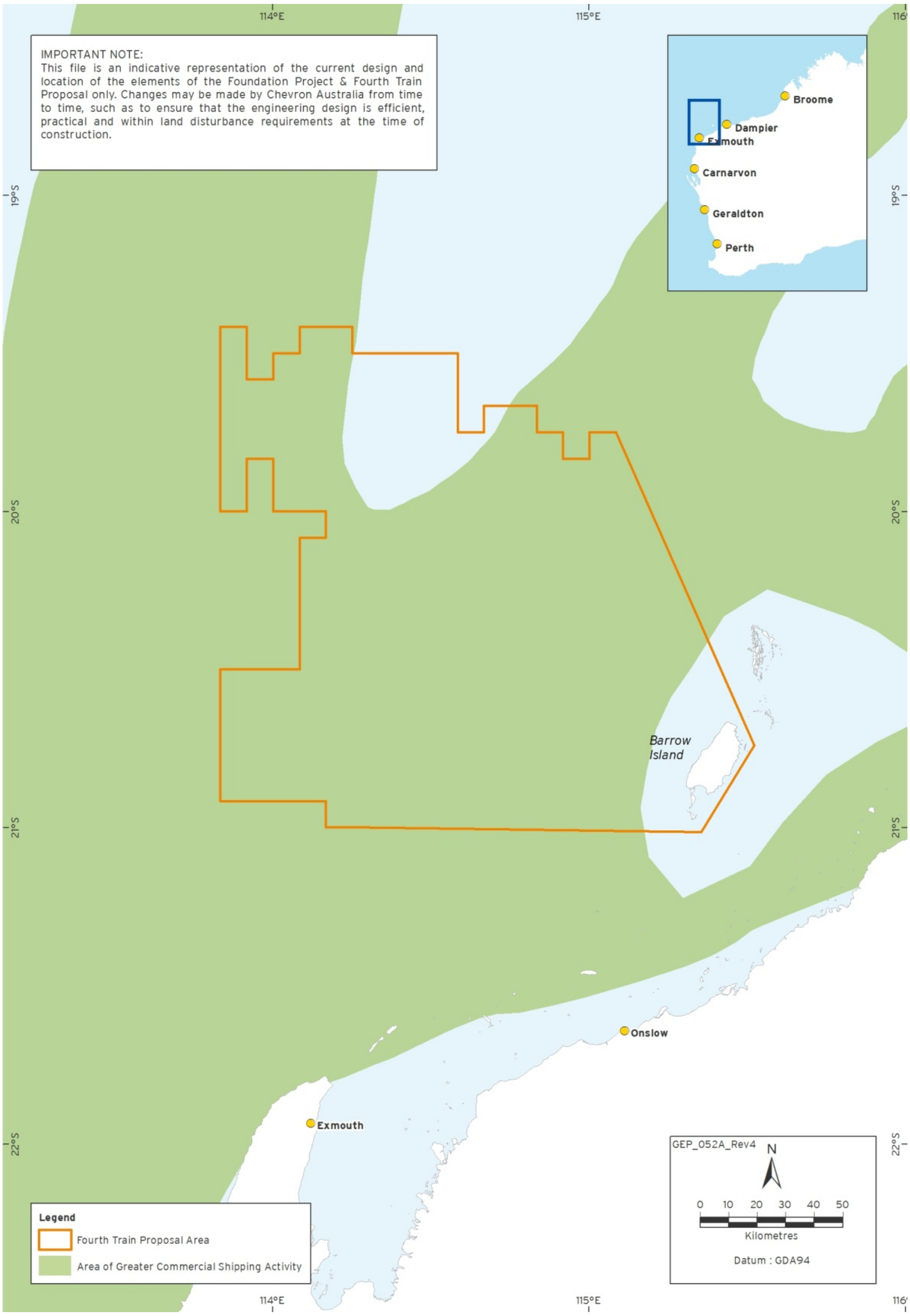


Figure 6-31: Area of Greater Commercial Shipping Activity

6.8.4.2.4 Maritime Tourism

Maritime tourism in the Fourth Train Proposal Area is largely limited to the charter vessel industry. Activities around Barrow Island are rare (DEC 2007) and no tourism activities are undertaken on Barrow Island. The majority of charter vessels visiting the Montebello/Barrow Islands Marine Conservation Reserve visit the Montebello Islands (DEC 2007). However, tourism here is also low due to the Montebello Islands' isolation, lack of visitor facilities, landing restriction and fast tidal currents (DEC 2007).

The Mackerel Islands are a group of ten islands, the closest of which is 69 km from Barrow Island. Two of these islands, Thevenard Island and Direction Island, offer a number of accommodation options and recreational activities. The major attraction to these islands is nature-based tourism activities, such as fishing, diving and snorkelling.

The Ningaloo Reef, approximately 150 km south-west of Barrow Island, is an important area for nature-based tourism in the region. In 2011, more than 18 tour operators provided access to Ningaloo Reef and surrounding areas. Services and activities included charter fishing and diving, sailing, quad biking, bicycling, snorkelling, hiking, surfing, off-road driving, helicopter and flying tours, and chartered flights from Perth’s Jandakot Airport direct to nearby Coral Bay.

Data on income generation derived from marine tourism in the Pilbara Region is difficult to quantify and is not readily available from official tourism organisations; it is also not known if the increased tourist activity in the area is a result of increased public access or increased awareness of the region.

6.8.4.2.5 Recreational Fishing

Recreational fishing is a popular pursuit among local residents of the Pilbara Region; it is managed by the Department of Fisheries through a variety of management tools that aim to limit catches to sustainable levels (DEC 2007). Closer to Barrow Island, recreational fishing is less common, mainly due to the remoteness of the area. The areas of highest recreational fishing activity in the Montebello/Barrow Island Marine Conservation Reserves are reported to be off the north-eastern end of Trimouille Island and in the waters south of the Montebello group (DEC 2007).

6.8.5 Local Communities

There is no local population on Barrow Island. The Pilbara Region comprises four local government areas: the Shires of Roebourne, Ashburton, and East Pilbara, and the Town of Port Hedland. Most Pilbara residents are located in the western third of the region, which includes the main towns of Karratha, Port Hedland, and South Hedland. A small number of Aboriginal communities occur in the eastern portion of the Pilbara Region.

6.8.6 Livelihoods

In 2001, the top three industries for employment in the Pilbara Region were mining, construction, and retail trade, with 44% of all employees in the region employed in these industries. These industries remained the top three employers in 2006, employing a total of 47% of all employees across the region (Pilbara Development Commission [PDC] and Department of Regional Development and Lands [DRDL] 2011). Mining continues to be a primary employer in the Pilbara.

Under the Pilbara Cities initiative, the region is expected to continue to diversify and deepen its economic base with further development of tourism, agriculture, retail and trade industries, and the expansion of existing manufacturing activities (PDC and DRDL 2011).

As most of the Pilbara’s population lives near the coast, fishing, diving, and other marine-based recreational pursuits are common. The region’s main towns also contain many recreational facilities.

6.8.7 National, State, and Regional Economy

6.8.7.1 National Economy

Australia’s abundant natural resources (such as coal, iron ore, copper, gold, natural gas, uranium, and renewable energy sources) attract a high level of foreign investment. The oil and gas industry is one of the major contributors to the Australian economy. The Australian

2012 Gross Domestic Product (GDP) was US$1542.1 billion (Department of Foreign Affairs and Trade [DFAT] 2012). The 2012 unemployment rate was 5.1% (July 2012) (DFAT 2012a).

The Commonwealth Government is focused on raising Australia's economic productivity to ensure the sustainability of growth and to maintain economic relationships with major importers of Australian resources, such as China. This is supported by major projects such as the approved Foundation Project.

6.8.7.2 State and Regional Economy

Western Australia is the location for a number of other major existing and potential oil, gas, and mining projects including the Pluto LNG Project, the Browse LNG Project, the Wheatstone Project, and the North West Shelf Joint Venture. In 2011–2012 Western Australia's Gross State Product (GSP) rose 6.7% and was AU$239 billion (16% of Australia's GDP) (Department of State Development [DSD] 2013). This is above the annual average growth over the previous five years of 4.6%, and was mainly driven by business investment, followed by mining and merchandise exports (DSD 2013). In 2011–2012, Western Australia accounted for 46% (AU$122 billion) of Australia's merchandise exports (DSD 2013). LNG exports also rose 24% to AU$10.7 billion in 2011–2012 accounting for 9% of State exports and 79% of national LNG exports (DSD 2013).

Rapid expansion of the resources sector and sustained economic growth in Western Australia has placed increasing pressure on tight labour market conditions. The 2011–2012 unemployment rate in Western Australia was 3.6% (DFAT 2012b).

The Pilbara is one of the most vital and dynamic wealth-producing regions in Australia. It is the source of two of the largest export revenue earners for the State: iron ore and LNG. The mining sector is the dominant feature of the Pilbara economy (PDC 2012). Other significant economic activities in the Pilbara include construction, manufacturing, real estate services, and the transport, postal and warehousing sector (PDC 2012). Smaller industries include services, wholesale trade, retail trade, education and training, tourism, agriculture and fishing.

The Pilbara's Gross Regional Product (GRP), calculated by the PDC, for the financial year ending June 2011 was AU$14 billion (PDC 2012). In 2011, the Pilbara contributed (PDC 2012a):

- 80% of Australia's oil and condensate production
- 85% of Australia's natural gas production (PDC 2012a)
- 81% of WA's mineral and petroleum production.

Other contributions to the wealth of the region include export income, taxation revenue, and skilled workforce employment. Key growth areas (outside the resources sector) include retail activity; the manufacturing industry consisting mainly of small businesses; agricultural production and the building industry (PDC and DRDL 2011). The total value of tourism expenditure increased from AU$160 million in 2001 to AU$249 million in 2009, despite total the estimated number of visitors dropping between 2001 and 2009 from 317 000 people to 285 000, respectively (PDC and DRDL 2011). In recent years, between 2009 and 2012, the reverse trend has been experienced for tourism in the Pilbara. In 2012 the total estimate number of visitors increased to approximately 334 800 visitors, but there was a decrease in the value of tourism expenditure, estimated at AU$199 million (PDC 2012).

As the main coastal Pilbara town—Karratha—is a service, housing, and local government centre for the rapidly expanding resources sector. Increasing employment opportunities in the Pilbara Region have resulted in population growth that has necessitated the development of a wide range of education, social, shopping, and recreational services in the local Shires (PDC and DRDL 2011).

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7. Stakeholder Engagement

7.1 Introduction

The GJVs are committed to open and accountable processes that encourage ongoing stakeholder engagement during all stages of development. In 2002, the GJVs commenced an extensive stakeholder engagement program that has been ongoing throughout the life of the approved Foundation Project.

Stakeholder engagement for the Fourth Train Proposal has built upon this established and effective engagement program and will continue to do so throughout the PER/Draft EIS process. This section outlines stakeholder engagement to date, issues raised during this process, and plans for ongoing stakeholder engagement for the Fourth Train Proposal.

7.2 Purpose of Stakeholder Engagement

The purpose of engaging stakeholders during the planning and assessment of the Fourth Train Proposal is to:

- inform stakeholders about the Fourth Train Proposal by providing accurate and accessible information
- provide adequate opportunities and time frames for stakeholders to consider the Fourth Train Proposal and to engage in meaningful dialogue
- identify and attempt to resolve potential issues
- consider and address issues raised by stakeholders and provide feedback
- ensure that there is alignment between the Fourth Train Proposal and approved Foundation Project stakeholder engagement activities
- consider stakeholder views in planning future engagement.

7.3 Key Stakeholders

A range of stakeholders has been engaged as part of the approved Foundation Project and the Fourth Train Proposal. Broadly, stakeholders can be categorised into these groups:

- Commonwealth Government
- State Government
- Local Government
- Community groups and environment Non-Government Organisations (eNGOs)
- Aboriginal groups
- Industry groups and representatives (including independent expert panels established for the Foundation Project)
- Internal stakeholders.

A comprehensive list of stakeholders for the Combined Gorgon Gas Development can be found in Appendix C [Key Stakeholder List].

7.4 Methods of Stakeholder Engagement

Stakeholder engagement activities for the Fourth Train Proposal will use similar processes to those that were, and are being used for the approved Foundation Project.

Relevant issues raised during the planning and assessment phase of the approved Foundation Project, including the initial Gorgon Gas Development, and the Revised and Expanded Gorgon Gas Development and Jansz Feed Gas Pipeline, were considered by the GJVs when scoping the assessment and preparation of this PER/Draft EIS (Section 7.5).

Specific stakeholder engagement activities for the Fourth Train Proposal to date have included:

- consulting with decision-making authorities on the PER Environmental Scoping Document
- conducting stakeholder meetings, briefings, and presentations (including an overall interagency briefing)
- sending a letter to eNGOs and interest groups.

The draft PER Environmental Scoping Document for the Fourth Train Proposal (Chevron Australia 2012) was submitted to the Western Australian EPA in October 2011. The EPA then referred the draft PER Environmental Scoping Document to relevant decision-making authorities and subsequently coordinated comments and feedback to Chevron Australia. These comments and feedback were used during the preparation of this PER/Draft EIS.

Following the review of the PER Environmental Scoping Document for the Fourth Train Proposal, briefings and meetings were held with the EPA to discuss the scope and issues associated with the Fourth Train Proposal and to provide an update on the progress of the approved Foundation Project. Chevron Australia representatives also met with the Commonwealth DotE (formerly SEWPaC) to discuss the Tailored Guidelines for the preparation of a Draft EIS for the Fourth Train Proposal (SEWPaC 2011), oil spill modelling, and approach to Environmental Management Plans for the Fourth Train Proposal. In addition, briefings were undertaken with the Shires of Ashburton and Roebourne, Onslow Community Reference Group, local Aboriginal groups, and independent expert panels (established as part of the Foundation Project) on the Fourth Train Proposal.

During the preparation of this PER/Draft EIS, a letter was sent to the eNGOs and interest groups listed in Appendix C [Key Stakeholder List]. The purpose of this correspondence was to inform the groups of the Fourth Train Proposal to enable them to prepare for the public review period of the PER/Draft EIS.

Table 7-1 summarises key stakeholder engagement activities to date. Future engagement activities for the Fourth Train Proposal during the PER/Draft EIS period are outlined in Section 7.6.

Table 7-1: Summary of Stakeholder Engagement from February 2011 to Present for the Fourth Train Proposal

Stakeholder Group	Date	Purpose
Relevant Commonwealth Ministers, advisors, and departments	March 2011	To introduce the Fourth Train Proposal
	September 2011	Field visit to Barrow Island to view progress of approved Foundation Project and discuss Fourth Train Proposal
	April 2011, May 2011, August 2011, February 2012, June 2012, August 2012	Discuss comments and feedback on DotE referral
	August 2012, March 2013	Discuss content of Draft EIS and answer any questions about how Tailored Guidelines have been met
Relevant State Ministers, advisors,	February 2011	To introduce the Fourth Train Proposal
	July 2011	Interagency briefing on Fourth Train Proposal

Stakeholder Group	Date	Purpose
and departments	September 2011	Field visit to Barrow Island to view progress of approved Foundation Project and discuss Fourth Train Proposal
	August 2011, January 2012, February 2012	Discuss comments and feedback on PER Environmental Scoping Document
	January 2013	Present draft PER to decision-making authorities
	January 2013, February 2013, May 2013	Discuss content of PER and how Scoping Document requirements have been met
	2011 to 2014	Regular meetings (approximately monthly) with the EPA to discuss progress of the Fourth Train Proposal PER and relevant issues
Relevant local governments	May 2011, October 2012, June 2014	To introduce the Fourth Train Proposal and discuss relevant issues
Community groups	April 2011, June 2011, October 2012, June 2014	To introduce the Fourth Train Proposal
Environmental non-government organisations	June 2014	To introduce the Fourth Train Proposal
Aboriginal groups	June 2011, October 2012, June 2014	To introduce the Fourth Train Proposal
Industry groups and representatives	June 2014	To introduce the Fourth Train Proposal

7.5 Stakeholder Issues

A number of key issues were previously raised by stakeholders as part of the approved Foundation Project. These issues, as well as the issues raised by stakeholders during consultation on the Fourth Train Proposal, are addressed in Table 7-2. These key issues have been considered in the preparation of this PER/Draft EIS.

Table 7-2: Key Issues Raised by Stakeholders

Issue	Stakeholder Comment	Response
Carbon dioxide injection	It is unclear whether the Fourth Train Proposal will inject the additional carbon dioxide volumes produced.	Addressed in Section 11.3.3
Australian Industry Participation	Planning and construction of the Fourth Train Proposal should actively provide opportunities for Australian industries to supply goods and services.	Addressed in Sections 14.6 and 14.8
Additional impact	The potential impacts of the Fourth Train Proposal, when added to the impacts assessed and approved for the Foundation Project, will result in greater impacts than were predicted for the approved Foundation Project alone.	Addressed throughout Sections 9 to14

Issue	Stakeholder Comment	Response
Cumulative impact	The potential impacts of the Fourth Train Proposal and the approved Foundation Project, when combined with other past, present, and reasonably foreseeable future actions (both related and unrelated) in the Fourth Train Proposal Area, will result in cumulative impacts on environmental and social factors.	Addressed in Section 15
Quarantine risk	Construction of the Fourth Train Proposal is expected to result in a longer construction period for the Combined Gorgon Gas Development, and thus extending the period of quarantine risk.	Addressed in Section 12
Vegetation clearing	The Fourth Train Proposal may require additional land to be cleared on Barrow Island above that allocated under the State Agreement.	Addressed in Section 4.5.2
Shipping movements	The Fourth Train Proposal will result in a permanent increase in the number of ships to the jetty, increasing potential impacts to quarantine and the marine and nearshore environments.	Addressed in Sections 4.4.3.7, 10, and 12
Spill	The Fourth Train Proposal will require more hazardous materials to be stored on site, increasing the risk of a spill.	Addressed in Sections 9.3.2.2, 9.4.2.3, 9.5.2.3, 9.6.2.2, and 9.7.2.3
Light spill	The Fourth Train Proposal will produce more light emissions than the approved Foundation Project, potentially impacting on marine turtles.	Addressed in Sections 5.3, 10.6.2.2, and 13.4.2.3.1
Fire	The Fourth Train Proposal may increase the frequency of bushfires on Barrow Island, impacting upon vegetation.	Addressed in Sections 9.5.2.4 and 9.6.2.4
Terrestrial noise	The Fourth Train Proposal may increase terrestrial noise emissions, which may affect local fauna populations.	Addressed in Sections 9.6.2.6 and 9.7.2.4
Seabed disturbance	The additional Feed Gas Pipeline System required as part of the Fourth Train Proposal may result in a substantial area of seabed disturbance.	Addressed in Sections 10.4.2.2 and 13.5.7

7.6 Ongoing Stakeholder Engagement

Stakeholders will continue to be informed throughout the planning of the Fourth Train Proposal and during construction. This PER/Draft EIS presents a significant opportunity for all stakeholders to provide feedback and comment, which will be responded to in the Response to Submissions in the final PER/EIS. Ongoing stakeholder engagement activities will be aligned and coordinated with those of the approved Foundation Project.

Stakeholders will be consulted as appropriate before, during, and upon completion of each component of the Fourth Train Proposal, including construction, drilling, and operation of Fourth Train Proposal infrastructure. This may include consultation with other sea users, such as fishing groups and operators of other oil and gas activities, during the planning and laying of the Feed Gas Pipeline System.

In addition to direct engagement with stakeholders, other communication methods will be used to inform the broader community of the PER/Draft EIS process. These communications will include Chevron Australia's Frontier Magazine and the Gorgon Project Update newsletter (both available on the Chevron Australia website at: http://www.chevronaustralia.com/news/publications, and website postings of relevant public documents.

Permanent stakeholder engagement specialists and annual stakeholder engagement work plans will be used to engage with stakeholders on specific concerns and to monitor overall stakeholder relationships on an ongoing basis.

7.7 References Cited in Section 7

Chevron Australia. 2012. *Gorgon Gas Development Fourth Train Proposal: Public Environmental Review – Environmental Scoping Document*. Chevron Australia, Perth, Western Australia.

Department of Sustainability, Environment, Water, Population and Communities. 2011. *Tailored Guidelines for the preparation of a Draft Environmental Impact Statement: Chevron Australia Pty Ltd – Gorgon Fourth Train Expansion Proposal (EPBC 2011/5942)*. Commonwealth Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory. Issued to Chevron Australia on 19 September 2011. Available from: http://www.environment.gov.au/cgi-bin/epbc/epbc_ap.pl?name=current_referral_detail&proposal_id=5942 [Accessed: 28 March 2012]

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Section 8: Table of Contents

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8. Assessment Method

This section describes the method used to identify and assess the potential impacts of the Fourth Train Proposal, to determine the mitigation and management measures the GJVs propose to implement to address these potential impacts, and to determine the environmental acceptability of the Fourth Train Proposal. The results of the assessment are presented and discussed in Section 5 and in Sections 9 to 15 of this PER/Draft EIS.

8.1 Scope and Approach

The assessment approach has been developed to ensure that it addresses the scope of assessment required under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Western Australian (WA) *Environmental Protection Act 1986* (EP Act). The assessment approach adopted also reflects that the Fourth Train Proposal is an expansion to the approved Foundation Project.

8.1.1 Assessment Scope

The scope of assessment was established following referral of the Fourth Train Proposal under the EPBC and EP Acts (Chevron Australia 2011, 2011a). The scope is presented in:

- a set of Tailored Guidelines for the preparation of a Draft Environmental Impact Statement for the Gorgon Fourth Train Proposal issued to Chevron Australia by the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) on 3 June 2011 (SEWPaC 2011, referred to as SEWPaC's Tailored Guidelines) and
- an Environmental Scoping Document for the Fourth Train Proposal (Chevron Australia 2012), which was approved by the WA EPA on 30 May 2012.

The scope of assessment covers the identification, prediction, and evaluation of the potential 'incremental' and 'additional' impacts of the Fourth Train Proposal in the context of those assessed and approved for the Foundation Project. Potential cumulative impacts of the Fourth Train Proposal were also identified and assessed. Table 8-1 lists and defines these impact terms and other terms used in the assessment method Table 8-1. The relationship between the impact terms is illustrated in Figure 8-1.

The scope of activities considered in the assessment is described in Section 1.2.

Table 8-1: Definitions of Impact Assessment Terms used in this PER/Draft EIS

Term	Definition
Additional impact	Refers to the *total* emissions, discharges, wastes, impacts, likelihood, or risk due to the Fourth Train Proposal when added to that of the approved Foundation Project. Additional impacts include potential direct, indirect, and facilitated impacts of the Fourth Train Proposal (as defined in SEWPaC's Tailored Guidelines [SEWPaC 2011]) when added to the impacts assessed and approved for the Foundation Project.
Additive impact	Where a particular factor is affected by more than one stressor from the Fourth Train Proposal or Foundation Project or both.
Consequence	The implication of the potential impact on a factor(s).

Term	Definition
Cumulative impact	Potential incremental impacts of the Fourth Train Proposal when combined with the approved Foundation Project and other present and reasonably foreseeable future actions.
Different	An emission, discharge, waste, or impact predicted for the Fourth Train Proposal that was not relevant or assessed for the approved Foundation Project.
Direct impact	As defined in SEWPaC's Tailored Guidelines (SEWPaC 2011), an impact that occurs as a direct result of the Fourth Train Proposal (e.g. change in air quality due to air emissions generated by the Fourth Train Proposal).
Facilitated impact	As defined in SEWPaC's Tailored Guidelines (SEWPaC 2011), an impact that results from the actions of third parties that are facilitated by the Fourth Train Proposal, such as increased shipping or road traffic as a result of the construction of a port or expansion of a facility.
Factor	Includes physical environmental resources (e.g. air, water resources) that are valued by society for their intrinsic worth and/or their social, cultural, or economic contribution, and receptors (e.g. people, communities, ecological entities).
Hazard	A source of potential harm, or a situation with a potential to cause loss or adverse effect. Hazard has the same meaning as 'threat'.
Impact	Interaction of a stressor with an environmental or social factor(s).
Incremental impact	Refers to the change in emissions, discharges, wastes, impacts, likelihood, or risk due to the implementation of the Fourth Train Proposal from that of the approved Foundation Project. Incremental impacts include potential direct, indirect, and facilitated impacts of the Fourth Train Proposal (as defined in SEWPaC's Tailored Guidelines [SEWPaC 2011]) and impacts of the Fourth Train Proposal considered to be different to those assessed by the approved Foundation Project (termed 'different impacts').
Indirect impact	As defined in SEWPaC's Tailored Guidelines (SEWPaC 2011), an impact that is not a direct result of the Fourth Train Proposal, and that may include offsite or downstream impacts, such as impacts on migratory species from changes to the hydrology of estuarine areas.
Likelihood	The probability of a stressor impacting on an environmental factor.
Likely impact	An impact that has a real or not remote chance or possibility of occurring, as defined in SEWPaC's Tailored Guidelines (SEWPaC 2011). Likely impacts have been incorporated into the term 'potential impacts' in this PER/Draft EIS.
Local/Localised	Impacts restricted to the area directly affected by the Fourth Train Proposal and in its immediate vicinity; e.g. the area confined to the limits of the Terrestrial or Marine Disturbance Footprints.
Long-term	More than five years.
Permanent	Impacts that may arise from irreversible changes in conditions caused by the Fourth Train Proposal, such as the removal of a natural feature.
Potential impact	An impact that can be reasonably expected or is likely to occur in the lifetime of the Fourth Train Proposal. Potential impacts include relevant, likely, direct, indirect, and facilitated impacts, as defined in SEWPaC's Tailored Guidelines (SEWPaC 2011).
Receptor	A biophysical entity (e.g. species, population, community, and habitat) or social/community entity (e.g. people, a community, local businesses)

Term	Definition
Relevant impact	Impacts that the Fourth Train Proposal has, will have, or is likely to have on each controlling provision for the Fourth Train Proposal, as defined in SEWPaC's Tailored Guidelines (SEWPaC 2011). Relevant impacts have been incorporated into the term 'potential impacts' in this PER/Draft EIS.
Residual impact	Impact remaining after the application of proposed mitigation and management measures.
Short-term	Fewer than five years.
Stressor	A source of potential harm, or a situation with a potential to cause loss or adverse effects.
Widespread	Impacts extending beyond the limits of the Terrestrial and Marine Disturbance Footprints as defined for the Fourth Train Proposal.

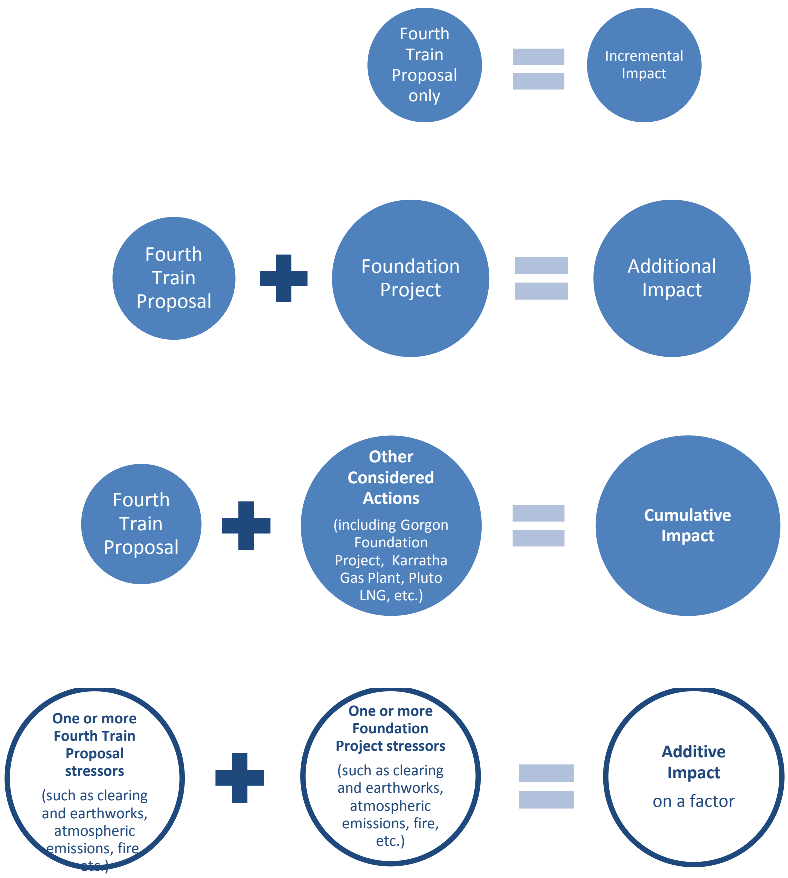

Figure 8-1: Impact Terms Diagram

8.1.2 Assessment Approach

As the Fourth Train Proposal is an expansion of the approved Foundation Project, the overall approach used to identify and assess the potential impacts of the Fourth Train Proposal was informed by the various environmental impact assessment studies completed for the

Foundation Project[6]. These studies included environmental risk assessments conducted as part of the preparation of environmental management and monitoring plans, environment plans, programs, systems, procedures, and reports (collectively referred to as EMPs) required under the Ministerial Conditions for the approved Foundation Project. These environmental risk assessments were used to help identify potential impacts associated with the Fourth Train Proposal but were not used to inform the magnitude or importance of potential impacts. Potential impacts were examined further throughout the preparation of the Environmental Scoping Document (Chevron Australia 2012) and the assessment phase of this PER/Draft EIS, as outlined in Section 8.3.

This approach was taken because the constituent parts of the Fourth Train Proposal, its design, and the proposed approaches to construction are largely the same as elements of the Foundation Project already covered by the Foundation Project assessments. As the Fourth Train Proposal will ultimately be operated with the Foundation Project, this approach also provides consistency and compatibility for compliance management. However, this assessment approach does not re-assess Foundation Project impacts as these have already been assessed and approved, as described in Section 3.

As the Foundation Project is currently under construction, the assessment of potential impacts also reflects the experience gained to date by the Foundation Project, including the experience gained from dealing with incidents. This approach aims to ensure that, wherever practicable, predictions about the Fourth Train Proposal made in this PER/Draft EIS have been validated.

8.2 Scoping Phase – Establishing the Assessment Context

The first step in the assessment process was to establish the assessment context. This involved:

- determining which Fourth Train Proposal activities could potentially result in environmental or social (including cultural and economic) impacts
- identifying Fourth Train Proposal stressors, environmental factors, and potential impacts that would require examination in the PER/Draft EIS
- identifying potential impacts of the Fourth Train Proposal, and scoping the investigations and studies required to support their assessment
- establishing the Fourth Train Proposal assessment framework to determine environmental acceptability.

8.2.1 Identification of Relevant Activities

Many of the activities associated with the Fourth Train Proposal are expected to be the same as, or similar to, those of the Foundation Project. Given these similarities, the activities examined by the Foundation Project were initially used to identify Fourth Train Proposal activities relevant for impact assessment. A comparison of Foundation Project and Fourth Train Proposal activities is provided in Table 4-2 and Table 4-7.

Note: Potential impacts associated with the activities of third-party facilities were not considered in this assessment. It is assumed that these facilities will operate under their own relevant approvals and/or licences.

[6] Sources used to inform the Fourth Train Proposal impact assessment process include Chevron Australia 2005, 2008, 2010, 2010a, 2011b, 2011c, 2011d, 2012a, 2012b, 2013, 2013a, 2014, 2014a, 2014b, 2014e; Mobil Australia Resources 2005, 2011; and Mobil Exploration and Producing Australia 2006.

8.2.2 Identification of Environmental Stressors and Factors that Could Cause Potential Impacts

Environmental stressors and environmental and social factors likely to be relevant to the Fourth Train Proposal were identified by comparing the scope of activities associated with the Fourth Train Proposal to those examined for the Foundation Project and adopting the same stressors and factors where the activities aligned. No stressors additional to those used for the Foundation Project were identified.

Environmental stressors and factors relevant to the Fourth Train Proposal were determined based on whether they may:

- pose incremental or additional impacts
- be of high community/public interest
- contribute to cumulative impacts.

Decision-making authorities were also engaged in this identification process to ensure that the selected stressors and factors reflected their expectations.

The resulting stressors and factors are listed in Table 8-2 and Table 8-3, respectively.

Table 8-2: Stressors Relevant to the Fourth Train Proposal

Stressor	Fourth Train Proposal Infrastructure and Activities Associated with Stressor	Considerations
Atmospheric emissions (except dust)	Combustion emissions from: • Power generation from the Foundation Project Gas Turbine Generators and Gas Turbine Drivers • Temporary Diesel Power Generators • Marine vessel, aircraft, and vehicle engines • Small portable power generators for construction Process waste emissions from: • Flaring • Acid gas venting • Tank and storage vessel fugitive emissions	• Atmospheric pollutants (i.e. nitrogen dioxide, sulfur dioxide, ozone, carbon monoxide, and particulate matter) • Air toxics (i.e. benzene, toluene, ethylbenzene, xylenes, and hydrogen sulfide) • Non-methane Volatile Organic Compounds
Unplanned carbon dioxide migration or release	• Injecting reservoir CO_2 into the Dupuy Formation	• Carbon dioxide
Artificial light	• Artificial lighting for construction activities • Marine vessel lighting (construction and operation) • Artificial lighting at the Gas Treatment Plant • Increased frequency of lighting at the LNG Jetty due to product loading • Ground Flares and Boil-off Gas (BOG) Flaring	• Light spill • Glow
Discharges to sea	• Drilling production wells (drilling fluids and cuttings) • Hydrotesting • Marine vessel discharges • Reject brine from the operation of the reverse osmosis facilities	• Chemical additives • Residual hydrocarbons • Heavy metals • Suspended solids • Nutrients

Stressor	Fourth Train Proposal Infrastructure and Activities Associated with Stressor	Considerations
	• Horizontal directional drilling (drilling fluids and cuttings)	• Dissolved oxygen changes • Salts • Ambient water temperature changes
Noise and vibration	• Marine vessel engines and positioning systems • Offshore drilling • Preparing and laying the offshore Feed Gas Pipeline System • Vertical Seismic Profiling • Barge and/or 'floatel' accommodation, barge laydown, and controlled grounding • Operational marine vessel movements • Aircraft movements • Construction activities (excavating, grading, trenching, blasting) • Horizontal directional drilling activities • Operation and maintenance of subsea infrastructure (wells, Feed Gas Pipeline System etc.) • Vehicle engines and movements • Gas Treatment Plant operation	• Anthropogenic noise • Vibration
Solid and liquid waste	• General waste • Solid hazardous or controlled waste • Liquid hazardous or controlled waste • Quarantine risk material	• Potential for spills, leaks or emissions associated with storage, transport, or disposal
Fire	• Personnel and workforce activities • Construction activities	• Smoke • Heat • Light • Habitat modification
Seabed disturbance	• Preparing, laying, and stabilising the offshore Feed Gas Pipeline System • Drilling production wells • Marine exit of horizontal directional drilling holes • Seabed preparation and controlled grounding of barge accommodation, barge laydown • Anchoring drill rigs and marine vessels	• Habitat disturbance • Suspended solids • Smothering • Abrasion
Vegetation clearing and earthworks	• Preparing horizontal directional drilling site • Excavating and earthworks • Trenching (for laying of Feed Gas Pipeline System onshore)	• Modification/removal of habitat • Site disturbance • Entrapment of fauna

Stressor	Fourth Train Proposal Infrastructure and Activities Associated with Stressor	Considerations
Physical interaction	• Preparing, laying and stabilising the offshore Feed Gas Pipeline System • Barge and/or 'floatel' accommodation, barge laydown, and controlled grounding • Horizontal directional drilling (marine) • Excavating foundations, drains, underground utilities, and trenches • Vehicle and marine vessel movements • Operating equipment and machinery • Workforce activities	• Road or marine vessel strike • Interaction/ disturbance/ entrainment
Physical presence of infrastructure	• Preparing, laying ,and operating the Feed Gas Pipeline System • Barge and/or 'floatel' accommodation, barge laydown • Offshore drilling • Marine vessels during construction and operation • Horizontal directional drilling (marine) • Additional hardstand areas at the horizontal directional drilling site and Gas Treatment Plant site	• Impermeable surfaces • Habitat modification • Local change in water flows and sediment flux • Visual amenity • Sea use
Introduction and/or spread of Non-indigenous Terrestrial Species and/or Marine Pests	• Moving marine vessels associated with the Fourth Train Proposal (construction and operation) • Discharging ballast and bilge water • Moving personnel, equipment, vehicles, and materials	• Potential for establishment on Barrow Island, State and/or Commonwealth waters • Eradication and/or population viability of native terrestrial and marine flora and fauna on Barrow Island, State and/or Commonwealth waters
Spills and leaks	• Storing, transporting, and handling of chemicals, fuels, drilling fluids, wastes, and other hazardous material • Refuelling (onshore and offshore) • Failure of equipment or pipelines • Frac-out during construction of the shore crossing • Pipeline rupture • Subsea well blowout • Marine vessel collision or grounding	• Smothering • Oxygen depletion • Introduction of toxic, persistent, or non-biodegradable substances • Change in pH • Suspended solids
Extreme weather events	• Workforce activities • Moving personnel, equipment, vehicles, and materials	• High wind speeds • Flooding

Table 8-3: Environmental Factors Potentially Impacted by the Fourth Train Proposal

Category	Environmental Factors Potentially Impacted by the Fourth Train Proposal[1]	Considerations
Atmosphere	Air quality[2]	Local and regional air quality
Terrestrial Environment	Soils and landforms	Soil characteristics, soil quality and landforms
	Surface and groundwater	Water quality, hydrological patterns and groundwater recharge
	Terrestrial flora and vegetation communities, including conservation-significant vegetation and flora	Species and community population size and/or habitat integrity
	Terrestrial fauna including protected species, their habitats and their population viability[2]	Species behaviour, population size and viability, and habitat integrity
	Subterranean fauna, including protected species[2]	Species behaviour, population size and viability, and habitat integrity
	Conservation areas	Terrestrial biophysical values including physical, geological, chemical, and biological characteristics
Coastal, Nearshore Environment and Commonwealth Marine Area	Foreshore	Stability and integrity of the beach
	Seabed (intertidal and subtidal[2])	Benthic landforms, seabed sediment physical and chemical characteristics
	Marine water quality[2]	Water quality
	Benthic primary producer habitats	Species and community population viability and/or habitat integrity
	Marine fauna, including protected species, their habitats, and non-benthic primary producer habitats	Species behaviour, population size and viability, and habitat integrity
	Conservation areas and National Heritage Places [2]	Ecological values
Social Environment	Workforce and public health and safety	Workforce and public health and safety and access to health care services
	Cultural heritage	Historical and cultural associations, Aboriginal and non-Indigenous heritage including historic shipwrecks
	Conservation areas	Social values, including aesthetic, recreational, heritage, and economic values, and access for conservation purposes
	Land and sea use	Other users of the land and sea (i.e. commercial shipping, fishing, tourism, and recreation)
	Livelihoods	Employment and skills
	Local communities	Social, cultural, and community structure and infrastructure

Category	Environmental Factors Potentially Impacted by the Fourth Train Proposal[1]	Considerations
	Commonwealth, State, and regional economy	Economic development and alignment with national, state, and local socioeconomic development policies and plans

Notes:

[1] 'Environmental Factors' is a term used by the EPA during the scoping phase of this PER/Draft EIS to broadly denote environmental receptors (EPA 2010). These environmental factors are derived from those used in the Foundation Project approvals documents (Chevron Australia 2005, 2008)

[2] Environmental factors relevant to matters of National Environmental Significance (NES) under the EPBC Act.

8.2.3 Preliminary Identification of Potential Impacts

Identification of potential impacts associated with the Fourth Train Proposal began during the scoping phase of this PER/Draft EIS. Potential impacts were initially identified by considering how each broad activity of the Fourth Train Proposal could result in a stressor that could impact upon an identified environmental or social factor. Potential impacts were identified that related to the construction, commissioning, operations, and decommissioning phases of the Fourth Train Proposal. The Foundation Project environmental impact assessment documents (Chevron Australia 2005, 2008; Mobil Australia Resources 2005; Mobil Exploration and Producing Australia 2006) were used to inform this identification process.

Identified potential impacts were then analysed by comparing them to those assessed for the Foundation Project. The objective was to establish the scope of assessment, data collection, and predictive studies needed to support the assessment.

The preliminary identification of potential impacts relevant to Western Australian (State) jurisdiction were presented in the Environmental Scoping Document for the Fourth Train Proposal approved by the EPA (Chevron Australia 2012). Potential impacts relevant to the Commonwealth (matters of NES) were identified through the preliminary identification process and supplemented with those potential impacts outlined in SEWPaC's Tailored Guidelines (SEWPaC 2011).

8.2.4 Establishing the Assessment Framework

The scoping phase also established the framework for determining the acceptability of impacts. This involved:

- establishing the legal and policy context for the assessment of impacts
- identifying environmental and social objectives against which impacts would be assessed for their acceptability
- consulting with relevant stakeholders on this assessment framework.

8.2.4.1 Environmental and Social Objectives

Environmental and social objectives were identified for each factor. Objectives were derived by aligning:

- the EPA's environmental principles and objectives (EPA 2010a)
- the EPBC Act's objects and principles for ecologically sustainable development
- the objectives used to assess Foundation Project impacts in the EIS/ERMP and the PER (Chevron Australia 2005, 2008).

The resulting objectives were presented to and approved by the EPA in the Environmental Scoping Document for the Fourth Train Proposal (Chevron Australia 2012). The established objectives are described under each environmental and social factor in Section 5 for emissions, discharges and wastes and in Sections 9, 10, 11, 13, and 14 for other environmental and social factors. These objectives were used to assess the acceptability of potential Fourth Train Proposal impacts (Section 8.3.6).

8.3 Assessment Phase

Following finalisation of the Environmental Scoping Document (Chevron Australia 2012), a more detailed assessment was undertaken during the preparation of this PER/Draft EIS, during which the identified stressors, factors and potential impacts were reviewed, confirmed, and/or amended.

During the assessment phase, a number of stressors that were included in the Environmental Scoping Document (Chevron Australia 2012) were screened out from further assessment. This screening process involved detailed prediction and evaluation of potential impacts, which determined that these stressors were not likely to occur, or were not likely to have any discernible consequence on any factor different to background levels. Table 8-4 lists these stressors and the factors to which they relate, together with an explanation for their exclusion from further assessment.

Table 8-4: Stressors Screened out from Further Assessment

Stressor	Relevant Factors	Justification for Exclusion from Further Assessment
Creation of dust	• Vegetation and flora • Terrestrial fauna • Marine water quality	The strong correlation observed between rainfall, plant health, and dust load since monitoring commenced for the Foundation Project in 2009 indicates that rainfall is most likely the main factor affecting the health of plants. Pairwise comparisons of distance from the dust source were not statistically significant (i.e. plant health did not differ significantly with distance from the dust source) (Chevron Australia 2012b). Given the smaller area of earthworks for the Fourth Train Proposal compared to that of the Foundation Project, and because most roads on Barrow Island that will be used by the Fourth Train Proposal are now sealed, significantly lower quantities of dust are expected to be generated by the Fourth Train Proposal. In the marine environment, dust may be generated during concrete coating of the Feed Gas Pipeline System prior to its installation on the seabed. However, a discernible impact on marine water quality parameters is considered unlikely given the open and highly dispersive nature of the marine environment off the west coast of Barrow Island.

Stressor	Relevant Factors	Justification for Exclusion from Further Assessment
Suppression of dust	• Soils and landforms • Vegetation and flora	This stressor was considered for the Foundation Project because of the intention to use sea water for dust suppression. However, sea water use for the Foundation Project was restricted to the Gas Treatment Plant site inwards of a 50 m buffer zone, as is also expected for the Fourth Train Proposal, reducing the potential for salinity impact to soils, vegetation, and flora. As a result, potential impacts to soils and vegetation relating to dust suppression have not been monitored during the Foundation Project to date. Note: Fluctuations in rainfall have been identified as the most likely main factor affecting the health of plants on Barrow Island (Chevron Australia 2012b).
Creation of shade	• Terrestrial fauna • Vegetation and flora • Marine fauna • Benthic primary producer habitat	Experience from the Foundation Project indicates that terrestrial fauna individuals have been attracted to shelter in the shade of infrastructure and vehicles, however, this behaviour is not expected to affect populations or wider behavioural patterns to the detriment of the species. In the marine environment, no permanent shade-creating infrastructure will be installed as part of the Fourth Train Proposal.
Creation of heat and/or cold	• Terrestrial fauna • Vegetation and flora • Marine fauna • Marine water quality	In the terrestrial environment, this stressor was assessed for the Foundation Project in the context of flaring (injury/death of avifauna, burning of surrounding vegetation etc.) and through attraction of fauna to cryogenic/cold equipment at the Gas Treatment Plant. While the Fourth Train Proposal is expected to increase the frequency of flaring compared to the Foundation Project (Section 5.2.3.2), the design of the Ground Flare and the containment of the Gas Treatment Plant site with fencing means that the likelihood of impacts occurring as a result of these activities is considered remote. In the marine environment, the discharge of cooling water from marine vessels (e.g. from marine pipe-laying vessels, LNG and condensate vessels) and heated fresh water during well testing is also not expected to result in observable discernable impact given the highly dissipative nature of the receiving marine environment. Reject brine from the Reverse Osmosis facilities on Barrow Island is near ambient water temperatures as no heating of intake water is required. Therefore, no change to water temperatures is expected.

The approach adopted to assess the potential impacts of this Fourth Train Proposal follows that used by the Foundation Project and is based on determining the likelihood and consequence of potential impacts occurring following exposure to one or more stressors. The assessment phase enables the level of potential impact to be determined and quantified where practicable, and mitigation and management efforts to be prioritised so that an overall acceptable level of potential impact can be achieved.

The assessment method was based on an internal Chevron Australia process aimed at managing risks associated with development opportunities. The assessment method is consistent with the standards International Organization for Standardization (ISO) 31000:2009 Risk management – Principles and guidelines (ISO 2009), and HB203:2006 Environmental risk management – Principles and process (Standards Australia 2006). The method adopted involved:

- systematically identifying potential incremental and additional impacts of the Fourth Train Proposal on environmental and social factors compared to those assessed and approved for the Foundation Project
- collecting and recording any experience and lessons learnt from the Foundation Project that could affect the assessment of incremental or additional impacts of the Fourth Train Proposal and/or the mitigation measures implemented for the Foundation Project
- determining the consequence and likelihood of the identified incremental and additional potential impacts occurring and subsequently categorising each residual impact as High, Medium, Low, or Trivial.

Engineering and environmental subject matter experts, construction managers, and field personnel from the Foundation Project and Fourth Train Proposal teams were involved in each of these steps.

8.3.1 Determining the Consequence of Potential Impacts

These elements were considered in determining the consequence of each identified potential impact:

- the duration, frequency, and reversibility of the potential impact
- the size, scale, geographic extent, and geographic distribution of the potential impact
- the sensitivity of the potentially impacted factor, including its nature, its importance (e.g. whether it is protected under Commonwealth or State legislation) and how adaptable or resilient the factor is to the impact. The legal and policy context (described in Section 8.2.4) that was relevant to protecting environmental and social factors was also considered in determining sensitivity. The sensitivity also considered the future baseline for the Fourth Train Proposal encompassing the Foundation Project and for relevant environmental factors (e.g. air quality, terrestrial fauna), it also took into account the activities of the existing WA Oil operations on Barrow Island.

The terminology used to describe these elements of consequence is defined in Table 8-1. The approach adopted to address any uncertainties around consequences is described in Section 8.3.4.

Wherever practicable, the magnitude of environmental stressors (e.g. emissions, discharges, and wastes) and of potential impacts was predicted quantitatively. These predictions have drawn on the results of predictive modelling and technical studies (described in Section 5) conducted specifically for the Fourth Train Proposal, the results of relevant technical studies completed for the Foundation Project, the monitoring data collected by the Foundation Project (e.g. marine water quality monitoring associated with horizontal directional drilling) and external research reports and papers. Where relevant, prediction methods have also reflected guidelines (e.g. Air Quality Modelling Guidance Notes [Department of the Environment 2006]; Guidance Statement No. 8 – The Assessment of Environmental Factors, Environmental Noise [EPA 2007]) and specialist technical studies undertaken by reputable industry specialists using recognised methods and approaches. Potential impacts are based on worst-case scenarios that reflect any uncertainty in design options still being considered and any potential overlap between Fourth Train Proposal and Foundation Project construction activities.

Where potential impacts could not be quantified, a qualitative approach was applied. In such situations, a comparison with impacts predicted for the Foundation Project was made to determine consequence. Where available, data collected and/or experience gained by the Foundation Project (including incidents) was used in the assessment.

The consequence criteria used for each environmental and social factor are presented in Appendix F1 [Risk Assessment Consequence Criteria].

8.3.2 Determining the Likelihood of Potential Impacts

The likelihood of a potential consequence occurring took into account the implementation of the mitigation and management measures adopted by the Foundation Project. Likelihood is determined based on experience that a consequence has occurred. Consideration of likelihood also took into account the influence that extreme environmental events such as cyclones could have on the occurrence of stressors and/or potential impacts.

Where practicable (e.g. for impacts associated with marine spills and leaks), the likelihood of a consequence occurring was quantified based on modelling predictions and published statistics.

The likelihood criteria used are shown in the assessment matrix (Figure 8-2).

8.3.3 Determining the Residual Potential Impact

The residual incremental and additional (where relevant) potential impacts of the Fourth Train Proposal were determined by evaluating the likelihood and consequence when mitigation and management measures are implemented. The size, extent, and/or duration of the residual impacts were used to determine the degree of potential impact to environmental or social factors. The level of each residual impact was determined by plotting the assigned consequence and likelihood levels onto an assessment matrix (Figure 8-2). Consolidated results of the risk assessment are presented in Appendix F2 [Consolidated Risk Assessment Results].

Where a positive impact or benefit was determined, a rating of ‘positive impact’ was assigned. This is the case for these factors:

- employment
- regional economy
- State economy
- national economy.

Where potential impacts on a factor from any particular stressor were not likely to occur or were not likely to have any discernible consequence different to background levels, an impact rating of ‘trivial’ was assigned. Table 8-5 summarises the potential impacts that were assessed as being trivial during the preparation of this PER/Draft EIS, including a justification for their exclusion from further assessment in this PER/Draft EIS.

Trivial impacts that were deemed to have a level of stakeholder interest were retained in the assessment, including those with potential to impact:

- subterranean fauna from unplanned CO_2 migration
- the foreshore from vegetation clearing and earthworks
- marine fauna from atmospheric emissions
- workforce and public health and safety from atmospheric emissions
- cultural heritage (shipwrecks) from physical interaction.

				Consequence Indices (refer to Appendix F1 for consequence criteria)					
				6	5	4	3	2	1
Likelihood Description (Likelihood of the Consequence, not the event occurring)	Likelihood Indices			Incidental	Minor	Moderate	Major	Severe	Catastrophic
				Decreasing Consequence ←					
Consequence can reasonably be expected to occur in the life of the Fourth Train Proposal	1	Likely	Decreasing Likelihood ↓						
Conditions may allow the consequence to occur in the life of the Fourth Train Proposal, or the event has occurred within the Foundation Project	2	Occasional						HIGH	
Exceptional conditions may allow consequences to occur within the life of the Fourth Train Proposal or it has occurred within Chevron Australia	3	Seldom				MEDIUM			
Reasonable to expect that the consequence will not occur for this Fourth Train Proposal. It has occurred several times in the industry but not in Chevron Australia.	4	Unlikely			LOW				
Has occurred once or twice within the industry	5	Remote							
Rare or unheard of	6	Rare		TRIVIAL					

Figure 8-2: Impact Assessment Matrix

Table 8-5: Potential Trivial Impacts Screened out from Further Assessment

Factor	Stressor	Potential Impact	Activity	Justification for Exclusion from Further Assessment
Terrestrial Environment				
• Soils and landform • Surface and groundwater	Fire	Change in soil, surface water, and groundwater quality resulting from run-off containing nutrients and chemicals	Run-off from water and foam used for fire control during construction or operation of terrestrial facilities	The likelihood of this impact occurring and affecting areas beyond the terrestrial disturbance footprint is considered rare based on experience from the Foundation Project and the mitigation measures in place. The Foundation Project has recorded one fire outside the Foundation Project tenure boundary, which was managed through existing measures and extinguished in the vicinity of the Foundation Project footprint and without the use of firefighting foam.
• Terrestrial fauna • Terrestrial flora	Unplanned CO_2 migration	• Asphyxiation of fauna in low-lying areas (e.g. fauna burrows) • Change in vegetation community composition	Unplanned CO_2 migration or release to the surface or near-surface environment from deep faults within the Dupuy Formation	Given the mitigation and management measures in place, the likelihood of this impact occurring and resulting in population-wide impacts is considered rare.
Terrestrial flora	Physical interaction	Loss of vegetation communities or conservation-significant flora outside the Fourth Train Proposal Footprint	Vehicles driving off road	Access to off-road areas is prohibited. Therefore, the likelihood of flora and vegetation communities being significantly damaged from vehicles driving off road is remote.

Factor	Stressor	Potential Impact	Activity	Justification for Exclusion from Further Assessment
Coastal and Nearshore Environment				
Foreshore	Vegetation clearing and earthworks	Disturbance to existing vegetation	Laying of temporary water supply system across dune zone and intertidal area; placement of clump weights to secure pipeline	No change to coastal dune vegetation is anticipated. Weight clumps will be placed so that they avoid any scattered dune vegetation.
	Physical presence of infrastructure	Disturbance to existing vegetation and localised erosion of the dune	Laying of temporary water supply system across dune zone and intertidal area; placement of clump weights to secure pipeline	No change to coastal dune vegetation is anticipated. Weight clumps will be placed so that they avoid any scattered dune vegetation.
	Spills and leaks	Impact on the integrity and stability of sediment above the high water mark	Frac-out (unplanned discharge) of drilling cuttings or fluids from drilling activities	Frac-out is unlikely in the foreshore area due to the distance between the horizontal directional drilling hole and the surface of the foreshore (approximately 10 m).
Seabed (intertidal and subtidal)	Discharges to sea	Change in seabed profile and changes to physicochemical sediment characteristics	Discharge of deck drainage, treated sewage, and cooling water from marine vessels; hydrotest water	Discharges to sea are of low toxicity and short term and will be into a highly dissipative marine environment, so are unlikely to migrate to sediments where they could impact sediment quality.
Marine water quality	Atmospheric emissions (except dust)	• Accumulation of dioxins and metals in marine waters • Acidification of marine waters from the deposition of CO_2	• Commissioning and start-up emissions (flaring etc.) • Additional operational process and ship loading emissions • Emissions associated with small additional workforce and their transport	Emission concentrations are not anticipated to impact water chemistry equilibriums. The concentrations of pollutants originating from the Fourth Train Proposal are well below their respective National Environmental Protection Measure (NEPM) criteria set for human health exposure limits. As such, impacts to marine water quality are unlikely.
Marine fauna	Physical interaction	Injury to, or mortality of, marine fauna resulting from entrainment	• Intake of water onto marine vessels and through water winning pipeline (for shore crossing construction) • Anchoring of marine pipe-lay and support vessels in anchor spread	• Intake of water may entrap pelagic or benthic fauna. However, given the diameter size of intake pipelines (e.g. ~150 mm for the water winning pipeline), any potential impact is anticipated to affect individuals only and not result in any species-wide impacts. • Anchoring could impact benthic fauna living in or on the seabed. Given the mitigation and management measures in place and the lack of any notable benthic faunal communities in these areas, any potential impact is

Factor	Stressor	Potential Impact	Activity	Justification for Exclusion from Further Assessment
				expected to result in a highly localised loss and rapid recolonisation following the completion of the construction activities. Mitigation and management measures will include careful selection and planning of anchoring areas and activities associated with west coast construction.
		Injury to, or mortality of, marine fauna resulting from anchoring	Anchoring of marine pipe-lay and support vessels	Anchoring could impact benthic fauna living in or on the seabed. Given the mitigation and management measures in place, including careful selection and planning of anchoring areas and activities associated with west coast construction activities, and the lack of any notable benthic faunal communities in these areas, any potential impact is expected to result in a highly localised loss and rapid recolonisation following the completion of the construction activities. Mobile marine fauna are anticipated to move away from the immediate vicinity with no effects on population viability predicted.
		Disturbance of nesting marine fauna	Workforce walking on the beach	Nuisance disturbance is not anticipated, as access to intertidal and foreshore areas will be strictly controlled with no access to beaches used for nesting during the Barrow Island nesting season (November to April).
	Seabed disturbance	Increase in suspended solids in water column resulting in physiological impacts or behavioural responses on marine fauna in the immediate vicinity	Thruster wash (from potential use of dynamically positioned marine vessels during laying of the Feed Gas Pipeline System in State Waters)	This activity will be short term and suspended solids will rapidly disperse and resettle onto the seabed. Discernible impacts on marine fauna populations are unlikely; any mobile marine fauna present are likely to temporarily avoid the area.

Factor	Stressor	Potential Impact	Activity	Justification for Exclusion from Further Assessment
Benthic primary producer habitats	Seabed disturbance	Loss or degradation of benthic primary producer habitat in the contact area	• Seabed preparatory activities for the controlled grounding of barge accommodation and/or barge laydown • Anchoring of floatel accommodation (option) during construction activities	The potential location for this proposed activity is alongside the WAPET Landing and/or Materials Offloading Facility, both of which were dredged as part of the Foundation Project. These areas are unlikely contain high-density benthic primary producer habitats and potential recolonisation may occur on removal of these structures.
Social Environment				
Land and sea use	Physical presence	Adverse impacts to other oil and gas facilities and operations	Short-term presence of marine construction and installation vessels in the vicinity of other oil and gas facilities	The activity is short term and given the distance of Fourth Train Proposal activities from other oil and gas facilities, the potential for any measurable impact occurring is considered remote.
		Navigation or snagging hazard	Presence of survey monuments or acoustic transponders on the sea floor	These structures are likely to be used only in deeper water (>600 m) and are removed once the survey is complete. There is low fishing activity in the vicinity of the drill sites and/or the Feed Gas Pipeline System routes where these monuments or transponders will be located; therefore, their potential to cause an impact to navigation or fishing activities is considered rare.
	Spills and leaks	Displacement of other land users (i.e. WA Oil) following a spill (short-term or long-term, depending on the magnitude of the spill)	Storing, handling, and using fuels and chemicals	Onshore spills and leaks will be remediated when detected; experience gained through construction of the Foundation Project indicates there will be no substantial impacts on other users of Barrow Island.

Factor	Stressor	Potential Impact	Activity	Justification for Exclusion from Further Assessment
Commonwealth Marine Environment				
Air quality	Atmospheric emissions	Depletion of stratospheric ozone	Use of ozone depleting substances on marine pipe-lay vessels and drilling rigs	No active use of ozone depleting substances is planned for the Fourth Train Proposal; however, these substances may be present in older marine vessels contracted by the Fourth Train Proposal. Given the small volumes (if any) of ozone depleting substances that may be used, the potential for any significant contribution to stratospheric ozone depletion is considered rare.
Marine benthic fauna and communities	Physical interaction	Direct physical injury to, or crushing of, benthic flora and fauna causing loss of species abundance and habitat and an increase in turbidity	• Accidental interaction of remotely operated vehicle with sea floor • Maintenance to Feed Gas Pipeline System during operation in shallower areas (i.e. seabed within photic zone) of the Commonwealth Marine Area	Seabed communities are expected to be well represented across the affected area. No unique features or communities are expected to be affected. The proposed scarp crossing hosts scattered corals. Any interaction between a remotely operated vehicle (ROV) and the sea floor would be localised and short term. In addition, the benthic habitats identified within the Fourth Train Proposal Area are considered to be well represented within the North-west Marine Region. In the Commonwealth Marine Area, ROVs will not be operating over any areas of significant benthic primary producer habitats, coral, or other discrete ecosystems.
		Direct physical injury or mortality of benthic communities (including Benthic Primary Producers) in contact area	Anchoring of construction and operational maintenance vessels	Two reef structures have been identified in pipeline surveys for the Northern Feed Gas Pipeline System Route: at the 50 to 60 m water depth and at 40 to 45 m water depth. The Fourth Train Proposal is anticipating using Dynamic Positioning when crossing these reef structures, thus avoiding the potential for impact.
Marine fauna	Discharges to sea	Physiological and genetic damage to marine fauna resulting in long-term impacts on species populations	Loss of radioactive sources during drilling and during Feed Gas Pipeline System maintenance and decommissioning	The potential for this impact to occur is considered rare given the small quantities of radioactive material that could be used/generated and the measures that will be implemented to comply with regulatory requirements.
	Physical Interaction	Injury to, or mortality of, marine fauna due to	Anchoring of marine construction and operational	Operations involving anchoring are expected to be geographically dispersed within the Commonwealth Marine

Factor	Stressor	Potential Impact	Activity	Justification for Exclusion from Further Assessment
		entanglement in anchor chains	maintenance vessels	Area, and short-term and static when in place; therefore, they will be avoidable by marine fauna.
	Physical presence	Creation of artificial habitats causing a change in population densities, composition, and distribution	Presence of drilling rig at well site during drilling campaign	Drilling rigs will be located offshore and any impact will be localised and short term. There may be some attraction of marine organisms (e.g. benthic fauna and pelagic fish, sessile encrusting organisms) but this will be localised.
		Physical injury or death of marine fauna due to entanglement	Presence of subsea infrastructure and Feed Gas Pipeline System on the seabed throughout the life of the Proposal	The potential for this impact to have any consequence beyond the level of individual fauna is considered remote. The subsea nature of the proposed development avoids the potential for more substantial impacts.
	Spills and leaks	Acute or chronic toxic effects on marine fauna, including EPBC Act-listed species	Accidental release of monoethylene glycol (MEG)	MEG is classified under the Centre for Environment Fisheries and Aquaculture Science (CEFAS) Offshore Chemical Notification Scheme as a chemical that poses little or no risk to the marine environment. The release of MEG in small quantities is not expected to result in any discernible adverse impact within the marine environment.
Marine water quality	Spills and leaks	Reduction in water quality	Accidental release of MEG	MEG is classified under the CEFAS Offshore Chemical Notification Scheme as a chemical that poses little or no risk to the marine environment. The release of MEG in small quantities is not expected to result in any discernible adverse impact within the marine environment.
	Discharges to sea		Planned release of small volumes of hydraulic fluid from valves in subsea infrastructure	Given the small volumes of discharge involved and the distance between discharge points, the potential for any persistent, observable impact on water quality is considered remote.

8.3.4 Dealing with Uncertainty

The impact assessment was undertaken based on available evidence, current knowledge, and through the application of professional judgement. However, some scientific uncertainty still exists with respect to the actual impacts that may occur; this uncertainty may be a result of a number of factors including variation in natural systems, limited understanding of complex systems and interactions between components, and unknowable or uncontrollable factors that may affect an impact pathway.

Any scientific uncertainty regarding the potential impact and its seriousness or reversibility resulted in the application of a conservative approach to the assessment and to the definition of mitigation and management measures. Where any identified potential impacts are likely to be unknown, unpredictable, or irreversible, a conservative approach was adopted by considering the 'worst-case' situation. For example, this applies to:

- potential impacts associated with any possible overlap in construction schedules between the approved Foundation Project and the Fourth Train Proposal, i.e. construction of the Fourth Train Proposal on either an operational Foundation Project, or on a Foundation Project still partially under construction, whichever is the worst-case for the specific stressor and/or factor
- predicting the consequence of unplanned events in which the realistic worst-case scenario has been predicted and evaluated
- uncertainties over the exact presence of a factor (e.g. a protected marine fauna) within an area of potential impact; the assessment has assumed those factors they are present and could potentially be affected
- multiple consequence scenarios that were identified for a stressor, or uncertainties over a consequence or likelihood categorisation, in which case the higher (i.e. more conservative) category was selected.

As the Foundation Project is still under construction, many impacts predicted for the Fourth Train Proposal, particularly for the operational phase, are based on predictions made for the Foundation Project. To address this potential limitation, the approach taken for this PER/Draft EIS has drawn on:

- the most recent environmental risk assessments conducted for the Foundation Project (i.e. those conducted as a requirement of Ministerial Conditions or other legislative approvals since the Foundation Project's EIS/ERMP and PER)
- the most recent and representative data on the emissions, discharges, and wastes of the Foundation Project. These reflect detailed engineering design studies completed for the Foundation Project and as such, the emissions presented for the Foundation Project in Section 5 of this PER/Draft EIS refines information presented in the EIS/ERMP and the PER for the Foundation Project[7]
- the findings presented in the Foundation Project's annual Environmental Performance Reports (Section 3)
- the experience of Foundation Project construction engineers and environmental personnel based in the field (collected through their participation in Fourth Train Proposal environmental risk workshops, through discussions during the development of this PER/Draft EIS, and through their involvement in reviewing this PER/Draft EIS).

[7] Note: This approach does not reassess the impacts of the Foundation Project as these have already been assessed and approved (Section 3.3).

8.3.5 Mitigation and Management of Impacts

The GJVs intend to adopt mitigation and management measures (as well as performance objectives, management triggers, objectives, and legal requirements) for the Fourth Train Proposal equivalent to, or consistent with, those approved for the Foundation Project, where the activities, designs, and impacts are alike. The included measures were taken into consideration when assessing the impacts of the Fourth Train Proposal.

The mitigation and management measures are defined for the Foundation Project in:

- the EMPs required under Commonwealth EPBC References: 2003/1294, 2005/2184, and 2008/4178, and Western Australian Ministerial Implementation Statements Nos. 769, 800, and 865 (refer to Section 3.4.2 for further detail on these EMPs)
- Subsidiary Documents, which include Environmental Plans required under other legislative instruments, Works Approvals, and Licences, as well as other internal documents such as Contractor and Subcontractor Plans, Procedures, Work Method Statements, and Job Hazard Analyses.

The mitigation and management measures illustrated in this PER/Draft EIS are based on those contained in current approved versions of Foundation Project EMPs and Subsidiary Documents (requiring regulatory approval) as relevant to Fourth Train Proposal activities. Mitigation and management measures for the Fourth Train Proposal were also identified by considering the experience gained from their implementation by the Foundation Project and taking into account any more recent developments in alternative techniques or technologies since the approval of the Foundation Project.

In many cases the approved Foundation Project EMPs are designed within an adaptive management framework, with required changes being identified through either the performance reporting process, the ecological monitoring management trigger process, or the incident response process. A number of EMPs and Subsidiary Documents may also be updated from time to time to reflect any changing circumstances, experience, and lessons. These changes will subsequently be adopted by the Fourth Train Proposal where its activities and designs are alike. This means that the mitigation and management measures in future approved versions of EMPs and relevant Subsidiary Documents would take precedence over the illustrative mitigation and management measures presented in this PER/Draft EIS.

If Fourth Train Proposal designs or activities diverge materially from those of the Foundation Project, predicted impacts will be re-evaluated and, where necessary, mitigation proposed for approval as part of the activity-specific EMPs or Subsidiary Documents (requiring regulatory approval) that will be prepared to cover Fourth Train Proposal activities. Any such changes made to mitigation and management measures should not affect conclusions of the assessment of potential impacts presented in this PER/Draft EIS as any amendments to EMPs or Subsidiary Documents requiring regulatory approval, must be approved and must still meet the objectives and specific requirements in the Ministerial Conditions.

When developing the mitigation and management measures for the Foundation Project, a hierarchy of mitigation and management options was considered to identify a preferred approach. This same approach was adopted for the Fourth Train Proposal and includes avoidance, minimisation, and restoration/remediation.

The selection of mitigation and management measures for the Fourth Train Proposal also reflects the objects and principles of the EPBC Act and the EP Act, where relevant (refer to Table 1-1).

Illustrative mitigation and management measures in this PER / draft EIS have been taken from Foundation Project EMPs and/or Subsidiary Documents requiring regulatory approval. Illustrative mitigation and management measures relevant to each stressor, factor, and controlling provisions are described in Section 5 and Sections 9 to 14. The GJVs intend to apply the illustrative measures for the implementation of the Fourth Train Proposal; however, when the Foundation Project EMPs are approved to incorporate and manage the environmental impacts of the Fourth Train Proposal, the final mitigation and management measures will be those stipulated in the relevant EMPs and Subsidiary Documents that are approved to apply to the Fourth Train Proposal. Further detail on the environmental management framework the GJVs intend to implement for the Fourth Train Proposal is provided in Section 16.

8.3.6 Predicted Environmental/Social Outcome

The acceptability of potential Fourth Train Proposal impacts was evaluated as a 'predicted environmental/social outcome'. The predicted environmental/social outcome of the Fourth Train Proposal on each environmental and social factor or relevant matter of national environmental significance was determined by taking into account:

- compliance of the Fourth Train Proposal with the environmental and social management objectives established for the assessment of impacts
- compliance of the Fourth Train Proposal with regulatory standards
- compatibility of the Fourth Train Proposal with established government policy, guidelines, and plans
- extent to which best practicable means have been applied to manage impacts of the Fourth Train Proposal (in accordance with EPA Guidance Statement No. 55 [EPA 2003]).

In addition, the predicted environmental outcome reflects the additive impacts of the different stressors on each environmental factor.

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Section 9: Table of Contents

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9. Terrestrial Environment – Impacts and Management

9.1 Introduction

This section describes the potential impacts of the Fourth Train Proposal on the terrestrial environment. The terrestrial environment is defined as the land area from the backshore of the coastal and nearshore environment and inland on Barrow Island.

The local and regional terrestrial environment relevant to the Fourth Train Proposal is described in Section 6. Factors of this environment with the potential to be affected by the Fourth Train Proposal, and the stressors that have been identified as potentially impacting them, are shown in Figure 9-1. For an explanation of this identification process, refer to Section 8.2.2.

The approach used to identify and assess potential impacts of the Fourth Train Proposal on the terrestrial environment is described in Section 8. Both the incremental (including different) impacts introduced by the Fourth Train Proposal alone, and additional impacts of the Fourth Train Proposal when added to the impacts assessed and approved for the Foundation Project have been identified, predicted, and evaluated for their acceptability.

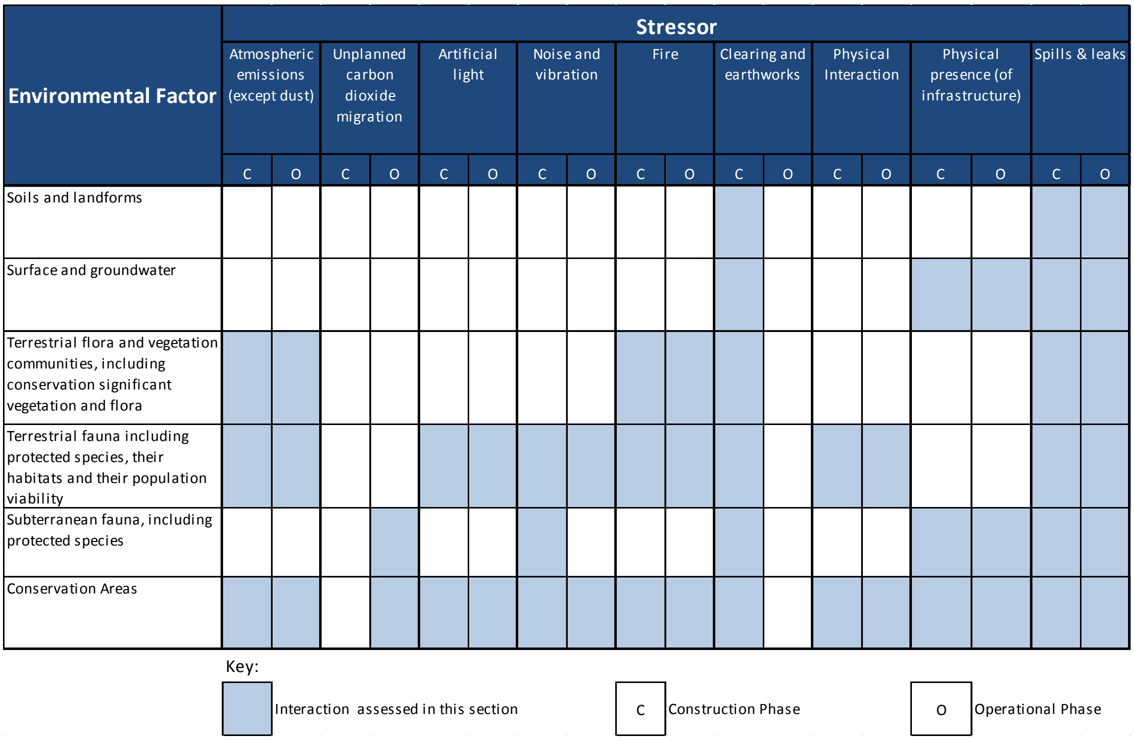

Figure 9-1: Environmental Factors of the Terrestrial Environment and Identified Stressor Interactions

Those stressors where the potential impact on the environmental factor was considered 'Trivial' were screened out from further assessment and are not discussed within this section. Further detail on this screening process is included in Section 8.2.2. The exception is potential impacts to subterranean fauna from unplanned carbon dioxide (CO_2) migration, which has been included due to regulator and public interest.

Table 9-1 lists the key Commonwealth and Western Australian (State) legislation for terrestrial environmental factors. Additional legislation, policies, and guidelines relevant to specific factors are detailed in Section 2 and the following sections.

Consideration of the potential for the introduction and/or spread of Non-indigenous Terrestrial Species is also not assessed within this section, but is discussed in Section 12. To date, there is no evidence of Non-indigenous Terrestrial Species establishing on Barrow Island as a result of the approved Foundation Project.

Table 9-1: Key Legislation Relevant to the Terrestrial Environment

Legislation	Intent
Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act)	Provides for the protection of threatened and migratory species listed as matters of National Environmental Significance (NES).
Environmental Protection Act 1986 (WA) (EP Act)	Provides for the prevention, control, and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement, and management of the environment in Western Australia.
Wildlife Conservation Act 1950 (WA) (Wildlife Conservation Act)	Provides a legal framework to protect and manage flora and fauna in Western Australia.

9.1.1 Checklist for Documents Submitted for Environmental Impact Assessment on Marine and Terrestrial Biodiversity

The Western Australian Environmental Protection Authority's (EPA) Checklist for Documents Submitted for Environmental Impact Assessment on Marine and Terrestrial Biodiversity (Appendix 2) has been completed for the Fourth Train Proposal and is presented in Appendix B1 [EPA Checklist for Documents Submitted for EIA on Marine and Terrestrial Biodiversity].

9.2 Terrestrial Disturbance Footprint

The GJVs intend to manage Fourth Train Proposal impacts to the terrestrial environment within the framework of a Terrestrial Disturbance Footprint (TDF).

The TDF established under the Foundation Project defines the area on Barrow Island within which environmental disturbance associated with the Foundation Project terrestrial facilities will be contained. Specifically, the approved Foundation Project TDF is the area to be disturbed by activities associated with the Terrestrial Facilities listed in the Ministerial Conditions. The objective of the TDF is to ensure Material or Serious Environmental Harm is not caused outside the TDF.

The TDF as it is currently defined applies during the construction of the Foundation Project. The construction TDF for the Foundation Project was assessed and approved through the Terrestrial and Subterranean Baseline State and Environmental Impact Report (Chevron Australia 2014).

The Foundation Project TDF includes the approved Foundation Project Footprint, and an area outside this footprint that includes the ecological elements assessed to be significant and at risk on Barrow Island. The approved Foundation Project TDF is three-dimensional; distances are specified in length, height, and width.

Three construction-related Foundation Project TDFs are currently defined, relating to different ecological elements that have the potential to be impacted (Table 9-2). The Foundation Project TDF does not relate to potential impacts arising from unplanned emergency responses.

Table 9-2: Dimensions of the Approved Foundation Project Construction TDF

Horizontal Dimension[1] (outside Foundation Project Footprint)	Vertical Above-ground Dimension (above the top of infrastructure)	Vertical Below-ground Dimension (below earthworks and excavations)
• 100 m (non-mobile elements; e.g. plants) • 200 m (groundwater) • 1000 m (mobile elements; e.g. fauna)	100 m	1 m

1. *Distance is from the external boundary of the approved Foundation Project Footprint*

The dimensions specified for the approved Foundation Project construction TDF are expected to be appropriate for the management of construction-related impacts outside the Fourth Train Proposal Footprint. However, it is proposed that a TDF applies to the Combined Gorgon Gas Development on Barrow Island, so that the TDF dimensions then apply from the external boundary of the Combined Gorgon Gas Development Footprint. It is proposed that this Combined Gorgon Gas Development TDF is approved through an amendment of the Terrestrial and Subterranean Baseline State and Environmental Impact Report (Table 16-2).

As the dimensions for the operations phase of the Foundation Project TDF have not yet been prescribed, it is not possible to assess how the operations phase TDF will be affected by the Fourth Train Proposal, or to propose an operational TDF for the Combined Gorgon Gas Development. However, the expected area of potential impact due to the Fourth Train Proposal, including the area of potential impact in addition to the approved Foundation Project construction and operations, are assessed below. In addition, the GJVs propose that the Terrestrial and Subterranean Baseline State and Environmental Impact Report continues to be the mechanism that defines TDF.

9.3 Soils and Landforms

9.3.1 Assessment Framework

9.3.1.1 Environmental Objective

The environmental objective established in this PER/Draft EIS for soils and landforms is:

> *To maintain the integrity, ecological functions, and environmental values of soils and landforms.*

9.3.1.2 Relevant Policies, Plans, and Guidelines

Table 9-3 lists specific State policy and framework documents relating to soils and landforms.

Table 9-3: Western Australian State Policy Relevant to Soils and Landforms

Policy, Plan, Guideline	Intent
EPA Guidance Statement No. 6 — Rehabilitation of Terrestrial Ecosystems (EPA 2006)	Recognises that a key aim of rehabilitation is to ensure the long-term stability of soils, landforms, and hydrology required for the sustainability of sites. When discussing abiotic factors, the Guidance Statement describes the maintenance of soil properties as being a key aspect of rehabilitation to ensure vegetation establishment and resistance to erosion.

9.3.2 Assessment and Mitigation of Potential Impacts

As detailed in Section 6.4.6, the Gas Treatment Plant site is characterised by up to 10 m of sands and clays overlaying limestone. Between the Feed Gas Pipeline System shore crossing at North Whites Beach and the Gas Treatment Plant site, the surface geology consists of outcrops of variably weathered Trealla limestone, interspaced with alluvial and colluvial deposits. These deposits are associated with the ephemeral creeks present on Barrow Island. The location of the horizontal directional drilling site, which includes an area for pipe stringing and installation, is located within the sand dunes system.

Potential stressors from the Fourth Train Proposal that may affect soils and landforms were identified and are discussed below. Potential stressors include:

- vegetation clearing and earthworks
- spills and leaks.

9.3.2.1 Vegetation Clearing and Earthworks

Earthworks can result in changes in landform from the removal of soils, and changes to physical characteristics; e.g. compaction. Erosion by wind or rain can potentially occur where soils are exposed by vegetation clearing.

An identified indirect potential impact on surface water and groundwater associated with erosion is increased sedimentation. This is discussed in Section 9.4.

Potential Impact on Soils and Landforms from Vegetation Clearing and Earthworks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Vegetation clearing and earthworks[1].	Additional clearing of land. Additional pipe-lay activities within the (cleared) Foundation Project Feed Gas Pipeline Systems Footprint. Additional earthworks at cleared land including the Gas Treatment Plant site and the Gorgon Gas Development Additional Construction, Laydown and Operations Support Area (Additional Support Area). Delay to Foundation Project reinstatement/re-clearing reinstated Foundation Project land	Construction: Low Operations: Not applicable (N/A)	Construction: Medium Operations: N/A

1 *Clearing will be within the allocated uncleared land available for tenure on Barrow Island under the Barrow Island Act 2003* (WA)

Vegetation clearing and earthworks activities, such as site preparation or excavation, will occur during construction of the Fourth Train Proposal. Vegetation clearing and earthworks will take place within the allocated uncleared land available for tenure on Barrow Island under the *Barrow Island Act 2003* (WA).

Changes to soil profiles will occur in areas subject to earthworks (e.g. disturbance of soil through excavation and refilling, and compaction of soil by the use of machinery and vehicles). Earthworks will occur over up to 10 ha of uncleared land at the Fourth Train Proposal horizontal directional drilling site. Earthworks will also take place in areas that were previously cleared, including at the Foundation Project horizontal directional drilling site, over approximately 50 ha at the Gas Treatment Plant site, over up to 32 ha at the Additional Support Area, and within approximately 15 ha of cleared area along the length of the Foundation Project Feed Gas Pipeline Systems Footprint (Section 4.4.2). Limited earthworks may also take place on areas of cleared land, e.g. for subsidiary infrastructure. Note: When the Fourth Train Proposal (if approved) is implemented, earthworks at the Gas Treatment

Plant site and the Additional Support Area will already have been carried out under the Foundation Project (Section 4.5.3.2), and therefore soil profiles will have been disturbed at these areas.

The construction of the Fourth Train Proposal horizontal directional drilling site will result in changes in landform over up to 10 ha. This area includes approximately 0.45% of Barrow Island's sand dunes (approximately 3.5 ha), which cover approximately 790 ha and extend up to 1.4 km inland. The Foundation Project horizontal directional drilling site and Additional Support Area will have already experienced changes to landform from approved Foundation Project earthworks. However, further changes to landform may result from Fourth Train Proposal earthworks. These earthworks may take place over approximately 10 ha and 32 ha at the Foundation Project horizontal directional drilling site and at the Additional Support Area respectively, although the area within which these earthworks are required (and thus the resulting change to landform) is expected to be smaller.

The potential for erosion in areas subject to vegetation clearing and earthworks is reduced through soil compaction as a result of the use of machinery or equipment. Stockpiled soil may be more susceptible to erosion, due to its raised profile and less compact nature. Coastal dunes are also identified as landforms that may be more vulnerable to erosion (Chevron Australia 2014). However, Foundation Project experience to date has demonstrated successful management of potential erosion issues, including the stabilisation of sand dunes (Section 3.5.2.4).

Vegetation clearing as a result of the Fourth Train Proposal will increase the area over which clearance will take place by up to 10 ha. Vegetation clearing additional to the approved Foundation Project will be within the allocated uncleared land available for tenure on Barrow Island under the *Barrow Island Act 2003* (WA). Earthworks will be confined to areas proposed to be cleared, and cleared areas elsewhere on Barrow Island. Earthworks additional to the approved Foundation Project will increase the area of sand dunes removed to approximately 7 ha, which is approximately 0.9% of the pre-Foundation Project total sand dune area on Barrow Island. The Fourth Train Proposal will also result in a delay to Foundation Project reinstatement activities (e.g. over approximately 20 ha at the Additional Support Area), or may require re-clearing of Foundation Project land that has been reinstated (e.g. along the Foundation Project Feed Gas Pipeline Systems Footprint or the Foundation Project horizontal directional drilling site), increasing the time within which erosional impacts may take place in those areas.

Illustrative measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Table 9-4 for assessment purposes.

Table 9-4: Illustrative Mitigation and Management Measures for Vegetation Clearing and Earthworks Activities

Approved Foundation Project EMP	Illustrative Measures
Terrestrial and Subterranean Environmental Protection Plan	• Additional measures to minimise sediment carry over as a result of civil works will include: ▪ Use of erosion barriers, flow diversion devices and sedimentation sumps. Where the installation of sediment sumps is not feasible, sediment flowing off the construction site will be controlled using an alternative method e.g. silt fencing, geo-textile fabric. ▪ Contour banks to intercept and disperse run-off will be installed on steep disturbed slopes where practicable.
Horizontal Directional Drilling Management and Monitoring Plan	• Measures to reduce the requirement for a larger cleared footprint at the horizontal directional drilling work site include the following: ▪ use of the pipeline right-of-way (Foundation Project Feed Gas Pipeline Systems Footprint) for site access, negating the need for additional clearing to access the horizontal directional drilling work site. ▪ waste forecasting and regular waste pick-ups to reduce the space requirements for waste storage.
	• The horizontal directional drilling work site will be constructed to enable management of surface water during heavy rainfall events, including appropriate drainage controls to direct surface water away from working areas. Potentially contaminated water from bunded areas at the horizontal directional drilling site shall be collected for disposal. The system shall be designed, constructed and maintained to allow for storm events (e.g. cyclones) without erosion or damage.
	• During clearing of the horizontal directional drilling site topsoil will be collected for use in site reinstatement after the horizontal directional drilling works.
Post-Construction Rehabilitation Plan	• After bedding and padding of pipelines in the trenches has been completed, the following steps will be undertaken: ▪ Trenches will be filled, compacted and covered with a crowned profile. ▪ Drainage will be re-established by creating breaks in the crown. ▪ Topsoil and vegetation will be respread across the pipeline easement (Foundation Project Feed Gas Pipeline Systems Footprint).

Potential incremental impacts to soils and landforms will be confined mainly within the Fourth Train Proposal Footprint, although limited localised erosion and sedimentation may take place in its immediate vicinity. Impacts will be short term at the horizontal directional drilling site, and over the Fourth Train Proposal Feed Gas Pipeline System Footprint in areas subject to reinstatement. As a result, the potential incremental impact to soils and landforms is assessed as 'Low'.

The Fourth Train Proposal additional to the approved Foundation Project will result in an increase in area, and an additional period within which vegetation clearing and earthworks will take place on Barrow Island. As a result, the potential additional impact to soils is assessed as 'Medium'. The Fourth Train Proposal is not expected to change the level of potential impact to soils and landform as a result of vegetation clearing and earthworks compared to that assessed for the approved Foundation Project; the area subject to vegetation clearing and earthworks is on a smaller scale than that of the Foundation Project, and the additional duration is limited to the construction of the Fourth Train Proposal.

9.3.2.2 Spills and Leaks

There is potential for soils to be degraded by hazardous materials (e.g. hydrocarbons, wastes, contaminated stormwater) from accidental spills or leaks. The release of contaminants into the natural environment is likely to have a negative impact on soil quality if such contaminants are not removed or remediated.

Potential Impact on Soils and Landforms from Spills and Leaks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Hydrocarbons and other hazardous materials will be used routinely during the construction and operation of the Fourth Train Proposal.	One additional Feed Gas Pipeline System. Additional LNG Train and supporting infrastructure within the GTP including one LNG tank (if required). Additional diesel infrastructure (if required). Additional volumes of hydrocarbons and hazardous substances. Additional solid and liquid waste.	Construction: Low Operations: Medium	Construction: Medium Operations: Medium

Spills and leaks could occur during construction and operation of the Fourth Train Proposal. Potential spills and leaks are associated with pipeline or equipment failure (including during hydrotesting), horizontal directional drilling fluid release, storage and handling of LNG and condensate, fuels and chemicals, and waste generation, storage and disposal. There is also potential for spills and leaks of hydrocarbons, wastes, and other hazardous materials during transport and transfer, or through the failure of new plant and/or equipment. Despite preventive measures included in the design and operation of Fourth Train Proposal, leaks or spills could occur.

Spills are expected to be contained through design controls (e.g. bunding) and/or timely spill response and clean-up actions. Spills and leaks recorded to date by the Foundation Project were largely contained in the hardstand area, with remediation undertaken where required. Spill procedures were found to be effective (Section 16.2.1).

The Fourth Train Proposal additional to the approved Foundation Project will result in increases in quantities of hazardous materials, and therefore the potential for spills and leaks, although no different sources of potential spills and leaks will be introduced compared to the approved Foundation Project. During construction, the number of Feed Gas Pipeline Systems will be increased from two to three, and the number of LNG tanks from two to three if an additional tank is required. Associated hydrotesting during pre-commissioning will require higher volumes of saline or fresh water and additives such as corrosion inhibitors than those required for the Foundation Project alone (Section 5.5.3.3). Wastes are predicted to increase by less than one-third (Section 5.6). Some vehicles will also remain on Barrow Island longer; therefore, more fuel, grease, and oil will be required for their extended use. During operations, waste is predicted to increase by less than one-third (Section 5.6) and increased volumes of production fluids (gas, condensate, and produced water with production chemicals) and monoethylene glycol (MEG) will be transported (Section 5.5.3.6).

Illustrative measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Table 9-5 for assessment purposes.

Potential incremental impacts to soils and landforms as a result of contamination due to spills and leaks are predicted to be contained within the Fourth Train Proposal Footprint or its immediate vicinity. During construction, this potential impact is assessed as 'Low'. Potential impacts are assessed as 'Medium' during operations, representing the increased potential for spills and leaks and the higher volumes of hazardous materials used.

The Fourth Train Proposal additional to the approved Foundation Project may result in potential impacts within the Combined Gorgon Gas Development Footprint or its immediate vicinity. The additional impact to soils and landforms is assessed to be 'Medium' during the

Fourth Train Proposal construction and operations activities, resulting from increases in the quantities of hazardous materials used than those used by the Fourth Train Proposal alone. This does not represent any change to the level of potential impact for the approved Foundation Project as spills are mostly expected to be contained through design controls (e.g. bunding) and/or timely spill response and clean-up actions.

Table 9-5: Illustrative Mitigation and Management Measures for Spills and Leaks

Approved Foundation Project EMP	Illustrative Measures
Terrestrial and Subterranean Environmental Protection Plan	• In relation to contamination, the surface water drainage system is designed to segregate, intercept, treat and/ or dispose of streams of potential contamination from the Gas Treatment Plant. • To ensure that any contaminated stormwater run-off and spills can be collected and routed to suitable treatment, the surface water drainage system is intended to be designed and installed on the Gas Treatment Plant and Additional Support Area, with some elements of the system commissioned and used during the Construction Phase of the Gas Treatment Plant.
	• Wherever practicable, non-hazardous (or least-hazardous) materials will be selected for use on site. • Hazardous material storage areas will be designed and engineered in accordance with applicable industry standards to safely handle the volumes and operating conditions required for each substance. • Tanks and machinery will be equipped with appropriate spill and leak protection devices in accordance with applicable design standards and specifications. • Legal requirements pertaining to hazardous materials and substances will be adhered to for packaging, segregating, storing, transporting, transferring and handling. • An inventory of hazardous materials stored at work sites will be maintained on site. • Major maintenance of vehicles and equipment will be conducted at designated maintenance areas. • Bulk transfer lines will be fitted with dry-break couplings. These will be fit-for-purpose, not outside design life limits and regularly checked for damage to prevent leaks. • Personnel will be trained in their roles, functions and responsibilities, including emergency response, prior to refuelling or fuel transfer. • Relevant personnel will be trained in spill response. • Sufficient and appropriate equipment, materials and resources will be available, and maintained, to respond to a spill incident. • Upon detection of a spill or leak, the person shall report the incident in accordance with the Gorgon Gas Development Incident Reporting Procedures. • Spills shall be contained and cleaned up immediately and product Material Safety Data Sheets consulted as applicable to guide clean-up actions.
Horizontal Directional Drilling Management and Monitoring Plan	The horizontal directional drilling work site will be constructed to enable management of surface water during heavy rainfall events, including appropriate drainage controls to direct surface water away from working areas. Potentially contaminated water from bunded areas at the horizontal directional drilling site shall be collected for disposal. The system shall be designed, constructed and maintained to allow for storm events (e.g. cyclones) without erosion or damage.

Approved Foundation Project EMP	Illustrative Measures
Solid and Liquid Waste Management Plan	Oily water treatment systems will be used to treat hydrocarbon-contaminated water (including hydrocarbon-contaminated stormwater) from being discharged on Barrow Island.

9.3.3 Proposed Management

The GJVs consider that the potential impacts to soils and landforms by the Fourth Train Proposal can be effectively managed under the relevant Ministerial Conditions for the Foundation Project. No measures or controls additional to those required for the approved Foundation Project have been assessed as being necessary to manage the incremental or additional potential impacts to soils and landforms from the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the various Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal's horizontal directional drilling activities, locations and potential impacts will also need to be prepared and approved as described in Section 16.2.3.3. However, the GJVs anticipate that the mitigation and management measures included within the Foundation Project Horizontal Directional Drilling Management and Monitoring Plan will also apply to and will prevent and manage any potential impact to relevant environmental factors, including protected species, as a result of the Fourth Train Proposal.

The EMPs that are relevant to addressing potential impacts to soils and landforms for the Fourth Train Proposal are:

- Terrestrial and Subterranean Environment Protection Plan and associated Procedures
- Horizontal Directional Drilling Management and Monitoring Plan
- Solid and Liquid Waste Management Plan
- Post-Construction Rehabilitation Plan and associated sub-Plan.

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

9.3.4 Predicted Environmental Outcome

The soils and landforms with the potential to be impacted as a result of the Fourth Train Proposal are well-represented on Barrow Island.

The Fourth Train Proposal will extend the duration of onshore construction activities, during which potential additional impacts to soils and landforms may take place. Potential impacts are predicted to be short term, and localised during construction. Potential impacts resulting from spills and leaks during operations are predicted to be short term and localised, as spills and leaks are expected to be mostly contained through design controls (e.g. bunding) and/or timely spill response and clean-up actions. No different impacts were identified.

The stressors discussed are not predicted to act synergistically or interact otherwise to cause a greater impact than when considered separately. Potential impacts are not predicted to impact the integrity, ecological functions, and environmental values of soils and landforms. The GJVs consider that the stressors to soils and landforms will be able to be adequately managed such that the impacts are environmentally acceptable and the environmental objective (Section 9.3.1.1) is met.

9.4 Surface Water and Groundwater

9.4.1 Assessment Framework

9.4.1.1 Environmental Objective

The environmental objective established in this PER/Draft EIS for surface water and groundwater is:

> *To maintain the quantity and quality of water so that existing and potential environmental values, including ecosystem function, are protected.*
>
> *To minimise the potential for erosion due to stormwater flow.*

9.4.1.2 Relevant Policies, Plans, and Guidelines

Table 9-6 lists specific State policy and framework documents relating to surface water and groundwater.

Table 9-6: Western Australian State Policy Relevant to Western Australian State Policy Relevant to Surface Water and Groundwater

Policy, Plan, Guideline	Intent
Operational Policy No. 5.12, Hydrogeological reporting associated with a Groundwater Well Licence (Department of Water 2009a)	Provides policy on the content and context of hydrogeology assessments with respect to taking of groundwater and/or ecological impacts management. The policy is intended to inform the Department of Water of the potential impacts that proposed projects may impose on the environment, other users, and available water resources.
Pilbara Water in Mining Guideline (Department of Water 2009b)	Builds on the Pilbara regional water plan, providing a specific focus on managing water associated with mining and resource projects.
Statewide Policy No. 5 – Environmental Water Provisions Policy for Western Australia (Water and Rivers Commission 2000)	Informs the Department of Water how water will be provided and managed to protect ecological values and sustainable development consistent with the requirements of the *Rights in Water and Irrigation Act 1914* (WA) and the *Environmental Protection Act 1986* (WA). The policy incorporates the concepts of Ecological Water Requirements and Ecological Water Provisions for water-dependent environments.

9.4.2 Assessment and Mitigation of Potential Impacts

As detailed in Section 6.4.8, a water divide running north to south along a central, elevated ridge divides the hydrological regime of Barrow Island (Chevron Australia 2008) (Figure 6-4). Creeks flow along a largely east–west/west–east orientation on either side of this divide; these creeks are highly ephemeral, usually dry, and generally flow in response to short intense rainfall rather than long duration rainfall events (Chevron Australia 2014).

On Barrow Island, the entire shallow relatively fresh groundwater aquifer provides habitat for subterranean fauna (stygofauna) (Section 9.7).

Potential stressors from the Fourth Train Proposal that may affect surface water and groundwater were identified and are discussed below. Potential stressors include:

- vegetation clearing and earthworks
- spills and leaks
- physical presence of infrastructure.

There is no planned discharge of drilling fluids and drilling cuttings onshore. All collected fluids and horizontal directional drilling cuttings will be stored for collection and disposal on the Western Australian mainland.

9.4.2.1 Vegetation Clearing and Earthworks

Vegetation clearing and earthworks activities have the potential to impact surface water and groundwater through erosion of soil, resulting in changes to surface water quality through sediment discharge and sedimentation of natural drainage systems, and disturbance to natural drainage patterns.

Potential Impact on Surface Water and Groundwater from Vegetation Clearing and Earthworks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
As described in Section 9.3.2.1.	As described in Section 9.3.2.1.	Construction: Low	Construction: Low
		Operations: N/A	Operations: N/A

The nearest ephemeral creek to the Fourth Train Proposal infrastructure within the Gas Treatment Plant site is located approximately 175 m to the south-east, approximately 120 m from the Gas Treatment Plant site. The nearest ephemeral creek to the horizontal directional drilling site is located approximately 200 m to the east. Given the proximity of the ephemeral creeks to vegetation clearing and earthworks activities, patterns of water flow which recharge the creeks are not anticipated to be impacted.

Trenching activities will cross 14 ephemeral creeks within the Foundation Project Feed Gas Pipeline Systems Footprint (Figure 6-4). Potential impacts to surface water may occur during short, intense rainfall events when surface water forms in the creeks. Sedimentation may result from erosion in areas that have been subject to vegetation clearing and earthworks, including in areas where the Fourth Train Proposal will delay Foundation Project vegetation reinstatement activities or require re-clearing of Foundation Project land that has been reinstated.

Groundwater has the potential to be impacted from sediment discharges resulting from erosion as a consequence of clearing and earthworks activities. At the Gas Treatment Plant site, perimeter bunding has proved to be effective in capturing run-off and sediment before being discharged; design capacity has not been exceeded. In addition, the horizontal directional drilling site drainage and the addition of culverts have proved effective, as demonstrated by the relatively limited site damage caused by Tropical Cyclone Carlos in 2011. Potential impacts to groundwater through sedimentation are predicted to be short term and confined to the immediate vicinity of the Fourth Train Proposal Footprint.

The Fourth Train Proposal additional to the approved Foundation Project will result in an additional period during within which vegetation clearing and earthworks activities will take place. The area subject to vegetation clearing and earthworks on Barrow Island will also be increased, as described in Section 9.3.2.1. However, due to the application of mitigation and management measures and the seasonal nature of rainfall on Barrow Island, potential impacts to surface water and groundwater from erosion of soil are predicted to remain short term and be confined to the immediate vicinity of the Combined Gorgon Gas Development Footprint.

Illustrative measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Table 9-4 for assessment purposes.

Potential incremental impacts to surface water are predicted to be short term and confined to the immediate vicinity of the Foundation Project Feed Gas Pipeline Systems Footprint. Potential incremental impacts to groundwater are predicted to be short term and localised. As a result, a 'Low' potential impact to surface and groundwater is predicted.

The Fourth Train Proposal additional to the approved Foundation Project will extend the duration and area over which vegetation clearing and earthworks will take place. Potential impacts to surface water and groundwater are predicted to be localised, resulting in a 'Low' potential impact. This represents a decrease to the level of potential impact determined for the Foundation Project, which was ranked as 'Medium'. This decrease is due to the experience gained during the Foundation Project to date, which demonstrates that mitigation and management measures have been successful in controlling potential erosion and sedimentation.

9.4.2.2 Physical Presence of Infrastructure

The physical presence of infrastructure has the potential to cause impacts to surface water and groundwater through changes in water infiltration and recharge rates affecting groundwater levels; through increased surface run-off; and by altering surface water drainage patterns.

Potential Impact on Surface Water and Groundwater from Physical Presence			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
The physical presence of the Fourth Train Proposal, including hardstand (unsealed and sealed).	Additional hardstand, including over approximately 10 ha at the horizontal directional drilling site and 50 ha at the Gas Treatment Plant site. Delay to Foundation Project reinstatement activities/re-clearing reinstated Foundation Project land	Construction: Low	Construction: Medium
		Operations: Low	Operations: Medium

The Fourth Train Proposal will require up to 10 ha of unsealed hardstand at the Fourth Train Proposal horizontal directional drilling site during construction. A proportion of this area may need to be sealed. The Fourth Train Proposal will also require approximately 50 ha of hardstand at the Gas Treatment Plant site, which has already experienced compaction as a result of construction of the Foundation Project, and this hardstand will remain in place during operations. The Fourth Train Proposal Feed Gas Pipeline System will be constructed over approximately 15 ha, which has already been compacted by machinery and vehicles during Foundation Project construction .

The Fourth Train Proposal will also require a delay to Foundation Project reinstatement activities while the Fourth Train Proposal is being constructed, e.g. at the Additional Support Area. Surface water will be affected to some degree through alteration of surface water flows, causing increased run-off. Unsealed hardstand areas have less potential to modify infiltration and run-off than sealed hardstand areas, with compacted areas having the least potential. However, it is likely there will be no change in the watertable level through alterations in recharge rate; the aquifer has been documented across Barrow Island (Chevron Australia 2014) and recharge from the Fourth Train Proposal Footprint represents a small proportion of total aquifer recharge.

The Fourth Train Proposal additional to the approved Foundation Project will extend the area over potential impacts from physical presence may occur, largely within the Combined Gorgon Gas Development Footprint. Following reinstatement, these potential impacts will be mostly constrained to the Gas Treatment Plant site. Experience gained as part of the Foundation Project (Section 3.5.1.6) indicates that groundwater levels have not been affected by construction at the Gas Treatment Plant site. No measurable change in the watertable level is expected.

Illustrative measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Table 9-5 and Table 9-7 for assessment purposes.

Table 9-7: Illustrative Mitigation and Management Measures for Physical Presence

Approved Foundation Project EMP	Illustrative Measures
Horizontal Directional Drilling Management and Monitoring Plan	Measures to reduce the requirement for a larger cleared footprint at the horizontal directional drilling work site include the following: • use of the pipeline right-of-way (Feed Gas Pipeline System Footprint) for site access, negating the need for additional clearing to access the horizontal directional drilling work site • waste forecasting and regular waste pick-ups to reduce the space requirements for waste storage.
Post-Construction Rehabilitation Management Plan	Surface drainage patterns (hydrology) will be rehabilitated on all disturbed areas to reduce erosion from surface water flow. Practices to achieve this will include: • recording the surface topography of the area prior to disturbance using standard survey techniques, consideration will be given to the use of remote sensing if it can achieve adequate resolution, include information on surface stability, soil structure and estimates of overland surface water flows • rehabilitate a surface profile with properties that exhibit similar infiltration and water retention characteristics for the targeted vegetation outcome to analogue sites • unless inappropriate for the targeted vegetation outcome, encourage local retention and infiltration of rainfall on rehabilitated areas by creating surface roughness through light cultivation on the contour, as required, and spreading vegetation mulch where available on the contour to restrict surface run-off and reduce erosion • installing banks or other appropriate earthworks, if required, to direct and control surface water flow at a local scale discharging on to undisturbed stable ground where practicable • review and repair gullies (>30 cm deep) on a case-by-case basis when they occur • monitor using Landscape Function Analysis or similar to measure water infiltration and retention
	When the disturbed area is available for rehabilitation, then the following tasks will be completed: • Depending on the characteristics of the target vegetation and desired substrate, the surface of the area to be rehabilitated will be ripped on the contour to the depth of any machinery-induced compaction. • Surface drainage patterns will be re-established to be consistent with that occurring prior to disturbance.
	After bedding and padding of pipelines in the trenches has been completed, the following steps will be undertaken: • Trenches will be filled, compacted and covered with a crowned profile. • Drainage will be re-established by creating breaks in the crown. • Topsoil and vegetation will be respread across the pipeline easement (Feed Gas Pipeline System Footprint).

Potential incremental impacts to surface water are predicted to be confined within the Fourth Train Proposal Footprint and its immediate vicinity during construction and operations. Potential impacts will be short term at the horizontal directional drilling site and the Feed Gas

Pipeline System Footprint in areas subject to reinstatement. As a result, a 'Low' potential impact to surface water and groundwater is predicted.

The Fourth Train Proposal additional to the approved Foundation Project will extend the area over which potential impacts may take place. As a result, the additional impact to surface water and groundwater is assessed as 'Medium'. The additional impact ranking does not represent a change in the level of potential impact to that assessed for the approved Foundation Project, primarily due to the similar land requirements and physical presence characteristics of the Combined Gorgon Gas Development compared with the approved Foundation Project.

9.4.2.3 Spills and Leaks

There is potential for surface water and groundwater to be degraded by hazardous materials (e.g. hydrocarbons, wastes, contaminated wastewater) from accidental spills or leaks.

Potential Impact on Surface Water and Groundwater from Spills and Leaks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
As described in Section 9.3.2.2.	As described in Section 9.3.2.2.	Construction: Low	Construction: Medium
		Operations: Medium	Operations: Medium

Spills and leaks have the potential to contaminate surface water if they occur in the vicinity of ephemeral creeks traversing the Fourth Train Proposal Feed Gas Pipeline System during periods of flow (typically after heavy rainfall events), or if contamination was present as surface water formed following rain. There is also potential for contaminants from spills and leaks to pass through the soil profile and enter the watertable before spreading. Spills or leaks could occur during construction and operation of the Fourth Train Proposal, as described in Section 9.3.2.2. Spills are expected to be contained through design controls (e.g. bunding) and/or timely spill response and clean-up actions, as has been demonstrated from the Foundation Project experience to date (Section 16.2.1). Despite all preventive measures included in the design and operation of Fourth Train Proposal, leaks or spills could occur. The Foundation Project has reported one detection of levels of analytes above reporting limits—hexavalent chromium was detected within the Gas Treatment Plant site at a single bore location—before returning to levels comparable with the baseline (Section 3.5.1.6). The Fourth Train Proposal additional to the approved Foundation Project will result in increased quantities of hazardous materials that have the potential to result in spills or leaks (Section 9.3.2.2). However, no different sources will be introduced. Potential impacts to groundwater may occur over the Combined Gorgon Gas Development Footprint or immediate vicinity. Ephemeral creeks traversing the Foundation Project Feed Gas Pipeline Systems Footprint have the potential to be affected within its immediate vicinity.

Illustrative measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Table 9-5 for assessment purposes.

Potential incremental impacts to surface water are predicted to be localised and short term. Potential impacts are not expected outside periods of high-intensity rainfall. Potential impacts to groundwater are predicted to be contained within the Fourth Train Proposal Footprint or its immediate vicinity. During construction, this is assessed as resulting in a 'Low' potential impact. Potential impacts are assessed as 'Medium' during operations, representing the increased likelihood for spills and leaks and the higher volumes of hazardous materials used during operations.

The Fourth Train Proposal additional to the approved Foundation Project may result in potential impacts within the Combined Gorgon Gas Development Footprint or its immediate vicinity. The additional impact to surface water and groundwater is assessed to be 'Medium' during Fourth Train Proposal construction and operations activities, resulting from increases in the quantities of hazardous materials used from those predicted to be used by the Fourth Train Proposal alone. This does not represent a change in the level of potential impact from the approved Foundation Project as spills are expected to be contained through design controls (e.g. bunding) and/or timely spill response and clean-up actions.

9.4.3 Proposed Management

The GJVs consider that the potential impacts to surface water and groundwater by the Fourth Train Proposal can be effectively managed under the relevant Ministerial Conditions for the Foundation Project. No measures or controls additional to those required for the Foundation Project were assessed as being necessary to manage the incremental or additional impacts to surface water and groundwater from the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the various Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal's horizontal directional drilling activities, locations and potential impacts will also need to be prepared and approved as described in Section 16.2.3.3. However, the GJVs anticipate that the mitigation and management measures included within the Foundation Project Horizontal Directional Drilling Management and Monitoring Plan, will also apply and will prevent and manage any potential impact to relevant environmental factors, including protected species, as a result of the Fourth Train Proposal.

The EMPs that are relevant to addressing potential impacts to surface water and groundwater for the Fourth Train Proposal are:

- Terrestrial and Subterranean Environment Protection Plan and associated Procedures
- Terrestrial and Subterranean Environmental Monitoring Program
- Horizontal Directional Drilling Management and Monitoring Plan
- Solid and Liquid Waste Management Plan
- Post-Construction Rehabilitation Plan and associated sub-Plan.

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

9.4.4 Predicted Environmental Outcome

For both construction and operations activities, potential incremental impacts to ephemeral creeks are expected to be localised, and confined to those ephemeral creeks traversing the Fourth Train Proposal Feed Gas Pipeline System Footprint. Surface water flows following rainfall will be affected on a localised scale, causing increased run-off in the immediate vicinity of the Fourth Train Proposal Footprint. Potential incremental impacts to groundwater are predicted to be localised. No different impacts were identified.

The Fourth Train Proposal will result in additional construction duration within which potential impacts resulting from vegetation clearing and earthworks may take place compared with the approved Foundation Project. The Fourth Train Proposal will increase the area over which localised potential impacts from all stressors may occur, for both construction and operation activities. However, potential impacts to surface water and groundwater are predicted to remain localised within the vicinity of the Combined Gorgon Gas Development Footprint.

The stressors are not predicted to act synergistically or interact otherwise to cause a greater impact than when considered separately. Potential impacts to surface water and groundwater are not predicted to impact existing and potential environmental values, including ecosystem function. The GJVs consider that the stressors to surface water and groundwater from the Fourth Train Proposal will be adequately managed such that the impacts are environmentally acceptable and the environmental objective (Section 9.4.1.1) is met.

9.5 Vegetation and Flora

9.5.1 Assessment Framework

9.5.1.1 Environmental Objective

The environmental objective established in this PER/Draft EIS for vegetation and flora is:

> *To maintain the abundance, diversity, geographic distribution, and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.*
>
> *To protect Declared Rare and Priority Flora, consistent with the provisions of the* Wildlife Conservation Act.

9.5.1.2 Relevant Policies, Plans, and Guidelines

Table 9-8 lists specific State policy and framework documents relating to vegetation and flora.

Table 9-8: Western Australian State Policy Relevant to Vegetation and Flora

Policy, Plan, Guideline	Intent
EPA Position Statement No. 2 – Environmental Protection of Native Vegetation in Western Australia (EPA 2000)	Provides an overview of the EPA's position on the clearing of native vegetation in Western Australia with particular reference to clearing within the agricultural area.
EPA Position Statement No. 3 – Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002)	Encourages proponents to focus their attention on the significance of biodiversity and therefore the need to develop and implement best practice in terrestrial biological surveys. It also enables greater certainty for proponents in the Environmental Impact Assessment (EIA) process by defining the principles the EPA will use when assessing proposals that may impact on biodiversity values.
EPA Guidance Statement No. 51 – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004a)	Provides guidance and information to environmental consultants and proponents about expected standards and protocols for terrestrial flora and vegetation surveys.
EPA Guidance Statement No. 6 – Rehabilitation of Terrestrial Ecosystems (EPA 2006)	Ensures the return of biodiversity in rehabilitated areas by increasing the quality, uniformity, and efficiency of standards and processes for rehabilitation of native vegetation in Western Australia.

9.5.2 Assessment and Mitigation of Potential Impacts

The vegetation and flora of Barrow Island exhibits floral affinities with both the arid Pilbara Region and the Cape Range area of the Australian mainland (Chevron Australia 2014). Further information about the vegetation and flora on Barrow Island is detailed in Section 6.5.1.

Barrow Island is a Class A Nature Reserve for the purposes of 'Conservation of Flora and Fauna'. A total of 825 vegetation associations have been identified on Barrow Island, not including habitats that were classed as disturbed (e.g. from previous and existing activities such as petroleum exploration and production) (Astron Environmental Services 2009, 2011). None of these associations occur entirely within the areas identified as Foundation Project

Footprint and/or Fourth Train Proposal Footprint. No Threatened Ecological Communities (TECs), as listed in Western Australian DPaW's TEC Database (DPaW 2013), have been recorded or are known to occur on Barrow Island.

The Western Australian Herbarium has identified and confirmed 226 plant taxa from 131 genera and 68 families on Barrow Island (Chevron Australia 2014). All plant taxa on Barrow Island occur on the mainland, except for *Cucumis* sp. Barrow Island (D.W. Goodall 1264) and *Amaranthus* sp. Barrow Island (R Buckley 6884). More recently, Astron Environmental Services (2011) identified 376 plant taxa, of which 28 are introduced species. No threatened flora listed under the EPBC Act, or Declared Rare Flora listed under the Wildlife Conservation Act have been recorded on Barrow Island (Chevron Australia 2014). Three Priority species listed by DPaW have been collected on Barrow Island.

Vegetation and flora species identified as conservation-significant on Barrow Island because of their restricted distribution are described in Section 9.5.2.5.

Potential stressors from the Fourth Train Proposal that may affect vegetation and flora were identified and are discussed below. Potential stressors include:

- vegetation clearing and earthworks
- spills and leaks
- fire
- atmospheric emissions.

9.5.2.1 Vegetation Clearing and Earthworks

Vegetation clearing and earthworks have the potential to impact vegetation and flora including:

- loss of and/or disturbance to vegetation and flora species, including Priority or Restricted communities and species
- smothering and loss of vegetation, including seeds, from sedimentation as a result of erosion
- loss or damage to vegetation and flora through pooling of water in cleared areas, or adjacent to cleared areas, following a rain event.

Potential Impact on Vegetation and Flora from Vegetation Clearing and Earthworks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
As described in Section 9.3.2.1.	As described in Section 9.3.2.1.	Construction: Medium	Construction: Medium
		Operations: N/A	Operations: N/A

The exact location, size and dimensions of the Fourth Train Proposal horizontal directional drilling site have not yet been finalised. However, it has been possible to assess potential impacts as design work to date has determined the Fourth Train Proposal horizontal directional drilling site will be located within the area depicted in Figure 4-4. This assessment therefore includes quantification of the vegetation associations contained within the horizontal directional drilling site area, an area of approximately 20 ha. It is important to note that that the horizontal directional drilling site, and the vegetation clearing necessary for its construction, will be over a smaller area—up to 10 ha—and restricted within the allocated uncleared land available for tenure on Barrow Island under the *Barrow Island Act 2003* (WA).

Up to 14 vegetation associations are contained within the horizontal directional drilling site area and may undergo clearing as part of the Fourth Train Proposal. Descriptions of these vegetation associations are provided in Table 6-2. All these vegetation associations exist elsewhere on Barrow Island, therefore no vegetation association will be completely cleared as a result of the Fourth Train Proposal (Table 9-9). Note: Chevron Australia has mapped approximately 11% of the total area of Barrow Island (23 567 ha). Therefore, it is likely that the proportions of specific vegetation types that may be cleared are underestimated.

Partial clearing of five vegetation associations that have restricted distribution on Barrow Island may be required for the Fourth Train Proposal, including one vegetation association typically containing more than 2% cover of the restricted distribution flora species *Erythrina vespertilio*. These vegetation associations are not protected by legislation and are discussed further in Section 9.5.2.5.

Table 9-9: Vegetation Communities that may be Affected by Vegetation Clearing

Vegetation Association	Area known on Barrow Island(ha)(1, 2)	Fourth Train Proposal Horizontal Directional Drilling Site Area		Fourth Train Proposal Additional to the Approved Foundation Project Vegetation Clearing	
		Total Area (ha)	Proportion of Association (%)	Total Area (ha)	Proportion of Association Prior to Foundation Project clearing (%)
C1c1 (3)	7.89 (8.84)	0.96	12.17	1.91	21.61
C2c2 (3)	7.39 (7.52)	0.07	0.95	0.2	2.66
C4a1 (3)	8.26 (9.60)	1.14	13.80	2.48	25.83
C4a2	5.95 (5.95)	0.50	8.40	0.5	8.40
C4a3	5.25 (5.68)	0.79	15.05	1.22	21.48
C4a4	7.70 (7.85)	2.83	36.75	2.98	37.96
F11b2 (4)	4.89 (6.25)	0.44	9.00	1.8	28.80
F4a2 (3)	3.41 (3.51)	0.10	2.85	0.11	3.21
F6a6	3.98 (4.28)	1.72	43.22	2.02	47.20
F6k2	5.65 (5.85)	0.57	10.09	0.77	13.16
F9n11	4.04 (4.13)	0.10	2.48	0.19	4.60
L12g12	52.85 (55.23)	7.59	14.36	9.97	18.05
L8c5	2.48 (2.97)	0.93	37.50	1.42	47.81
L8q2	3.84 (4.54)	1.20	31.25	1.9	41.85

Notes:

1. *Areas in parenthesis denote area known on Barrow Island prior to Foundation Project vegetation clearing.*
2. *Currently, Chevron Australia has mapped 2733 ha of vegetation on Barrow Island, which is approximately 11% of the total area of Barrow Island (23 567 ha). Therefore, it is likely that vegetation associations have a greater extent on Barrow Island and actual proportions of specific vegetation associations that may be cleared are less than presented.*
3. *Conservation-significant vegetation: Vegetation restricted in areal coverage on Barrow Island, based on total land area of Barrow Island (Astron Environmental Services 2011).*
4. *Conservation-significant vegetation: Vegetation that satisfies one of the four categories of distribution restricted vegetation plus contains more than 2% cover of flora that are either Declared Rare, Priority, EPBC Act-listed or Specially Protected (Astron Environmental Services 2011).*

Potential impacts to vegetation and flora from erosion, resulting from smothering and sedimentation, may occur during high-intensity rain and/or wind events. High-intensity rain events may also cause localised pooling of surface water adjacent to cleared land, with resulting damage to vegetation. Resulting potential incremental impacts are predicted to be limited to the immediate vicinity of the Fourth Train Proposal Footprint, and in Foundation Project areas where reinstatement is delayed or where re-clearing of Foundation Project land is required as a result of the Fourth Train Proposal.

Areas no longer required for future construction or operation, including at the horizontal directional drilling sites and Foundation Project Feed Gas Pipeline Systems Footprint, will be rehabilitated. Areas that will not be rehabilitated include maintenance areas and access routes.

Illustrative mitigation and management measures for this stressor taken from currently approved Foundation Project EMPs are presented in Table 9-10, and, for erosion and surface water pooling, in Table 9-4 and Table 9-7, respectively.

Table 9-10: Illustrative Mitigation and Management Measures for Vegetation Clearing and Earthworks Activities

Approved Foundation Project EMP	Illustrative Measures
Horizontal Directional Drilling Management and Monitoring Plan	Measures to reduce the requirement for a larger cleared footprint at the horizontal directional drilling work site include the following: • use of the pipeline right-of-way (Feed Gas Pipeline System Footprint) for site access, negating the need for additional clearing to access the horizontal directional drilling work site • waste forecasting and regular waste pick-ups to reduce the space requirements for waste storage.
	• A seed collection program for *Erythrina vespertilio* will be initiated prior to clearing commencing.
	• Erosion barriers and sediment control structures will be put in place. • The work site will also be stabilised as soon as practicable after completion of the shore crossing.
Post-Construction Rehabilitation Plan	The following tasks shall be completed prior to clearing taking place: • Boundaries of each area will be surveyed and marked, the perimeters recorded and mapped in the Gorgon Geographic Information System (GIS) and provided to all appropriate contractors. • Map and segregate NIS and weed infestations with an appropriate buffer; identify specific management requirements. • An internal Ground Disturbance Certificate will be obtained. • Surface topography, hydrological and soils information will be recorded for each site including: ▪ physical and topographical ▪ groundwater ▪ fauna and flora (including ecological communities, significant habitats) ▪ topsoil properties ▪ storage location. This information will be used for vegetation and soil management and to inform reconstruction of the landform during rehabilitation. • If more than one vegetation community was identified on the site in initial surveys, then the boundaries of vegetation communities will be identified. • If seed or fruits are present on the vegetation to be cleared, then where practicable these should be collected and stored appropriately.
	When the disturbed area is available for rehabilitation, then the following tasks will be completed: • Depending on the characteristics of the target vegetation and desired

Approved Foundation Project EMP	Illustrative Measures
	substrate the surface of the area to be rehabilitated will be ripped on the contour to the depth of any machinery-induced compaction. • Surface drainage patterns will be re-established to be consistent with that occurring prior to disturbance. • Topsoil from a similar vegetation community will be respread at no greater depth than originally removed; if required, topsoil may be spread more thinly. • If seeds of species in the target vegetation communities are available they should be respread. • Should monitoring indicate that grazing is significantly impeding rehabilitation recovery, then the perimeter of rehabilitation areas may be fenced to exclude grazing fauna. The fence will be maintained until such time the vegetation is sufficiently established to withstand grazing pressure.

Potential incremental impacts to vegetation and flora will be confined mainly within the Fourth Train Proposal Footprint, although limited impacts may occur within its immediate vicinity. Vegetation communities that will be impacted by clearing associated with the Fourth Train Proposal are well-represented outside the Fourth Train Proposal Footprint. Vegetation clearing and earthworks activities are predicted to result in a largely short-term, localised decrease in the abundance of flora, and a short-term, localised impact to vegetation community structure. Areas to be cleared include vegetation associations and flora of restricted distribution on Barrow Island, which are not protected by legislation, resulting in a 'Medium' potential impact.

9.5.2.1.1 Assessment of Additional Impacts

Vegetation clearing and earthworks additional to the approved Foundation Project are described in Section 9.3.2.1. These activities will result in an additional area and period within which these activities will take place.

Thirteen of the fourteen vegetation associations that may be partially cleared as part of the Fourth Train Proposal were subject to clearing as part of the approved Foundation Project. Table 9-9 details the area of these vegetation associations known on Barrow Island prior to the Foundation Project, and the proportions affected by the approved Fourth Train Proposal additional to the Foundation Project. Further vegetation associations were cleared as a result of the Foundation Project. These are not affected by vegetation clearing activities resulting from the Fourth Train Proposal and therefore are not included in Table 9-9.

The Fourth Train Proposal additional to the approved Foundation Project will extend the duration of potential impacts as the construction of the Fourth Train Proposal will continue past the construction of the Foundation Project. The area over which vegetation clearing and earthworks activities will take place will increase by up to 10 ha, within the 332 ha of uncleared land available for tenure on Barrow Island under the *Barrow Island Act 2003* (WA) for the Combined Gorgon Gas Development. This includes increased proportions of restricted distribution vegetation associations, including vegetation associations containing *E. vespertilio*.

The potential additional impact to vegetation and flora is assessed as 'Medium', which is the same level of potential impact as determined for the Foundation Project using the assessment methodology detailed in Section 8. This is due to the smaller clearing and earthworks requirements of the Fourth Train Proposal (up to 10 ha) compared with the Foundation Project (up to 332 ha), and the low number of restricted distribution vegetation associations identified as being impacted as a result of the Fourth Train Proposal compared with the Foundation Project.

9.5.2.2 *Atmospheric Emissions (except dust)*

Changes to vegetation community composition and taxon dominance may result from the release of atmospheric emissions causing nitrogen enrichment of soil, changes in soil acidity, and physiological effects on plants from pollutants.

Potential Impact on Vegetation and Flora from Atmospheric Emissions			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Atmospheric emissions will be produced during routine operations of the Fourth Train Proposal Gas Treatment Plant.	Additional atmospheric emissions, consisting of key pollutants including oxides of nitrogen (NO_X), oxides of sulfur (SO_X), and ozone (O_3), will be produced by the Fourth Train Proposal	Construction: N/A	Construction: Low
		Operations: Low	Operations: Low

In the absence of Australian ecosystem-specific criteria for acid deposition (sulfur dioxide and nitrogen) and ozone, comparison to the World Health Organization (WHO) Air Quality Guidelines for Europe (WHO 2000) has been used as the most relevant criteria to assess the potential for impacts to vegetation and flora. Section 5.2 contains a full discussion of atmospheric emissions over the life of the Fourth Train Proposal, including predicted air quality impacts, and mitigation and management measures that will be implemented for each major emissions source.

The Air Quality Assessment conducted on the operation of the Fourth Train Proposal Gas Treatment Plant predicted ozone and acid deposition from the Fourth Train Proposal and baseline (including the Foundation Project) (Table 5-8 and Table 5-9). The modelled acid deposition loads and ozone levels for Barrow Island and the Pilbara Region are within the specified WHO guidelines (WHO 2000). Modelling studies indicate that the predicted change to the ambient air quality due to the incremental emissions from the Fourth Train Proposal on Barrow Island will be negligible (Table 5-8 and Table 5-9).

Vegetation and flora on Barrow Island will be exposed to atmospheric emissions from the Fourth Train Proposal additional to the approved Foundation Project, but at concentrations considerably below the relevant critical levels and loads that have been determined as potentially harmful.

Vegetation and flora will be exposed to atmospheric emissions emitted over the lifetime of the Fourth Train Proposal. This is assessed as resulting in a ‘Low’ potential impact. Potential impacts to vegetation and flora from atmospheric emissions are not expected to result in a measureable impact to vegetation and flora species on Barrow Island.

The Fourth Train Proposal additional to the approved Foundation Project is predicted to result in a ‘Low’ potential impact. Atmospheric emissions are not expected to result in a measureable potential impact to vegetation and flora species on Barrow Island.

9.5.2.3 *Spills and Leaks*

There is potential for vegetation and flora to be degraded by direct contact with hazardous materials (e.g. hydrocarbons, wastes, contaminated wastewater) from accidental spills or leaks.

Potential Impact on Vegetation and Flora from Spills and Leaks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
As per Section 9.3.2.2	As per Section 9.3.2.2	Construction: Low	Construction: Low
		Operations: Low	Operations: Low

Hydrocarbons and other hazardous materials will be used routinely during the construction and operation of the Fourth Train Proposal (Section 9.3.2.2). Vegetation has the potential to be impacted during construction if spills or leaks occur outside the Fourth Train Proposal Footprint. During operations, reinstated vegetation within the Combined Gorgon Gas Development Footprint could also be potentially impacted if spills or leaks occur along the Fourth Train Proposal Feed Gas Pipeline System. Spills and leaks are expected to be contained through design controls (e.g. bunding) and/or timely spill response and clean-up actions, as demonstrated by the Foundation Project experience to date (Section 9.3.2.2), reducing the potential for impacts to vegetation and flora.

The Fourth Train Proposal additional to the approved Foundation Project will result in increases in the quantities of hazardous materials and therefore in the potential for spills and leaks to occur, although no different sources of potential spills and leaks will be introduced (Section 9.3.2.2).

Illustrative measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Table 9-5 for assessment purposes.

Potential incremental impacts to vegetation and flora, including vegetation and flora of conservation significance, as a result of contamination due to spills and leaks are predicted to be contained within the Fourth Train Proposal Footprint or its immediate vicinity, and are expected to be short term. This is assessed as resulting in a 'Low' potential impact.

The Fourth Train Proposal additional to the approved Foundation Project may result in short-term potential impacts within the Combined Gorgon Gas Development Footprint or its immediate vicinity. The additional impact to vegetation and flora is assessed to be 'Low'. This does not represent a change to the level of potential impact to that assessed for the approved Foundation Project.

9.5.2.4 Fire

Impacts to vegetation and flora from unplanned fire will vary depending on the scale and intensity of the fire, but can result in loss of vegetation associations and individual flora species, change in species composition and community structure, and loss of seed stock.

Potential Impact on Vegetation and Flora from Unplanned Fire as a Result of the Fourth Train Proposal			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Use of machinery and equipment.	Extension of construction period and associated higher fire-risk activities.	Construction: Medium	Construction: Medium
		Operations: Low	Operations: Low

Machinery and equipment use, including blasting and hot works such as welding and grinding, can act as an ignition source due to combustion or high temperatures occurring during use. Resulting small fires have the potential to ignite vegetation, particularly during periods of low rainfall.

During operations, there is a decreased potential for fires to occur as higher-risk activities, and therefore potential ignition sources, will be reduced. Machinery use within the Gas Treatment Plant site during both construction and operations has a lower potential to ignite vegetation, as the site has been cleared under the Foundation Project.

Unplanned fires as a result of the Fourth Train Proposal are expected to be prevented or rapidly extinguished, and contained within the Fourth Train Proposal Footprint or its immediate vicinity. Under the Foundation Project, small fires have occurred within the Foundation Project Footprint, but have been restricted to Foundation Project equipment or facilities and quickly extinguished (Chevron Australia 2012, 2013). The Foundation Project has recorded one fire outside the Foundation Project tenure boundary, approximately 750 m south of the Gas Treatment Plant site. The fire was managed through existing measures.

The Fourth Train Proposal additional to the approved Foundation Project will result in additional construction activities, increasing the time within which higher fire-risk activities will take place more frequently than during operations.

A future decrease in rainfall, leading to drier conditions and a change in vegetation as a result of climate change, could increase the intensity of an unplanned fire. However, the Fourth Train Proposal does not present any different fire ignition sources than those for the Foundation Project and therefore the current fire prevention and management measures, are expected to be adequate. However, Chevron Australia's commitment to continuous improvement means that the Fire Management Plan will be adapted to new information where required.

Illustrative measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Table 9-11 for assessment purposes.

Table 9-11: Illustrative Mitigation and Management Measures for Unplanned Fire as a Result of the Fourth Train Proposal

Approved Foundation Project EMP	Illustrative Measures
Fire Management Plan	• Site-based personnel working on the Gorgon Gas Development and Jansz Feed Gas Pipeline will undertake appropriate inductions that include information on fire management. • Train selected personnel in the use of firefighting equipment. • Current access roads that also serve as firebreaks shall be kept clear of vegetation. • Firebreaks will be established and maintained around facilities in accordance with the *Bush Fires Act 1954* (WA), unless exemptions have been granted. • Provide and locate firefighting equipment in accordance with the relevant standards and requirements for all work that may cause fire, e.g. hot work, earth moving during construction activities. • Provide vehicular firefighting capabilities for Onshore Feed Gas Pipeline and Horizontal Directional Drilling Pipeline activities. • Before an off-road permit is granted the fire warning level issued for the mainland by the Bureau of Meteorology will be taken into account. Permits will not be granted on days of 'extreme' fire danger where practicable. Where this is not practicable, the risk of fire will be discussed at pre-start meetings and included in job hazard analysis risk assessments at an operational level. • Stationary activities in the construction phase that are a potential ignition source must have appropriate firefighting equipment on site, with trained fire spotters for hot work as detailed in the internal hot work permit for the activity.
	• Provide and locate firefighting equipment in accordance with the relevant standards and requirements for all work that may cause fire, e.g. hot work, earthmoving. • Establish emergency response teams trained in firefighting operations and equipped with appropriate firefighting equipment. • Permit smoking only in designated smoking areas that have portable firefighting equipment, fixed point lighters and butt disposal facilities. • Activities with a potential to ignite a fire require an internal permit, e.g. welding, cutting. • Mobile refuelling will be undertaken in areas with appropriate fire mitigation measures in place.

Potential incremental impacts to vegetation and flora from unplanned fire as a result of the Fourth Train Proposal are predicted to be short term and contained within the Fourth Train Proposal Footprint or its immediate vicinity. This is assessed as resulting in a 'Medium' potential impact during construction and 'Low' during operations.

The Fourth Train Proposal additional to the approved Foundation Project may result in short-term potential impacts within the Combined Gorgon Gas Development Footprint or its immediate vicinity. The additional impact to vegetation and flora is assessed to be 'Medium' during the Fourth Train Proposal construction, and 'Low' during operations. This represents a decrease to the level of potential impact determined for the Foundation Project during operations, which was ranked as 'Medium'. This decrease is due to the experience gained during the Foundation Project to date, which demonstrates that the measures in place are effective in preventing or controlling fires, and the decreased likelihood of potential impact from fire during operations.

9.5.2.5 Conservation-significant Vegetation and Flora

No ecological communities listed under the EPBC Act or TECs listed in DPaW's TEC Database (DPaW 2013) are known to occur on Barrow Island.

Barrow Island Creekline Vegetation, listed by DPaW as a PEC occurring on Barrow Island, has the potential to be impacted by sedimentation caused by erosion in the immediate vicinity of the Foundation Project Feed Gas Pipeline Systems Footprint. However, no significant impact on surface water landforms from activities related to the Foundation Project has been detected in the areas monitored using LiDAR data captured between 2009 and 2012. A degree of sediment deposition appeared in some sites in 2011, but this is considered to be a natural phenomenon following a heavy rainy season in 2010 during which approximately 650 mm of water fell over a period of five months, with 380 mm in a single cyclonic event (Chevron Australia 2012, 2013).

No threatened flora listed under the EPBC Act, or Declared Rare Flora protected under the Wildlife Conservation Act are known to occur on Barrow Island (Chevron Australia 2014). No Priority 1 or 2 Flora species as listed by DPaW are predicted to be impacted due to their proximity to the Fourth Train Proposal; the closest recording of a Priority 1 or 2 Flora species is approximately 1.15 km outside the horizontal directional drilling site (Section 6.5.1.5). The Priority 3 species *Corchorus congener* is present in the vicinity of the Fourth Train Proposal horizontal directional drilling site. However, this spreading shrub is widely distributed on parts of Barrow Island, and is well recorded from Cape Range on the mainland (Astron Environmental Services 2011); therefore, it is not considered as conservation-significant flora.

The Fourth Train Proposal will result in the partial clearing of up to five vegetation associations considered locally sensitive due to their restricted distribution on Barrow Island, although they are not protected by legislation. None of these vegetation associations will be completely cleared as a result of the Fourth Train Proposal; they are well-represented in vegetation that will remain following clearing activities. Table 9-12 details the approximate proportion of conservation-significant vegetation associations on Barrow Island that are within the horizontal directional drilling site area, and therefore have the potential to be affected from the Fourth Train Proposal.

One of these five vegetation associations (F11b2) is also deemed conservation-significant as it contains more than 2% of *Erythrina vespertilio. E. vespertilio* is widespread across the northern Australian mainland (Astron Environmental Services 2011), and is not protected by legislation. However, *E. vespertilio* is identified as having restricted distribution on Barrow Island (Astron Environmental Services 2011). Twenty-five individuals of *E. vespertilio* are present within the horizontal directional drilling site area, and some of these individuals may be removed for the construction of the horizontal directional drilling site. Targeted searches for *E. vespertilio* elsewhere on Barrow Island have verified the presence of four additional populations (Astron Environmental Services 2011), none of which are within the Combined Gorgon Gas Development Footprint. Clearing of *E. vespertilio* is not expected to impact the population viability of this species on Barrow Island.

The Fourth Train Proposal shore crossing has been designed to reduce the amount of clearing required, including in conservation-significant vegetation associations, through the use of horizontal directional drilling. Other design measures include locating the horizontal directional drilling site largely to the south of the Foundation Project horizontal directional drilling site, where a smaller area of conservation-significant vegetation associations and individuals of *E. vespertilio* are present (Figure 9-2 and Figure 6-10).

Table 9-12: Conservation-significant Vegetation Associations within the Fourth Train Proposal Horizontal Directional Drilling Site Area

Vegetation Association	Description	Habitat	Area known on Barrow Island (ha) [1]	Approximate size of association within the horizontal directional drilling site area (ha)	Approximate proportion of total vegetation association
C1c1 [2]	Grassland of *Spinifex longifolius* over very open herbs of *Threlkeldia diffusa* with low scattered shrubs of *Rhagodia preissii* subsp. *obovata* and *Frankenia pauciflora* var. *pauciflora*.	Ridges and back slopes of white sandy foredunes	7.89	0.96	12.1%
C2c2 [2]	Open grassland of *Spinifex longifolius* with low scattered *Atriplex isatidea*, *Myoporum montanum*, *Euphorbia myrtoides* and *Salsola tragus* shrubs and herbs.	Seaward face of white sandy foredunes	7.39	0.07	0.9%
C4a1 [2]	Low open shrubland to shrubland of *Acacia coriacea* subsp. *coriacea* with *Threlkeldia diffusa* over hummock grassland to closed hummock grassland of *Triodia epactia*.	Back slopes of secondary dune slopes and ridges	8.26	1.14	13.8%
F11b2[3]	Low open woodland of *Erythrina vespertilio* over low open shrubland of *Pentalepis trichodesmoides*, *Solanum lasiophyllum,* and *Trichodesma zeylanicum* over hummock grassland of *Triodia epactia* with patches of *T. wiseana*.	Red sandy flats with some limestone outcropping	4.89	0.44	9.0%
F4a2 [2]	Hummock grassland to closed hummock grassland of *Triodia angusta* with scattered *T. epactia* and *Eulalia aurea*.	Fringing claypan in shallow basin with loamy red silts	3.41	0.10	2.85%

Source: Astron Environmental Services 2011

Notes:

1. *Currently, Chevron Australia has mapped 2 733 ha of vegetation on Barrow Island, which is approximately 11% of the total area of Barrow Island (23 567 ha). Therefore, it is likely that vegetation associations have a greater extent on Barrow Island and actual proportions of specific vegetation associations that may be cleared are less than those presented*
2. *Conservation-significant vegetation: Vegetation restricted in areal coverage on Barrow Island, based on total land area on Barrow Island (Astron Environmental Services 2011)*
3. *Conservation-significant vegetation: Vegetation that satisfies one of the four categories of distribution restricted vegetation plus contains more than 2% cover of flora that are either Declared Rare, Priority, EPBC Act-listed, or Specially Protected (Astron Environmental Services 2011).*

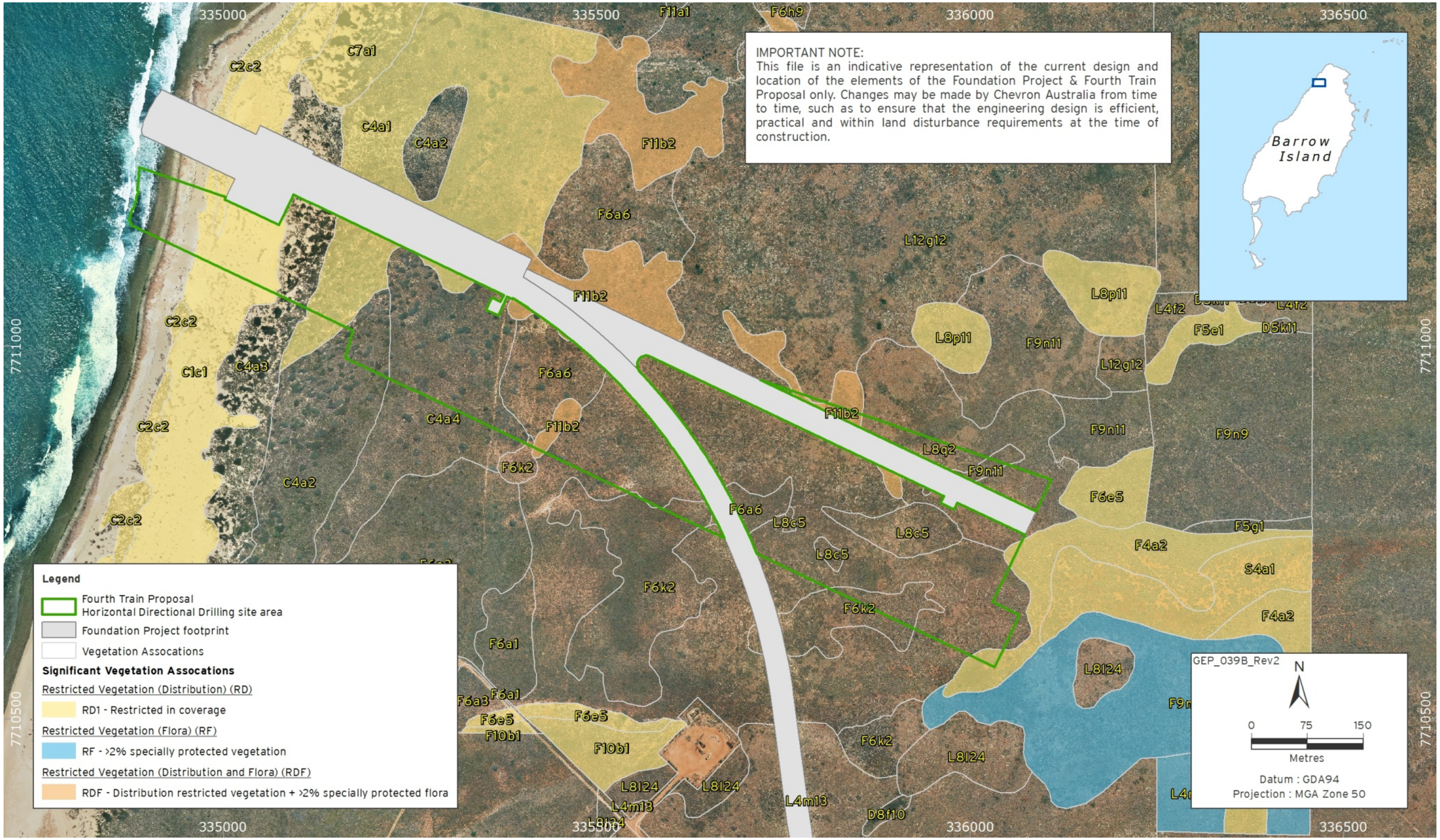

Figure 9-2: Conservation-significant Vegetation Associations in the Vicinity of the Fourth Train Proposal Horizontal Directional Drilling Site Area

9.5.3 Proposed Management

The GJVs consider the potential impacts to vegetation and flora by the Fourth Train Proposal can be effectively managed under the relevant Ministerial Conditions for the Foundation Project. No measures or controls additional to those required for the Foundation Project were assessed as being necessary to manage the incremental or additional potential impacts to vegetation and flora of the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the various Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal's horizontal directional drilling activities, locations and potential impacts will also need to be prepared and approved as described in Section 16.2.3.3. However, the GJVs anticipate that the mitigation and management measures included within the Foundation Project Horizontal Directional Drilling Management and Monitoring Plan, will also apply and will prevent and manage any potential impact to relevant environmental factors, including protected species, as a result of the Fourth Train Proposal.

The EMPs that are relevant to addressing potential impacts to vegetation and flora for the Fourth Train Proposal are:

- Terrestrial and Subterranean Environment Protection Plan and associated Procedures
- Terrestrial and Subterranean Environment Monitoring Program
- Fire Management Plan
- Horizontal Directional Drilling Management and Monitoring Plan
- Air Quality Management Plan
- Solid and Liquid Waste Management Plan
- Post-Construction Rehabilitation Plan and associated sub-Plan.

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

9.5.4 Predicted Environmental Outcome

Of the vegetation associations and flora identified on Barrow Island, none occur entirely within the areas identified as Foundation Project Footprint and Fourth Train Proposal Footprint.

For both construction and operations, potential incremental impacts to vegetation and flora are expected to impact plant individuals, and not result in a widespread or long-term decrease in abundance of flora, or impact the vegetation community structure. No different impacts to vegetation and flora were identified. Vegetation associations and flora species subject to clearing are well-represented elsewhere on Barrow Island.

The Fourth Train Proposal will result in additional construction activities (during which potential impacts may take place) compared with the construction for the approved Foundation Project. The Fourth Train Proposal additional to the approved Foundation Project will also increase the area over which impacts will occur, primarily due to clearing activities.

The stressors are not predicted to act synergistically or interact otherwise to cause a greater impact than when considered separately. Potential impacts to vegetation and flora are not predicted to impact the abundance, diversity, geographic distribution, and/or productivity of flora at species and/or ecosystem levels. The GJVs consider that the stressors to vegetation and flora from the Fourth Train Proposal will be adequately managed such that the impacts are environmentally acceptable and the environmental objective (Section 9.5.1.1) is met.

9.6 Terrestrial Fauna

9.6.1 Assessment Framework

9.6.1.1 Environmental Objective

The environmental objective established in this PER/Draft EIS for terrestrial fauna is:

> *To maintain the abundance, diversity, geographic distribution, and productivity of fauna at species and ecosystem levels through avoidance or management of adverse impacts and improvement of knowledge.*
>
> *To protect Specially Protected (Threatened) Fauna, consistent with the provisions of the* Wildlife Conservation Act.
>
> *To protect EPBC Act-listed threatened and migratory species.*

9.6.1.2 Relevant Policies, Plans, Guidelines

Table 9-13 lists specific policy and framework documents relating to terrestrial fauna.

Table 9-13: Western Australian State Policy Relevant to Terrestrial Fauna

Policy, Plan, Guideline	Intent
EPA Guidance Statement No. 56 – Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004b)	Provides direction and information on general standards and protocols for terrestrial fauna surveys to environmental consultants and proponents engaged in EIA activities.
EPA Position Statement No. 3 – Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002)	Encourages proponents to focus their attention on the significance of biodiversity and therefore the need to develop and implement best practice in terrestrial biological surveys. It also enables greater certainty for proponents in the EIA process by defining the principles the EPA will use when assessing proposals that may impact on biodiversity values.
EPA Guidance Statement No. 20 – Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009)	Provides direction and information on general standards and protocols for short-range endemic invertebrate fauna to environmental consultants and proponents engaged in EIA activities.

9.6.2 Assessment and Mitigation of Potential Impacts

Barrow Island is a Class A Nature Reserve, reflecting its importance as a refuge for wildlife species. Thirteen species of terrestrial mammals have been recorded as resident on Barrow Island, with a further two species of bats recorded as vagrants (Chevron Australia 2014). Barrow Island also hosts 45 species of terrestrial reptiles, and one species of frog. Fifty-one species of terrestrial avifauna have been recorded on Barrow Island, 16 of which are residents or regular migrants to Barrow Island. More than 2200 terrestrial invertebrate species have been identified to date on Barrow Island, several of which have been identified as short-range endemics (SREs). Section 6.5.3 provides further information on terrestrial fauna.

This section focuses on potential impacts to terrestrial mammals, reptiles, avifauna, and invertebrates. Particular consideration was given to species afforded specific protection under Commonwealth and/or State legislation. Table 9-14 lists fauna species deemed to be conservation-significant.

The following habitats defined as significant (Chevron Australia 2014) were also considered:

- Boodie warrens – habitat for Boodies, which are fauna of high conservation significance

- termite mounds that support high species-richness
- nests of raptors (birds of prey) that are not represented on Barrow Island in high numbers, and which provide habitat for fauna of high conservation significance.

Table 9-14: Conservation-significant Fauna Species Relevant to the Fourth Train Proposal

Common Name	Scientific Name	Commonwealth Protection[1]	State Protection[2, 3]
Mammals			
Barrow Island Euro	*Macropus robustus isabellinus*	V	Sch 1[2]
Spectacled Hare-wallaby	*Lagorchestes conspicillatus conspicillatus*	V	Sch 1[2]
Barrow Island Golden Bandicoot	*Isoodon auratus barrowensis*	V	Sch 1[2]
Boodie	*Bettongia lesueur*	V	Sch 1[2]
Water Rat	*Hydromys chrysogaster*	-	P4[3]
Avifauna			
White-winged Fairy-wren (Barrow Island)	*Malurus leucopterus edouardi*	V	Sch 1[2]

Notes:

1 *Status under the EPBC Act: V = Vulnerable; E = Endangered; CE = Critically Endangered; M = Migratory (matters of NES)*

2 *Status under the Wildlife Conservation Act: Sch 1 = Schedule 1: threatened flora or fauna*

3 *DPaW Current Threatened and Priority Fauna Ranking: P4 = Priority Four: rare or near threatened taxa or taxa requiring monitoring*

Potential stressors from the Fourth Train Proposal that may affect terrestrial fauna were identified and are discussed below. Potential stressors include:

- vegetation clearing and earthworks
- spills and leaks
- atmospheric emissions (except dust)
- fire
- physical interaction
- noise and vibration
- light emissions.

9.6.2.1 *Vegetation Clearing and Earthworks*

Clearing of vegetation can reduce the overall carrying capacity for fauna in the wider habitat. Fauna moving from cleared areas into adjacent habitat may experience increased resource competition among species already using the habitat.

Potential impacts relating to physical interaction during vegetation clearing and earthworks activities are discussed in Section 9.6.2.5.

Potential Impact on Terrestrial Fauna from Vegetation Clearing and Earthworks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
As per Section 9.3.2.1	As per Section 9.3.2.1	Construction: Low	Construction: Low
		Operations: N/A	Operations: N/A

Clearing of vegetation will occur over up to 10 ha at the Fourth Train Proposal horizontal directional drilling site, and over up to 25 ha of reinstated Foundation Project land (Section 9.3.2.1). Displacement of fauna may lead to the local loss of individuals through competition (Chevron Australia 2008), which may include individuals of conservation-significant species. However, clearing is expected to affect only a small number of terrestrial animals because of the small size of the area to be cleared, which is approximately 0.1% of Barrow Island.

No terrestrial fauna, including conservation-significant fauna, are known as restricted in distribution to the area nominated for clearing as part of the Fourth Train Proposal. There are no terrestrial fauna populations on Barrow Island that depend on the area nominated for clearing as a refuge. The vegetation associations within the area nominated for clearing, which provide habitat for fauna, are well-represented elsewhere on Barrow Island (Section 9.5.2.1).

While there is scope for SREs be restricted at small spatial scales, terrestrial habitats at the Fourth Train Proposal horizontal directional drilling site are well-represented elsewhere on Barrow Island. The vegetation clearing is at a small scale compared with the Foundation Project, and SREs are well-represented across Barrow Island. No isolated habitats are expected to be cleared and further SRE surveys are unwarranted.

Vegetation clearing additional to the approved Foundation Project will increase the area over which clearance will take place from approximately 1.41% to approximately 1.46% of Barrow Island. Vegetation clearing additional to the approved Foundation Project will be within the allocated uncleared land available for tenure on Barrow Island under the *Barrow Island Act 2003* (WA).

In addition, the Fourth Train Proposal is planned to delay reinstatement of vegetation at the Additional Support Area, which will delay the availability of approximately 20 ha of land for fauna to use as habitat following rehabilitation activities. There are no species dependent of the reinstatement of this land.

Illustrative measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Table 9-4 for assessment purposes.

Potential incremental impacts to terrestrial fauna as a result of vegetation clearing and earthworks are predicted to result in a short-term, localised impact to a small number of individuals without compromising the population viability of species on Barrow Island. This is assessed as resulting in a ‘Low’ potential impact during construction activities.

The Fourth Train Proposal additional to the approved Foundation Project will result in an additional period and an increase in area within which clearing and earthworks will take place. The additional impact to terrestrial fauna is assessed as ‘Low’ during Fourth Train Proposal construction activities. This does not represent an increase in significance of impact to that assessed for the approved Foundation Project, primarily due to the similar land requirements and physical presence characteristics of the Combined Gorgon Gas Development compared with the approved Foundation Project.

9.6.2.2 Spills and Leaks

Spills and leaks could potentially impact terrestrial fauna through direct contact and subsequent effects, or indirectly through loss or damage to terrestrial fauna habitat. There is also the potential for entrapment of terrestrial fauna in spills.

Potential Impact on Terrestrial Fauna from Spills and Leaks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
As per Section 9.3.2.2	As per Section 9.3.2.2	Construction: Low	Construction: Low
		Operations: Low	Operations: Low

Spills and leaks may occur during the life of the Fourth Train Proposal (Section 9.3.2.2), but are expected to be contained through design controls (e.g. bunding) and/or timely spill response and clean-up actions. During both construction and operations activities, the potential impacts to terrestrial fauna from spills and leaks associated with the Fourth Train Proposal are expected to be constrained to low numbers of individuals of small, less mobile fauna, such as invertebrates, that may come into contact with a spill or leak as it occurs. Even lower numbers of individuals of small, less mobile fauna are expected to be indirectly affected through potential impacts to vegetation from spills and leaks.

The Fourth Train Proposal additional to the approved Foundation Project will result in increases in the quantities of hazardous materials and therefore the potential for spills and leaks, although no different sources of potential spills and leaks will be introduced (Section 9.3.2.2). Although this may increase the number of fauna individuals that may be affected, potential impacts are still expected to be constrained to low numbers of individuals of small, less mobile fauna largely within the Combined Gorgon Gas Development Footprint and its immediate vicinity.

Illustrative measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Section 9.3.2.2 for assessment purposes. Mitigation and management measures for this stressor also include established procedures to manage injured fauna.

Potential incremental impacts to terrestrial fauna from spills and leaks are predicted to be contained within the Fourth Train Proposal Footprint or its immediate vicinity. This is assessed as resulting in a ‘Low’ potential impact.

The Fourth Train Proposal additional to the approved Foundation Project may result in potential impacts within the Combined Gorgon Gas Development Footprint or its immediate vicinity. The additional impact to terrestrial fauna from spills and leaks is assessed to be ‘Low’. This does not represent a change to the level of potential impact compared to that assessed for the approved Foundation Project, as potential spills and leaks are considered to be managed.

9.6.2.3 Atmospheric Emissions (except dust)

Potential impacts to terrestrial fauna from atmospheric emissions include sublethal effects from inhalation of pollutants or ingestion of pollutants which may be deposited on vegetation, or direct toxic effects from emissions.

Potential Impact on Terrestrial Fauna from Atmospheric Emissions			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Routine operations of the Fourth Train Proposal Gas Treatment Plant	Additional atmospheric emissions, consisting of key pollutants including oxides of nitrogen (NO_X), oxides of sulfur (SO_X), and ozone (O_3), will be produced by the Fourth Train Proposal	Construction: N/A	Construction: Low
		Operations: Low	Operations: Low

Impacts of atmospheric pollutants and air toxics on the terrestrial fauna of Barrow Island are assessed with reference to human exposure limits established in the National Environment Protection (Ambient Air Quality) Measure (NEPM). Section 5.2 describes the atmospheric emissions over the life of the Fourth Train Proposal, and the illustrative mitigation and management measures that will be implemented for each major emissions source. Modelling studies indicate that the predicted change to the ambient air quality due to the incremental emissions from the Fourth Train Proposal on Barrow Island will be negligible (Section 5.2.5 and Table 5-8).

Atmospheric emissions from the Fourth Train Proposal additional to the approved Foundation Project are predicted to result in a minor reduction to ambient air quality at Barrow Island and in the Pilbara Region. Concentrations are considerably below the relevant critical levels that have been determined as potentially harmful to terrestrial fauna. Fauna may ingest contaminants at very low concentrations from the foliage of plants, although this is unlikely to have any measurable impact. Atmospheric emissions are therefore not predicted to cause measureable impact to fauna species on Barrow Island or in the Pilbara Region.

Potential incremental impacts to terrestrial fauna as a result of atmospheric emissions as a result of the Fourth Train Proposal are assessed as ‘Low’. The Fourth Train Proposal additional to the approved Foundation Project is predicted to result in a ‘Low’ potential impact to terrestrial fauna.

9.6.2.4 Fire

Fire has the potential to cause a loss of native vegetation. Terrestrial fauna that remains in the vegetation during the fire, including conservation-significant fauna, would be at risk of direct impact through injury or mortality. Indirect impacts may occur through loss of habitat. Secondary effects to fauna in areas adjacent to unplanned fire include increased competition or predation from animals entering the area due to loss of habitat. The severity of the impact would depend on the extent of the area affected by a fire .

Potential Impact on Terrestrial Fauna from Unplanned Fire as a Result of the Fourth Train Proposal			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
As per Section 9.5.2.4	As per Section 9.5.2.4	Construction: Medium	Construction: Medium
		Operations: Low	Operations: Low

As detailed in Section 9.5.2.4, machinery and equipment use, including blasting and hot works, can act as an ignition source due to combustion or high temperatures occurring during use.

Unplanned fires as a result of the Fourth Train Proposal are expected to be prevented, or rapidly extinguished and contained within the Fourth Train Proposal Footprint or its immediate vicinity (Section 9.5.2.4). This may result in the loss of low numbers of individuals of small, less mobile fauna, such as invertebrates, if vegetation is impacted. Impacts to vegetation from fire would also result in short-term effects on fauna habitat, and animals are expected to return to the area when the vegetation re-establishes (Chevron Australia 2008).

The Fourth Train Proposal additional to the approved Foundation Project will result in additional construction activities, increasing the time within which higher fire-risk activities, such as welding, will take place more frequently than during operations. The Fourth Train Proposal does not present any different fire ignition sources than those for the Foundation Project.

No faunal species known on Barrow Island are restricted to habitat in the vicinity of the Combined Gorgon Gas Development, or known to use it as a refuge. Potential impacts to terrestrial fauna from unplanned fire are not expected to result in the loss of overall viability of terrestrial fauna species on Barrow Island.

Illustrative measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Table 9-11 for assessment purposes.

Potential incremental impacts to terrestrial fauna from an unplanned fire as a result of the Fourth Train Proposal are predicted to be short term and contained within the Fourth Train Proposal Footprint or its immediate vicinity. This is assessed as resulting in a 'Medium' potential impact, which will decrease to a 'Low' potential impact during operations.

The Fourth Train Proposal additional to the approved Foundation Project may result in short-term potential impacts from unplanned fire within the Combined Gorgon Gas Development Footprint or its immediate vicinity. The additional impact to terrestrial fauna from unplanned fire is assessed as 'Medium' during Fourth Train Proposal construction activities, and 'Low' during operations. This represents a decrease to the level of potential impact determined for the Foundation Project during operations, which was ranked as 'Medium'. This decrease is due to the experience gained during the Foundation Project to date, which demonstrates that the measures in place are effective in preventing or controlling fires (Section 16.2.1) and the decreased likelihood of potential impact from fire during operations.

9.6.2.5 Physical Interaction

Mobile terrestrial fauna are at risk of injury or mortality from physical interaction; e.g. with vehicles. Terrestrial fauna entering an excavation are also at risk of entrapment, which can potentially lead to fauna fatality by starvation, dehydration, drowning, or injuries. Fauna trapped in excavations are also more susceptible to predation.

Potential Impact on Terrestrial Fauna from Physical Interaction			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Use of equipment and machinery, and vehicle movements. Excavation of foundations, drains, underground utilities, pipeline trench etc.	Additional construction activities. Additional clearing of land.	Construction: Medium Operations: Low	Construction: Medium Operations: Medium

The potential for impacts as a result of physical interaction is higher during construction of the Fourth Train Proposal than in operations, due to the higher vehicle movements, machinery use (e.g. during clearing activities), and open excavations.

Physical interaction with vehicles on roads is expected to pose a higher risk to terrestrial fauna than other physical interaction stressors. Highly mobile terrestrial animals, particularly larger mammals and large reptiles (Perentie) are more affected by roads than populations of small mammals (Spellerberg 2002). The potential for physical interaction is higher at night, when mammals are most active on Barrow Island, and on roads that are subject to frequent vehicle movements, such as from Butler Park (Construction Village) to the Gas Treatment Plant site.

Risk to terrestrial fauna from physical interaction on roads is expected to increase following rainfall events, and may be due to two reasons:

- an increase in animal numbers following breeding (rainfall supports abundant food sources that allow animals to breed)
- higher animal activity following rainfall.

Construction machinery is expected to have less potential to impact fauna than vehicles travelling on roads. Of these construction machinery-related activities, vegetation clearing is expected to pose the highest risk to terrestrial fauna. Vegetation clearing is expected to result in the loss of some individuals of small fauna (e.g. invertebrates). It is expected that birds and many of the larger mammals and reptiles will be able to relocate and therefore avoid direct impacts from clearing activities. However, the loss of a small number of these individuals may occur. Other activities, e.g. grading and trenching, are expected to pose less risk as most fauna will have left the area following clearing.

Terrestrial fauna are also at risk of entrapment in open excavations during construction; these excavations are necessary for installing the components of the Feed Gas Pipeline System, drainage, sumps etc. Excavations will mostly take place at the Fourth Train Proposal horizontal directional drilling site, Fourth Train Proposal Feed Gas Pipeline System (within the Foundation Project Feed Gas Pipeline Systems Footprint), and within 50 ha at the Gas Treatment Plant site.

During operations, the potential for impacts from physical interaction is decreased—fewer vehicles will be travelling on the roads, clearing activities will not be taking place, and fewer excavations, e.g. trenches, will be open.

Potential incremental impacts to fauna from physical interaction are expected to be less than that posed by the Foundation Project, as the Fourth Train Proposal is predicted to require fewer vehicles during construction as a result of its smaller size. The Fourth Train Proposal also requires less clearing than the Foundation Project, and requires fewer excavations.

The Fourth Train Proposal additional to the approved Foundation Project will result in additional construction activities. However, peak vehicle numbers are not predicted to rise from those of the Foundation Project. The area within which vehicles will operate will remain largely the same; physical interactions will therefore not be extended to fauna whose home ranges do not coincide with this area.

Vegetation clearing additional to the approved Foundation Project will extend the area over which clearing activities – and resulting potential impacts to fauna - will take place. Vegetation clearing additional to the approved Foundation Project will be within the allocated uncleared land available for tenure on Barrow Island under the *Barrow Island Act 2003* (WA).

Illustrative measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Table 9-15 for assessment purposes. To reduce the potential for physical interaction, these Illustrative Measures are subject to regular review to take into account changes, such as natural fluctuations in fauna populations and monitoring results, and to facilitate continuous improvement of environmental performance. Foundation Project reviews to date have resulted in the inclusion of In-Vehicle Monitoring Systems to monitor vehicle speeds, erecting signage in areas identified as potential fauna-interaction hotspots, and incorporating these locations into driver education.

Table 9-15: Illustrative Mitigation and Management Measures for Physical Interaction

Approved Foundation Project EMP	Illustrative Measures
Fauna Handling and Management Common User Procedure	• Targeted searches for fauna in shelters such as wood, nests and/or termite mounds, will be undertaken within five days prior to clearing operations by Chevron Australia. Animals caught during these searches will be relocated. • Termite mounds will be disturbed/broken up, and microhabitat/shelters will be broken up or removed to the degree practicable, to initiate egress of fauna living within them and to reduce the available habitat within the site to be cleared. • Mechanical clearing will progress in a systematic manner, slowly progressing so as not to confuse or trap evacuating fauna. Clearing will (where reasonably practicable) progress to an undisturbed area that will not be impacted by roads and construction facilities. • Fauna will be flushed opportunistically immediately prior to and during clearing of vegetation. • Inspections of cleared areas will be made immediately after clearing, and fauna handlers will be called in if displaced or injured animals are found. • Management measures to reduce fauna access and entrapment to open water and mud will include, but are not limited to: ▪ fauna exclusion fencing ▪ fauna exit ramps or fauna ladders ▪ regular inspections of open drains and stormwater ponds at the Gas Treatment Plant site ▪ lids on tanks where design permits ▪ sides will be sloped to allow animal to egress where practicable. • The walls and floors of all excavations are to be inspected for fauna before lowering of pipes or cables and prior to backfilling no more than 2 hours prior to activity. • Open excavations containing water, mud or other liquids/slurries will be inspected for trapped fauna at least twice daily. • Fauna handlers or appropriately inducted and/or trained fauna observers are to inspect and clear open trenches daily: ▪ No later than three hours after sunrise ▪ No earlier than four hours before sunset ▪ During the day, where practicable ▪ Nocturnally, if required for further studies undertaken at night. Timing: Twice daily when trenches remain open • Where exit ramps are not feasible, other mitigation techniques must be considered; these can include, but are not limited to: ▪ fauna exclusion fences ▪ fauna ladders and scramble nets ▪ tightly fitting foam plugs (to cap excavations). • At least one fauna handler per operational fauna handling team will have experience and/or training in all of the following: ▪ attending to accidents involving wildlife ▪ inspecting trenches for fauna ▪ handling and capturing fauna (including venomous snakes) ▪ identifying fauna

Approved Foundation Project EMP	Illustrative Measures
	▪ assessing injured fauna for release, euthanasia or rehabilitation ▪ providing care of, or euthanising sick, injured or abandoned, animals ▪ senior first aid (for human safety/health considerations). • Based on level of distress or injury of an injured or distressed animal, a fauna handler will undertake an assessment to determine the appropriate treatment.
Traffic Management Common User Procedure	• The following traffic management measures will assist in reducing impacts to fauna on Barrow Island through vehicle strikes: ▪ Barrow Island traffic awareness through a site induction process. ▪ Adherence to speed limits and access restrictions on Barrow Island. • The following conditions apply to personnel driving on roads or facilities maintained exclusively, or in part, for the purpose of the construction and/or operation of the Gorgon Gas Development and Jansz Feed Gas Pipeline: ▪ Vehicles shall drive on existing roads. Off-road access is prohibited. ▪ Access outside the camp facilities and work sites shall be strictly controlled. ▪ When safe to do so, drivers shall give way to fauna within construction areas and on roads. ▪ Prior to any ground vegetation disturbance, personnel shall obtain an approved Ground and Vegetation Disturbance certificate. ▪ Removing carcasses from roads as soon as practicable to minimise the congregation of predators on roads. ▪ Drivers to check for fauna sheltering under a parked vehicle immediately prior to driving the vehicle. ▪ Drivers to check for fauna sheltering under a parked vehicle immediately prior to driving the vehicle. • Personnel can only drive on Barrow Island if they have: ▪ completed a Chevron Australia-approved driving course ▪ completed a Chevron Australia-approved Gorgon Gas Development and Jansz Feed Gas Pipeline site induction ▪ completed a Barrow Island on-site driver awareness training.

Potential incremental impacts to terrestrial fauna from physical interaction will be primarily confined within the Fourth Train Proposal Footprint and its immediate vicinity and roads on Barrow Island. Physical interaction is predicted to potentially impact fauna individuals, including individuals of conservation-significant species. The potential incremental impact to terrestrial fauna from physical interaction is assessed as ‘Medium’ during construction activities, and ‘Low’ during operations, reflecting the fewer physical interactions predicted during operations due to a lower volume of vehicle and machinery activity, and the decreased possibility for entrapment.

The Fourth Train Proposal additional to the approved Foundation Project will extend the area over which vegetation clearing and earthworks will take place and result in additional duration of construction on Barrow Island. Physical interaction is predicted to potentially impact fauna individuals, including individuals of conservation-significant species, without compromising the population viability of species on Barrow Island. Therefore, the potential additional impact to terrestrial fauna from physical interaction is assessed as ‘Medium’ during construction activities, and ‘Low’ during operations.

9.6.2.6 *Noise and Vibration*

Although few studies are available regarding the impacts of noise on terrestrial animals, many of these studies show that animal populations appear to habituate or avoid noise (EPA 2007). The EPA (2007) qualified this by also stating that there may be less-obvious impacts that research has not revealed to date. Less-obvious impacts could include behavioural changes such as heightened alertness, physiological stress, abandonment of young, reduction in time feeding, and retreat from favourable habitat (Larkin *et al*. 1996).

Vibration is not identified as a stressor to terrestrial fauna on Barrow Island.

Potential Impact on Terrestrial Fauna from Noise and Vibration			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Construction-related noise emissions. Noise from the operational Gas Treatment Plant.	Additional construction activities. Increased noise levels during operations.	Construction: Low	Construction: Medium
		Operations: Medium	Operations: Medium

Construction-related noise emissions are described in Section 5.4.3.1.2. Noise from the operational Gas Treatment Plant is described in Section 5.4.3.2.2.

Noise can potentially interfere with communications used to maintain the social structure within populations of animals on Barrow Island. However, the following points are important in assessing noise impacts to Barrow Island's fauna:

- Olfactory and visual cues are more important forms of communication for mammals such as the Barrow Island Euro, which have limited vocalisations (Croft 1981).
- Reptiles are not highly vocal and are not often communal.
- Most invertebrates are not heavily reliant on hearing, apart from some groups that call to attract mates (e.g. crickets, grasshoppers, cicadas) (Kamien pers. comm. 2008).
- Raptors (Osprey, Brahminy Kite, and White-bellied Sea-eagle) have limited vocalisations and are relatively solitary (Debus 2001).

Many of Barrow Island's fauna species, including conservation-significant fauna (discussed further in Section 9.6.2.8), are not thought to have a critical reliance on hearing to either avoid predators, or to locate or hunt prey (Chevron Australia 2014) because:

- there are few carnivores on Barrow Island
- all mammals (except the Barrow Island Euro and Black-flanked Rock-wallaby) are primarily nocturnal, whereas the top-level predators (the varanids and raptors) are primarily diurnal
- raptors rely predominantly on sight to locate prey. Noise is unlikely to directly affect their hunting ability (Kamien pers. comm. 2008), and reduced prey (due to animals potentially vacating an area due to noise) is unlikely to be an issue given that these raptors typically prey upon marine species. However, noise pollution does have the potential to affect courtship behaviours in some raptors, which may lower the overall breeding success
- the ability of varanids to locate and hunt prey is unlikely to be compromised by noise. Kamien (pers. comm. 2008) indicates that reptiles typically hunt using chemoreception and vision, and King and Green (1999) state that varanids primarily use smell for detecting food.

Passerine birds (or songbirds)—for example, the White-winged Fairy-wren (Barrow Island)—appear to be the most noise-sensitive type of animal on Barrow Island. Noise can potentially interfere with communications of passerine birds, which rely on calling to establish and maintain territories, and to attract mates.

The noise produced by the Fourth Train Proposal construction at the Gas Treatment Plant site is expected to be largely dominated by noise emissions from the operational Foundation Project. However, fauna may be alarmed by sudden loud noises and could temporarily vacate the immediate area, returning to normal behaviour when the noise has stopped. Construction noise emissions are not predicted to significantly affect the ability of fauna to locate prey, hunt prey, or avoid predators. Foundation Project experience to date has shown no evidence that construction-related activities have had any direct impact on the abundance of mammals or the White-winged Fairy-wren (Barrow Island) as a result of noise (Chevron Australia 2012, 2013).

During operations, noise from the Gas Treatment Plant has the potential to cause short-term behaviour changes to terrestrial fauna in adjacent areas. Initially, terrestrial fauna may move away from the Gas Treatment Plant but then become more accustomed to the noise levels and relocate back into the area they moved from. However, the White-winged Fairy-wren (Barrow Island) has the potential to be impacted within the 60 dB(A) contour. Further detail on potential impacts to the White-winged Fairy-wren (Barrow Island), and identification of the 60 dB(A) as an appropriate noise level for impact assessment, is discussed in Section 9.6.2.8.3.

During normal operation of the Fourth Train Proposal, the 60 dB(A) contour increases by approximately 100 m from the Gas Treatment Plant site (at its furthest point) from that of the Foundation Project alone (Figure 9-3). The predicted 60 dB(A) contour for normal operation of the Fourth Train Proposal additional to the approved Foundation Project ranges from 0 m to approximately 800 m from the boundary of the Gas Treatment Plant site (Figure 9-3). This area represents no increase to the impacts assessed and approved for the Foundation Project.

Information on Fourth Train Proposal noise reduction measures is included in Section 5.4.4.

Potential incremental impacts to terrestrial fauna as a result of noise emissions associated with the Fourth Train Proposal are predicted to be localised, and are assessed as ‘Low’ during construction, and ‘Medium’ during operations.

Potential additional impacts are assessed as ‘Medium’ during both construction and operations activities. The Fourth Train Proposal does not change the level of potential impact to terrestrial fauna as a result of noise compared to that assessed for the approved Foundation Project; the area identified within which potential impacts may take place is approximately the same to that assessed and approved for the Foundation Project.

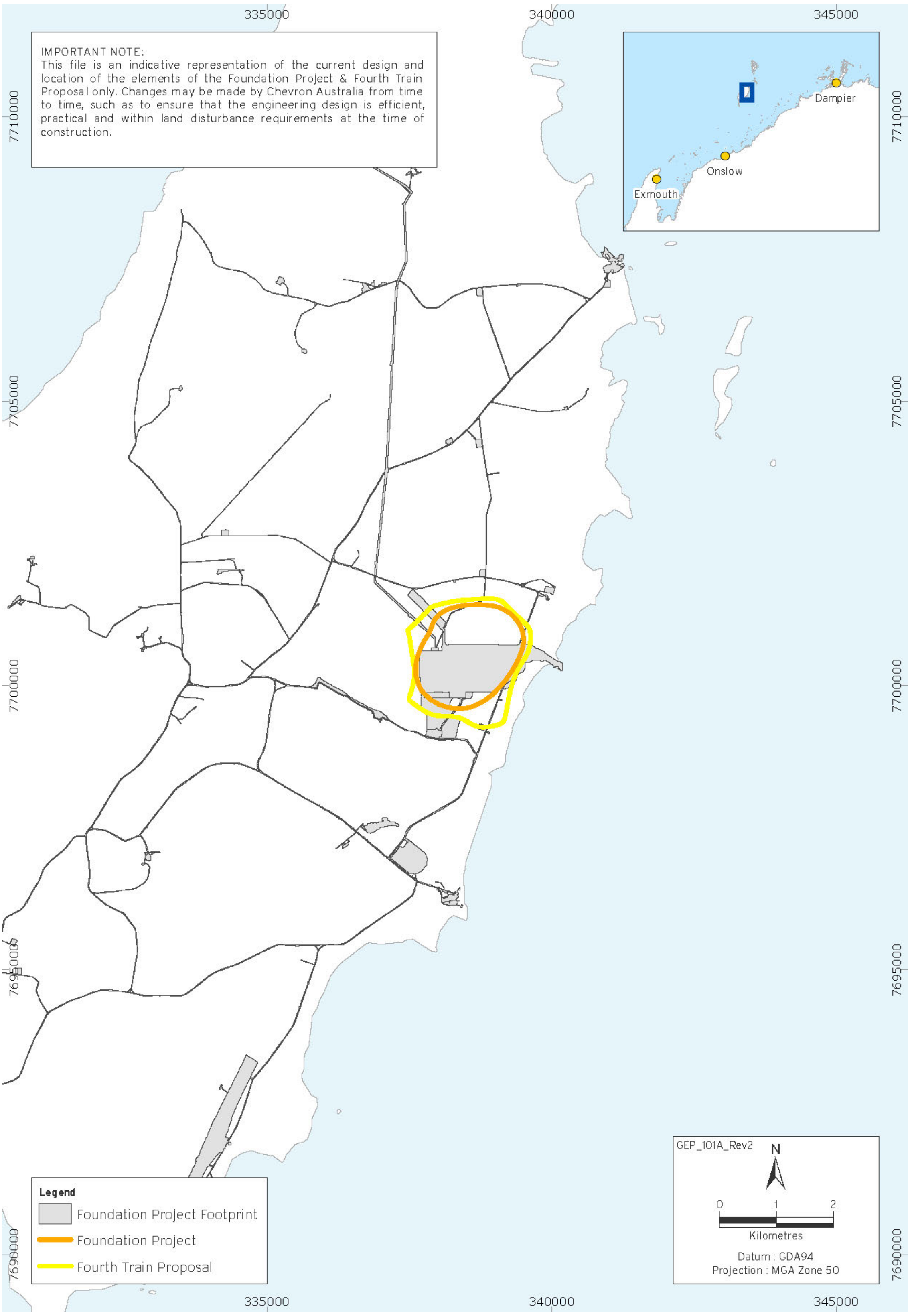

Figure 9-3: 60 dB(A) Noise Contours on Barrow Island during Normal Operations of the Fourth Train Proposal Additional to the Foundation Project

9.6.2.7 Artificial Light

Artificial light and light spill has the potential to act as an attractant or repellent to fauna, interrupt natural behaviours, expose individuals to higher predation levels, and/or disrupt navigational abilities.

Potential Impact on Terrestrial Fauna from Artificial light			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Horizontal directional drilling activities	Additional artificial light from the horizontal directional drilling site.	Construction: Low	Construction: Low
Fourth Train Proposal construction at the Gas Treatment Plant Operation of Fourth Train Proposal Gas Treatment Plant	Increased duration of lighting source from occupied accommodation Additional operational flaring Additional lighting at the Gas Treatment Plant	Operations: Low	Operations: Low

The Fourth Train Proposal additional to the approved Foundation Project will increase the duration within which artificial light emissions will be experienced in the vicinity of North Whites Beach (for the horizontal directional drilling sites) and along the Foundation Project Feed Gas Pipeline Systems Footprint during construction. The Fourth Train Proposal will also contribute to light emissions from the Gas Treatment Plant site during construction activities. It is expected that construction activities for the Fourth Train Proposal will occur 24 hours a day and will require artificial lighting for safety requirements (Section 5.3.3.1).

During operations the Fourth Train Proposal additional to the Foundation Project, isolux contours are predicted to diminish to less than 10^{-3} lux within 100 m from Gas Treatment Plant infrastructure during normal lighting conditions, which is a level comparable to the natural luminance levels of a moonless, clear night sky (Sections 5.3.3.2 and 5.3.3.3).

Barrow Island's top-level predators (varanids and raptors) hunt in the daytime, and therefore are not expected to be attracted to light pools. However, attraction of insects to light will increase the availability of food for adaptable birds and bats. This has the potential to result in changes in species community structure in areas affected by light spill. Lamps have been demonstrated to elicit flight-to-light behaviour for moths from 3 m to 130 m (Frank 2006). Due to the nature of the light emissions, terrestrial fauna are not expected to be exposed to significantly higher predation levels from the Fourth Train Proposal compared with the Foundation Project, and no different impacts to terrestrial fauna were identified.

The Fourth Train Proposal additional to the Foundation Project will result in artificial lighting during construction and operations activities that may cause localised potential impacts. This may result in behavioural changes in fauna attracted to light pools and increased predation of insects. Potential impacts during construction may occur in the immediate vicinity of the horizontal directional drilling sites, the Feed Gas Pipeline System Footprint, and the Gas Treatment Plant site. During operations, it is estimated that some terrestrial fauna may be influenced by artificial light emissions up to 100 m from Fourth Train Proposal light sources at the Gas Treatment Plant site. Conservation-significant fauna are not predicted to suffer mortality or reduced breeding success due to artificial light emissions.

Illustrative Measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Section 5.3.4 for assessment purposes.

Potential incremental impacts to terrestrial fauna as a result of artificial light associated with the Fourth Train Proposal construction are predicted to be short term and localised. During operations, potential incremental impacts are predicted to be limited to the vicinity of the Gas

Treatment Plant site and localised. Potential incremental impact to terrestrial fauna are assessed as 'Low' during construction and operations activities.

The Fourth Train Proposal additional to the approved Foundation Project will extend the duration of artificial light emissions during construction activities. During operations, the Fourth Train Proposal is not expected to change the level of potential impact compared to that assessed for the approved Foundation Project. Therefore, additional potential impacts are assessed as 'Low'.

9.6.2.8 Conservation-significant Species and Habitats

Further information is provided below on conservation-significant fauna identified as likely to occur in the vicinity of the Fourth Train Proposal. These conservation-significant fauna have already been included in the assessment for terrestrial fauna in Sections 9.6.2.1 to 9.6.2.7.

9.6.2.8.1 Barrow Island Euro, Spectacled Hare-wallaby, Golden Bandicoot, and Boodie

The Barrow Island Euro and Spectacled Hare-wallaby are widely observed across Barrow Island habitats, including within existing oilfield operations (Chevron Australia 2014). The Golden Bandicoot shelters in limestone crevices, Spinifex tussocks and termite mounds across most of Barrow Island, and rapidly occupies artificial habitats (Chevron Australia 2014). Boodies are dependent upon their warrens, which are dispersed widely and evenly across Barrow Island at low density (Section 9.6.2.8.4), and are expected to have limited ability to disperse to surrounding areas (Chevron Australia 2005).

Vegetation clearing (Section 9.6.2.1) is identified as having the potential to cause impacts on these EPBC Act-listed mammals through removal of habitat, reducing the total area on Barrow Island available for grazing, foraging and refuge. The limited size of clearing represents a small proportion of Barrow Island that will be unavailable for grazing and foraging until the area is (mostly) rehabilitated following construction. The Fourth Train Proposal horizontal directional drilling site has been situated away from Boodie warrens (Section 9.6.2.8.4), reducing the potential for habitat removal impacts to occur to Boodies. Approximately 70 termite mounds are expected to be removed, which may provide habitat to the Golden Bandicoot. However, these termite mounds represent a small proportion of the termite mounds present on Barrow Island (Section 9.6.2.8.4), and new termite mounds are likely to form through natural processes including in areas that are rehabilitated following construction activities. Spinifex, which is known to provide refuge to the Golden Bandicoot and Spectacled Hare-wallaby, is present over a large percentage of the vegetation to be cleared during construction. However, spinifex is widespread across Barrow Island. These Barrow Island mammals are therefore not expected to be dependent on the horizontal directional drilling site for habitat. Potential impacts to mammals as a result of vegetation clearing are predicted to be largely short term (where reinstatement will take place) and localised. The mobile nature and large home range sizes of these mammals (Section 6.5.3.2) are expected to limit potential impacts resulting from vegetation clearing to a small number of individuals that will use alternative areas for grazing, foraging and refuge due to the suitability of neighbouring habitats.

Physical interaction, primarily from vehicles, has potential to impact these Barrow Island mammals. The potential for impacts are higher during construction activities when there are a greater number of vehicle movements (Section 9.6.2.5). Barrow Island mammal individuals have potential to be affected, predominantly on roads located on the north-eastern and eastern areas of Barrow Island. The rate at which individuals may be impacted is not expected to increase compared with the Foundation Project, as the workforce—and therefore number of vehicle movements—is not expected to increase above Foundation Project levels. However, the Fourth Train Proposal extends the construction period duration, and the duration of construction-level potential impacts will be extended as a result.

The Foundation Project monitors the Barrow Island Euro, Spectacled Hare-wallaby, Golden Bandicoot, and Boodie in both an 'At Risk' zone (equivalent to the Foundation Project construction TDF) and a 'Reference Zone' (equivalent to outside the Foundation Project construction TDF) (discussed further in Section 3.5.1.3).

The monitoring of the Barrow Island mammal populations indicates that the construction of the Foundation Project to date is not affecting the population viability the Barrow Island Euro, Spectacled Hare-wallaby, Golden Bandicoot, and Boodie.

Potential impacts to the Barrow Island mammals as a result of the Fourth Train Proposal are more likely to occur during construction activities than during operations, due to the increases in clearing activities and vehicle movements that take place during construction than operations. The Fourth Train Proposal additional to the approved Foundation Project will increase the duration of the construction period and the area of clearing to take place on Barrow Island. However, no additional or additive potential impacts are predicted to the population viability of the Barrow Island Euro, Spectacled Hare-wallaby, Golden Bandicoot, and Boodie.

9.6.2.8.2 Water Rat

Water Rats generally inhabit rocky crevices and forage on adjacent sandy beaches and intertidal areas, and may forage in or near the Fourth Train Proposal horizontal directional drilling site. Vegetation clearing and earthworks is identified as the primary stressor for this species, which may affect a small number of animals through the removal of their foraging habitat. Given the small size of the area to be cleared adjacent to sandy beaches—up to 10 ha, which represents 0.43% of Barrow Island—it is not expected that potential additive impacts will result in behavioural changes except for a very small number of individuals only.

9.6.2.8.3 White-winged Fairy-wren (Barrow Island)

Site clearing for the Fourth Train Proposal horizontal directional drilling site will lead to the loss of a limited area that may be used by the White-winged Fairy-wren (Barrow Island). The White-winged Fairy-wren (Barrow Island) is known to forage and nest widely over a range of habitats on Barrow Island (Chevron Australia 2014; Bamford and Moro 2011). The Fourth Train Proposal horizontal directional drilling site does not contain *Melaleuca cardiophylla*—identified as a species that may be favoured, but not relied upon, by the White-winged Fairy-wren (Barrow Island) (Bamford and Moro 2011). Therefore, site clearing would occur across a very small part of the habitat used by the White-winged Fairy-wren (Barrow Island) on Barrow Island. The Fourth Train Proposal will also result in a delay to Foundation Project reinstatement activities, and may require re-clearing of Foundation Project land that has been reinstated, which will prevent these areas from being used as habitat by the White-winged Fairy-wren (Barrow Island) until they are finally rehabilitated.

The White-winged Fairy-wren (Barrow Island) has the potential to be impacted by noise. White-winged Fairy-wren (Barrow Island) communications incorporate at least five distinct calls to maintain social structure (establish territory, maintain group cohesion, raise alarm, establish contact, indicate hunger or subordination) (Tidemann 1980). Dooling and Popper (2007) suggest that masking of bird communication could impact behavioural or physiological effects in the area included in the 50 to 60 dB(A) continuous noise contour (impulse noise does not mask communication). Foundation Project experience to date has shown no impact to the White-winged Fairy-wren (Barrow Island) during construction (Chevron Australia 2012), (Section 3.5.4). However, continuous noise has the potential to interfere with White-winged Fairy-wren (Barrow Island) communications during operations.

The 50 to 60 dB(A) contour suggested by Dooling and Popper (2007) was determined by examining the response of birds to highway noise. Traffic noise generally shows a sloping spectrum with less energy from 2 to 4 kHz than at lower frequencies (Dooling and Popper 2007). This is comparable with the predicted operational noise emissions, shown at points north, south, and west of the Gas Treatment Plant at the 60 dB(A) contour in Figure 9-4. Dooling and Popper's estimate is based on average data from masking studies, and represents a '*typical*' bird. However, passerine birds that vocalise at lower peak frequencies (the frequency with the most energy) and the lowest overall frequency have a greater potential to be impacted by low-frequency noise than species vocalising at higher frequencies (Goodwin and Shriver 2011). The White-winged Fairy-wren (Barrow Island) is expected to be less sensitive to operational noise from the Gas Treatment Plant than the '*typical*' bird, as Fairy-wren vocalisations include frequencies above the range that typical birds vocalise and hear best, suggested by Dooling and Popper (2007) as around 2 to 4 kHz. For example, Variegated Fairy-wren (*Malurus lamberti*) Type II songs range in frequency from an average of 2.89 to 7.32 kHz (Greig *et al*. 2010), and Superb Fairy-wrens (*Malurus cyaneu*) give an alarm call with an average peak frequency of 9.1 kHz (Leavesley and Magrath 2005; Magrath *et al.* 2007).

Dooling and Popper (2007) suggest the 50 to 60 dB(A) level as a '*very conservative*' estimate for potentially masking songbird communication. This assessment uses the 60 dB(A) as a conservative sound level contour within which the White-winged Fairy-wren (Barrow Island) may be affected (Figure 9-3). This is a change from the Foundation Project EIS/ERMP (Chevron Australia 2005) that used the 50 dB(A) contour as an indication of area within which impacts may occur, but had not taken into account the frequency of Fairy-wren vocalisations or the limitations of the Dooling and Popper paper discussed above. Fairy-wrens rarely venture far from vegetation cover (Rowley and Russell 2007) and therefore operational noise emissions are assessed to have the potential to impact the White-winged Fairy-wren (Barrow Island) where vegetation is present.

No additive potential impacts to the population viability of the White-winged Fairy-wren (Barrow Island) are predicted, either from loss of habitat or from direct impact.

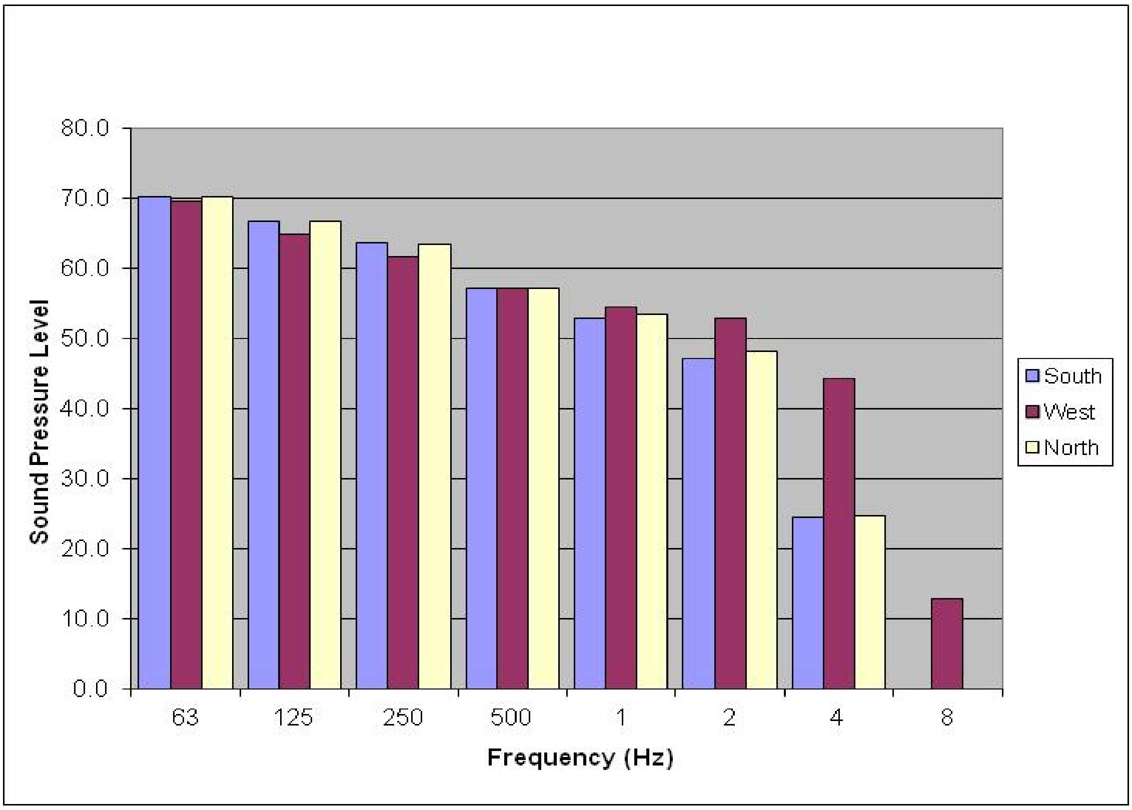

Figure 9-4: Modelled Noise Frequency Spectra at the 60 dB(A) Noise Contour during Normal Operations of the Fourth Train Proposal Additional to the Foundation Project

9.6.2.8.4 Conservation-significant Fauna Habitats

Boodies occupy warrens that are widely distributed across Barrow Island. No Boodie warrens are currently present in areas to be cleared as part of the Fourth Train Proposal. The Fourth Train Proposal horizontal directional drilling site has been located to the south of the Foundation Project horizontal directional drilling site, away from the Boodie warren to the north. The Foundation Project impacted one active Boodie warren through vegetation clearing and earthworks activities during construction of the Gas Treatment Plant site (Chevron Australia 2008).

Ospreys and White-bellied Sea-eagles occur and nest in a variety of locations around Barrow Island. No nests are currently present in areas to be cleared as part of the Fourth Train Proposal Footprint, or were cleared as part of the Foundation Project (Chevron Australia 2008).

Termite mounds, which support high species-richness, are present in the area that will be cleared as part of the Fourth Train Proposal. Approximately 70 termite mounds are anticipated to be removed as part of the Fourth Train Proposal, which represents a small proportion of this habitat. Foundation Project experience to date has shown that disturbing/breaking up termite mounds prior to site clearance has been successful in initiating egress of fauna. Fauna found residing in termite mounds during destructive searches are relocated to nearby uncleared areas of appropriate comparable habitat.

The Fourth Train Proposal additional to the approved Foundation Project will increase the number of termite mounds cleared from approximately 640 to approximately 710. Termite mounds are found in large numbers across Barrow Island, averaging approximately 1.8 mounds per hectare; the distribution of approximately 10 000 termite mounds has been mapped over an area of approximately 5 770 ha (Figure 6-11). Therefore, a resulting reduction in the overall carrying capacity for fauna on Barrow Island is not predicted.

9.6.3 Proposed Management

The GJVs consider the potential impacts to terrestrial fauna by the Fourth Train Proposal can be effectively managed under the relevant Ministerial Conditions for the Foundation Project. No measures or controls additional to those required for the Foundation Project have been assessed as being necessary to manage the incremental or additional potential impacts to terrestrial fauna from the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the various Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal's horizontal directional drilling activities, locations and potential impacts will also need to be prepared and approved as described in Section 16.2.3.3. However, the GJVs anticipate that the mitigation and management measures included within the Foundation Project Horizontal Directional Drilling Management and Monitoring Plan, will also apply and will prevent and manage any potential impact to relevant environmental factors, including protected species, as a result of the Fourth Train Proposal.

The following Foundation Project construction and operations EMPs are relevant to addressing potential impacts to terrestrial fauna for the Fourth Train Proposal:

- Terrestrial and Subterranean Environment Protection Plan and associated Procedures
- Terrestrial and Subterranean Environment Monitoring Program
- Fire Management Plan
- Horizontal Directional Drilling Management and Monitoring Plan
- Air Quality Management Plan
- Long-term Marine Turtle Monitoring Plan
- Solid and Liquid Waste Management Plan
- Post-Construction Rehabilitation Plan and associated sub-Plan.

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

9.6.4 Predicted Environmental Outcome

Potential incremental impacts to listed terrestrial species and their habitats during construction and operations activities are predicted to be localised. No different impacts were identified.

The Fourth Train Proposal will result in additional onshore construction activities, during which localised potential additional impacts to terrestrial fauna may take place. The Fourth Train Proposal will increase the area over which potential impacts may occur. During operations, potential additional impacts are similar to those of the Foundation Project alone and are expected to be localised.

Of the stressors discussed, vegetation clearing and earthworks and physical interaction may interact to cause a greater additive impact than when considered separately. However, the level of potential impact is not assessed to increase, as potential impacts are predicted to remain localised. Potential additive impacts are considered to be managed.

The potential impacts to terrestrial fauna as a result of the Fourth Train Proposal are expected to impact individuals, but not result in impacts to population viability. Terrestrial fauna that have the potential to be impacted are well-represented elsewhere on Barrow Island.

Potential impacts are not predicted to the abundance, diversity, geographic distribution, and/or productivity of terrestrial fauna at species and/or ecosystem levels. Conservation-significant fauna are considered to be afforded protection in line with the EPBC Act and the Wildlife Conservation Act.

The GJVs consider that the stressors to terrestrial fauna will be able to be adequately managed such that the impacts are environmentally acceptable and the environmental objective (Section 9.6.1.1) is met.

9.7 Subterranean Fauna

9.7.1 Assessment Framework

9.7.1.1 Environmental Objective

The environmental objective established in this PER/Draft EIS for subterranean fauna is:

> *To maintain the abundance, diversity, geographic distribution, and productivity of fauna at species and ecosystem levels through avoidance or management of adverse impacts and improvement of knowledge.*
>
> *To protect EPBC Act-listed threatened and migratory species.*
>
> *To protect Specially Protected (Threatened) Fauna, consistent with the provisions of the* Wildlife Conservation Act.

9.7.1.2 Relevant Policies, Plans, Guidelines

Table 9-16 lists specific State policy and framework documents relating to subterranean fauna.

Table 9-16: Western Australian State Policy Relevant to Subterranean Fauna

Policy, Plan, Guideline	Intent
Environmental Assessment Guideline No. 12 – Consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia (EPA 2013)	Provides a general guide to environmental impact assessment when there is a likelihood of subterranean fauna occurring in groundwater or caves.
EPA Draft Guidance Statement No. 54a – Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia (EPA 2007)	Specifically addresses survey design and sampling methods for subterranean fauna. It provides information that the EPA will consider when assessing proposals where subterranean fauna is a relevant environmental factor in an assessment.

9.7.2 Assessment and Mitigation of Potential Impacts

Barrow Island has a high conservation value for subterranean fauna at national, State, and regional scales, because it supports a range of subterranean species that are protected under State and Commonwealth legislation (Biota Environmental Sciences 2007). Barrow Island subterranean fauna are listed by DPaW as Priority 1 Priority Ecological Community (PEC).

Nineteen troglobitic and 63 stygofauna taxa have been recorded on Barrow Island. Subterranean fauna taxa, along with their conservation status, are detailed in Section6.5.3.5. The subterranean fauna ecological community at the Gas Treatment Plant site and the Additional Support Area includes:

- subterranean fauna endemic to Barrow Island
- four Schedule 1 fauna species (fauna specified as rare or is likely to become extinct under the Wildlife Conservation Act): *Nedsia hurlberti*, *Milyeringa justitia*, *Draculoides bramstokeri*, and *Speleostrophus nesiotes*
- three stygofauna taxa and one troglofauna taxa yet to be recorded elsewhere on Barrow Island.

There is no evidence of large caves or other large-scale geomorphological features that might create barriers to gene flow between the Fourth Train Proposal Footprint and adjacent habitats on Barrow Island.

Potential stressors from the Fourth Train Proposal that may affect subterranean fauna were identified and are discussed below. Potential stressors include:

- vegetation clearing and earthworks
- spills and leaks
- noise and vibration
- physical presence of infrastructure
- unplanned CO_2 migration or release.

9.7.2.1 Vegetation Clearing and Earthworks

Vegetation clearing and earthworks activities are associated with a subsequent alteration in the quality of groundwater, which has the potential to result in alterations to stygofauna habitat.

Surface vegetation provides the input of organic material into the subterranean habitat, which provides nutrients and food for subterranean fauna. Vegetation clearing therefore has the potential to reduce the organic inputs to the underlying subterranean habitat, leading to a potential reduction of nutrients available to subterranean fauna.

Earthworks activities have the potential to impact subterranean fauna by removing areas of troglofauna habitat or by potentially altering stygofauna habitat, e.g. through alteration of pore spaces or open karst spaces underneath or adjacent to areas subject to clearing or earthworks.

Potential Impact on Subterranean Fauna from Vegetation Clearing and Earthworks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
As per Section 9.3.2.1	As per Section 9.3.2.1	Construction: Low	Construction: Medium
		Operations: N/A	Operations: N/A

Vegetation clearing and earthworks will be required during construction of the Fourth Train Proposal, as described in Section 9.3.2.1. Alterations in groundwater quality as a result of clearing and earthworks activities are described in Section 9.4.2.2.

The Gas Treatment Plant site is considered to be of high conservation value for subterranean fauna in a regional context, but of moderate conservation significance compared to other parts of Barrow Island, taking into account the overall extent of subterranean fauna habitat (Biota Environmental Sciences 2007). However, the Gas Treatment Plant site and Foundation Project Feed Gas Pipeline Systems Footprint have been subject to vegetation clearing and earthworks as part of the Foundation Project. Vegetation clearing and earthworks conducted as part of the Fourth Train Proposal are much smaller in scale than those for the Foundation Project. There is very little scope for sedimentation of the groundwater or reduction of organic inputs, except in localised areas, where some very short-term effects might occur (Section 9.4.2.2).

The Fourth Train Proposal additional to the approved Foundation Project will result in an increase in the duration and area within which vegetation clearing and earthworks take place, as described in Section 9.3.2.1.

Illustrative Measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Sections 9.3.2.1 for assessment purposes, and also address indirect potential impacts from alterations in groundwater quality.

Potential incremental impacts to subterranean fauna from vegetation clearing and earthworks as a result of the Fourth Train Proposal are predicted to be localised. This is assessed as resulting in a 'Low' potential impact to subterranean fauna during construction activities.

The Fourth Train Proposal additional to the approved Foundation Project is assessed as a 'Medium' potential impact, resulting from the larger area within which clearance and earthworks activities will occur. The Fourth Train Proposal is not expected to change the level of potential impact than that assessed for the approved Foundation Project, primarily due to the smaller vegetation clearing and earthworks requirements of the Fourth Train Proposal compared with the Foundation Project.

9.7.2.2 Physical Presence of Infrastructure

The physical presence of infrastructure has the potential to impact subterranean fauna habitat through alterations in the quantity and quality of groundwater infiltration.

Potential Impact on Subterranean Fauna from Physical Presence			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
The physical presence of the Fourth Train Proposal, including hardstand (unsealed and sealed).	Additional clearing of land. Approximately 50 ha of compaction area/hardstand at the Gas Treatment Plant site and up to 10 ha at the horizontal directional drilling site. Delay to Foundation Project reinstatement activities/re-clearing reinstated Foundation Project land	Construction: Low Operations: Low	Construction: Medium Operations: Medium

The physical presence of infrastructure has the potential to cause impacts to groundwater as described in Section 9.4.2.2. No change in the watertable level is anticipated as a result of the Fourth Train Proposal or the Fourth Train Proposal additional to the approved Foundation Project. However, reduced groundwater recharge under the Gas Treatment Plant site may affect humidity and groundwater in the subterranean environment where surface water is diverted to drains, which has the potential to result in the localised loss of troglofauna and stygofauna individuals.

The Fourth Train Proposal additional to the approved Foundation Project will extend the area over which potential impacts to subterranean fauna may take place (Section 9.4.2.2). However, no different impacts will be introduced.

Illustrative Measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Section 9.4.2.2 for assessment purposes.

Potential incremental impacts to subterranean fauna will be confined within the Fourth Train Proposal Footprint and its immediate vicinity. As a result, a ‘Low’ potential impact to subterranean fauna is predicted for both construction and operations activities.

The Fourth Train Proposal additional to the approved Foundation Project is assessed to result in a ‘Medium’ potential impact to subterranean fauna. The additional impact ranking does not represent a change to the level of potential impact to that assessed for the approved Foundation Project, primarily due to the similar land requirements and physical presence characteristics of the Combined Gorgon Gas Development compared with the approved Foundation Project.

9.7.2.3 Spills and Leaks

Contamination of subterranean fauna habitats is the key potential impact to subterranean fauna associated with spills and leaks. This can potentially result in the reduced health or loss of troglofauna or stygofauna individuals.

Potential Impact on Subterranean Fauna from Spills and Leaks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
As per Section 9.3.2.2	As per Section 9.3.2.2	Construction: Low	Construction: Medium
		Operations: Medium	Operations: Medium

There is potential for hazardous materials (e.g. hydrocarbons or contaminated wastewater) to impact subterranean fauna habitats, including groundwater, from accidental spills or leaks. In the event of an uncontained spill, contaminants would have only a small impact area within troglofauna habitat, as liquids will pass through the soil profile and enter the watertable before spreading (Chevron Australia 2014). Groundwater pollution arising from the Gas Treatment Plant would not be expected to spread more than 200 m over a five-year period, which does not represent degradation of a large portion of the stygofauna habitat on Barrow Island (Chevron Australia 2014). Although spills could occur during construction and operation of the Fourth Train Proposal, these are expected to be contained through design controls (e.g. bunding) and/or timely spill response and clean-up actions. Based on the groundwater monitoring results to date, Foundation Project construction activities have not adversely impacted groundwater as a habitat for stygofauna (Section 3.5.1.6). The Fourth Train Proposal additional to the approved Foundation Project will result in increased quantities of hazardous materials that have the potential to result in spills or leaks (Section 9.3.2.2). However, no different sources will be introduced.

Illustrative Measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Section 9.3.2.2 for assessment purposes.

Potential incremental impacts to subterranean fauna as a result of contamination due to spills and leaks are predicted to be contained within the Fourth Train Proposal Footprint or its immediate vicinity. During the construction activities, this is assessed as resulting in a 'Low' potential impact. Potential impacts are assessed as 'Medium' during operations, representing the increased potential for spills and leaks and the higher volumes of hazardous materials used.

The Fourth Train Proposal additional to the approved Foundation Project may result in potential impacts within the Combined Gorgon Gas Development Footprint or its immediate vicinity without compromising the population viability of subterranean fauna species identified on Barrow Island. The additional impact to subterranean fauna is assessed to be 'Medium' during Fourth Train Proposal construction and operations activities, resulting from the increased likelihood of a spill or leak due to the increases in the quantities of hazardous materials used than those used by the Fourth Train Proposal alone. This does not represent an change in the level of potential impact to that assessed for the approved Foundation Project as spills and leaks are expected to be contained through design controls (e.g. bunding) and/or timely spill response and clean-up actions.

9.7.2.4 Noise and Vibration

Vibration emissions have the potential to cause damage including rock fractures or collapse, which could lead to localised fracturing or impacts to subterranean fauna habitat and resulting local loss of troglofauna and stygofauna. Shock waves may have the potential to impact subterranean fauna individuals.

Noise is not predicted to be a stressor for subterranean fauna.

Potential Impact on Subterranean Fauna from Noise and Vibration			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Blasting Drilling Installation of piles	Additional construction activities.	Construction: Low	Construction: Low
		Operations: N/A	Operations: N/A

Vibration emissions will occur during construction activities of the Fourth Train Proposal; the most significant emissions will be from blasting, drilling, and piling (if required). Blasting may be required during earthworks at the Gas Treatment Plant site and at the Additional Support Area (Section 4.5.3.2), although it is expected to be on a smaller scale than that experienced for the Foundation Project. Drilling and piling will be required at the Gas Treatment Plant site (e.g. for installation of earthing rods, and for a third LNG tank if required) (Section 4.5.3.2).

The Draft EIS/ERMP (Chevron Australia 2005) identified that karst formations may collapse as a result of blasting and vibration (e.g. from piling activities) during construction. Subsequent geotechnical investigation of the Gas Treatment Plant site showed it is reasonable to assume that no significant unstable areas are anticipated beneath the Gas Treatment Plant site. This is based on observations and data collected during the drilling of boreholes, and the use of electrical resistivity imaging and microgravity surveying (geophysics) (Chevron Australia 2014). Typically, excavation at the Additional Support Area will involve relatively shallow depths, reducing the potential for impacts to subterranean fauna habitat.

The Draft EIS/ERMP (Chevron Australia 2005) also indicated shock waves could impact subterranean fauna individuals. Although most invertebrates are highly resistant to shock, subterranean fish with swim bladders may be vulnerable to shock waves (Section 9.7.2.6).

Potential impacts to subterranean fauna or habitat resulting from vibration emissions are likely to be limited to the karst substrate immediately below the areas where earthworks are conducted. Thus, it is assumed that potential impacts will be restricted to subterranean fauna individuals and subterranean fauna habitat in the vicinity of the Fourth Train Proposal. Potential impacts of the Fourth Train Proposal additional to the approved Foundation Project are restricted to the vicinity of the Combined Gorgon Gas Development Footprint, which represents a small area of the available subterranean fauna habitat on Barrow Island. Note: Both the Gas Treatment Plant site and the Additional Support Area will already have been subject to earthworks and related potential impacts as part of the Foundation Project.

Illustrative Measures to mitigate and manage potential impacts for this stressor taken from Foundation Project EMPs are presented in Section 5.4.3.1.2 for assessment purposes.

Potential incremental impacts to subterranean fauna will be short term and confined within the Fourth Train Proposal Footprint and its immediate vicinity. As a result, a ‘Low’ potential impact to subterranean fauna from noise and vibration is predicted.

The Fourth Train Proposal additional to the approved Foundation Project will extend the duration over which potential impacts may take place. The additional impact to subterranean fauna from noise and vibration is assessed as ‘Low’. The additional impact ranking does not represent a change to the level of potential impact assessed for the approved Foundation Project.

9.7.2.5 *Unplanned Carbon Dioxide Migration*

Migration of CO_2 has the potential to impact stygofauna by acidifying the groundwater, or reducing the concentration of oxygen available for troglofauna.

Potential Impact on Subterranean Fauna from Unplanned Carbon Dioxide Migration			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Injection of reservoir CO_2 into the Dupuy Formation.	Approximately 2% increase in the rate of injection of reservoir CO_2 into the Dupuy Formation to that expected for the approved Foundation Project.	Construction: N/A	Construction: N/A
		Operations: Trivial	Operations: Trivial

The Fourth Train Proposal will dispose of reservoir CO_2 via injection using Foundation Project infrastructure (Section 11.3.3). No additional CO_2 injection wells or CO_2 pipeline will be required for the Fourth Train Proposal.

The development of the Fourth Train Proposal is predicted to increase the maximum annual average rate of available reservoir CO_2 by approximately 2% above the approved Foundation Project as documented in the PER for the approved Foundation Project, and can be accommodated within the scope of the currently approved Foundation Project's Carbon Dioxide Injection System as authorised under Section 13 of the *Barrow Island Act 2003* (WA). (Section 11.3.3.3). The Fourth Train Proposal is not expected to introduce any different subsurface, volumetric and rate uncertainties associated with CO_2 injection, compared to those assessed and approved for the Foundation Project (Section 11.3.3.2).

Potential incremental and additional impacts to subterranean fauna from unplanned CO_2 migration are not expected to compromise the population viability of subterranean fauna species on Barrow Island. Foundation Project design includes the selection of the Dupuy Formation for injection of reservoir CO_2, which provides multiple baffles and barriers to contain the injected CO_2 and prevent/slow CO_2 migration. In addition, the Foundation Project has committed to ensuring that decommissioned wells completed in the Dupuy Formation will be worked over to ensure suitability for CO_2 service. Given the current measures to mitigate risks associated with unplanned CO_2 migration, it is considered highly unlikely that such a situation would eventuate over the life of the Combined Gorgon Gas Development. As a result, the potential impact to subterranean fauna from unplanned CO_2 migration is assessed as 'Trivial'.

9.7.2.6 *Conservation-significant Species*

The Barrow Cave Gudgeon (*Milyeringa justitia*) is assessed as a Schedule 1 species (species that are rare or likely to become extinct) under the Wildlife Conservation Act. The blind eel (*Ophisternon* sp.) has not been identified to species level, but is taken as *Ophisternon candidum* for the purposes of conservation status (Humphreys *et al.* 2013). *Ophisternon candidum* is listed as Vulnerable under the EPBC Act and as a Schedule 1 species under the Wildlife Conservation Act.

The blind eel and the Barrow Cave Gudgeon can be assumed to be widespread on Barrow Island due to the extensive freshwater aquifer that provides their habitat. Sampling to date has not located these species in the vicinity of the Gas Treatment Plant site, although a single Barrow Cave Gudgeon individual was collected from a sampling bore on the Administration and Operations Complex site close to the Additional Support Area. Eight other subterranean fauna species recorded on Barrow Island are listed as Schedule 1 protected species under the Wildlife Conservation Act—Troglobites *Draculoides bramstokeri* and *Speleostrophus nesiotes*, and six species of stygobite: *Nedsia fragilis, N. humphreysi, N. hurlberti, N sculptilis/macrosculptilis, N. straskraba*, and *N. urifimbriata*. These species have all been recorded outside the Combined Gorgon Gas Development Footprint (Chevron Australia 2014); this Footprint would represent only a very small percentage of available habitat on Barrow Island. For example, Humphreys (2002), cited in Larson *et al.* (2013), reports that habitat suitable to support the Barrow Cave Gudgeon may extend over approximately 7800 ha (approximately 35%) of Barrow Island; the Gas Treatment Plant site and the Additional Support Area represent approximately 2.7% of this potentially suitable habitat.

The Subterranean Blind Snake (*Ramphotyphlops longissimus*) is listed by DPaW as a Priority 2 species. There are no documented caves, sinkholes, or rock shelters in the Foundation Project Footprint (Chevron Australia 2014) that might provide habitat for this species, reducing the likelihood of direct impact to this species from the Fourth Train Proposal.

Potential impacts to subterranean fauna are predicted to be restricted to individuals (and thus a very small percentage of the population), and a small proportion of the subterranean fauna habitat on Barrow Island. Conservation-significant species are predicted to be well-represented outside this area and are impacts to population viability are not predicted.

9.7.3 Proposed Management

The GJVs consider the potential impacts to subterranean fauna by the Fourth Train Proposal can be effectively managed under the relevant Ministerial Conditions for the Foundation Project. No measures or controls additional to those required for the Foundation Project have been assessed as being necessary to manage the incremental or additional potential impacts to subterranean fauna from the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the various Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal.

The following Foundation Project construction and operations EMPs are relevant to addressing potential impacts to subterranean fauna for the Fourth Train Proposal:

- Terrestrial and Subterranean Environment Protection Plan and associated Procedures
- Terrestrial and Subterranean Environment Monitoring Program
- Solid and Liquid Waste Management Plan
- Post-Construction Rehabilitation Plan and associated sub-Plan
- Carbon Dioxide System Monitoring Program.

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

9.7.4 Predicted Environmental Outcome

There is no evidence of large caves or other large-scale geomorphological features that might create barriers to gene flow between the Fourth Train Proposal Footprint and adjacent habitats on Barrow Island.

Potential incremental impacts are predicted to be short term during construction activities. Potential impacts during operations are also predicted to be short term, except for potential impacts from the physical presence of infrastructure. No different impacts were identified.

The Fourth Train Proposal will result in additional duration of construction during which potential impacts to subterranean fauna may take place compared with the construction period for the approved Foundation Project alone. During operations, the Fourth Train Proposal will result in additional hardstand area than that for the Foundation Project alone, increasing the area over which potential impacts from physical presence of infrastructure could occur. However, potential impacts are predicted to be localised for all stressors.

Potential additional impacts are predicted to be largely short term during operations, except for potential impacts from the physical presence of infrastructure.

The stressors are not predicted to act synergistically or interact otherwise to cause a greater impact than when considered separately. All stressors are predicted to result in localised potential additional impacts, which would result in the potential loss of small numbers of individuals and no reduction in the local population viability on Barrow Island. Potential impacts are not predicted to impact the abundance, diversity, geographic distribution, and productivity of subterranean fauna at species and/or ecosystem levels, including conservation-significant species.

The GJVs consider that the stressors to subterranean fauna will be able to be adequately managed such that the impacts are environmentally acceptable and the environmental objective (Section 9.7.1.1) is met.

9.8 Conservation Areas

Barrow Island is reserved under the Western Australian *Land Administration Act 1997* as a Class A nature reserve for the purposes of 'Conservation of Flora and Fauna'. The environmental objective established in this PER/Draft EIS for the Barrow Island Reserve is:

> *To protect the environmental values of areas identified as having significant environmental attributes.*

Stressors with the potential to impact the terrestrial conservation values of the protected area, and illustrative mitigation and management measures to address potential impacts, are discussed and assessed in Sections 9.3 to 9.7.4. Intertidal areas are vested as part of the Barrow Island Reserve; stressors with the potential to impact the conservation values of intertidal areas are included in Sections 10.3and 10.6.

The Fourth Train Proposal, including when considered additional to the approved Foundation Project, is not expected to affect the described ecological values of the Barrow Island Reserve. No unacceptable impacts are predicted. Therefore, the GJVs consider that potential impacts on the Barrow Island Reserve can be managed to acceptable levels through implementation of the EMPs that have been approved, or are required for the Foundation Project (with minor amendments as set out in Section 16.2.3). As such, potential impacts on Conservation Areas are environmentally acceptable and the environmental objective is met.

9.9 Decommissioning Activities

The future decommissioning of the Fourth Train Proposal has the potential to result in impacts, including from atmospheric emissions, noise and vibration, light emissions, and solid and liquid wastes. Section 4.8 outlines current industry practice in decommissioning strategies, noting there will be advances in decommissioning technology and information and potential changes to decommissioning procedures and regulatory requirements in the interim.

Assuming current practices and technologies, decommissioning is predicted to result in similar impacts as the construction of the Fourth Train Proposal:

- Atmospheric emissions during decommissioning are predicted to be similar to those for the construction of the Fourth Train Proposal. Therefore, atmospheric emissions are not expected to result in impacts to flora and fauna above those predicted for the construction of the Fourth Train Proposal.
- Noise and vibration emissions are predicted to be similar to or less than those related to construction activities of the Fourth Train Proposal. Potential impacts to fauna and subterranean fauna are predicted to be less than during construction or operation of the Fourth Train Proposal.

- Light emissions and potential impacts to fauna are predicted to be similar to those for construction activities of the Fourth Train Proposal.
- Solid and liquid wastes are expected to be disposed of in line with legislative requirements at appropriately licensed facilities.
- Physical interaction with fauna is predicted to result in potential impacts similar to or less than those for the construction of the Fourth Train Proposal.

The following Foundation Project EMPs are relevant to addressing potential impacts from decommissioning of the Fourth Train Proposal:

- Project Site Rehabilitation Plan
- Decommissioning and Closure Plan.

Depending upon the timing of the development, these EMPs may be submitted for approval for the Combined Gorgon Gas Development. However, if these EMPs have already been approved for Foundation Project, they will be revised to incorporate the Fourth Train Proposal.

Potential impacts as a result of decommissioning activities are predicted to meet the environmental objectives for each factor (Sections 9.3 to 9.7). The development areas are predicted to be returned to Commonwealth or State agencies in an appropriate condition following decommissioning activities.

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10. Coastal and Nearshore Environment – Potential Impacts and Management

10.1 Introduction

This section describes the potential impacts of the Fourth Train Proposal on the coastal and nearshore environment. The 'coastal and nearshore environment' is defined as the area from the backshore (the inland limit of the coastal area that may be subject to inundation during extreme tides or weather events) out to three nautical miles (nm)[8], which falls under Western Australian (State) jurisdiction[9]. It includes the State Waters surrounding Barrow Island and also the adjacent Pilbara mainland. The scope of the assessment covered in this section is shown in Figure 10-1.

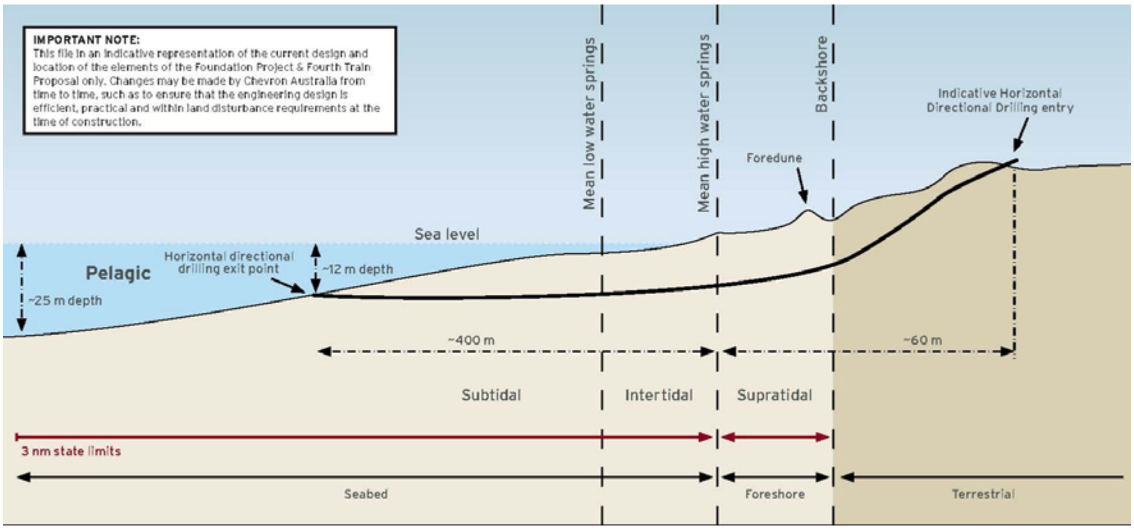

Figure 10-1: Defined Coastal and Nearshore Environment

The coastal and nearshore environment within the Fourth Train Proposal is described in Section 6. Factors of this environment with the potential to be affected by the Fourth Train Proposal and the stressors that have been identified as potentially impacting these factors are shown in Figure 10-2.

The approach used to identify and assess potential impacts of the Fourth Train Proposal on the coastal and nearshore environment is described in Section 8. Both the potential incremental (including different) impacts introduced by the Fourth Train Proposal alone, and additional impacts of the Fourth Train Proposal when added to the impacts assessed and approved for the Foundation Project have been identified, predicted, and evaluated for their acceptability.

[8] This definition of the coastal and nearshore environment differs slightly to that presented in the Environmental Scoping Document, which ended at the Mean High Water Springs (MHWS), and did not consider the backshore (Chevron Australia 2012).

[9] Marine waters beyond 3 nm to the limit of the Australian Exclusive Economic Zone fall under Commonwealth jurisdiction. The assessment of environmental factors in the Commonwealth Marine Area is described in Section 13.

Environmental Factor	Stressor: Atmospheric emissions (except dust)		Artificial light		Discharges to sea (including run-off)		Noise and vibration		Seabed disturbance		Vegetation clearing and earthworks		Physical Interaction		Physical presence (of infrastructure)		Spills & leaks	
	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O
Foreshore																	X	X
Seabed (intertidal and subtidal)					X				X						X	X	X	X
Marine Water Quality					X	X			X								X	X
Marine Fauna, including protected species, their habitats and non benthic primary producer habitats			X	X	X	X	X	X	X				X	X	X	X	X	X
Benthic Primary Producer Habitats					X	X			X						X	X	X	X
Conservation Areas			X	X	X	X	X	X	X				X	X	X	X	X	X

Key: Interaction (shaded; shown as X) | C Construction Phase | O Operations Phase

Figure 10-2: Environmental Factors of the Coastal and Nearshore Environment and Identified Stressor Interactions

Those stressors where the potential impact on the environmental factor was considered 'Trivial' were screened out from further assessment and are not discussed in this section, except for atmospheric emissions (except dust) identified for marine fauna, which has been included due to stakeholder interest. Refer to Section 8.2.2 for further details. The potential for the introduction and/or spread of Marine Pests is also not assessed in this section, but is discussed in Section 12.

Table 10-1 lists the key Commonwealth and State legislation for coastal and nearshore factors. Additional legislation, policies, plans, and guidelines relevant to specific factors are detailed in Section 2 and the following sections.

Table 10-1: Key Legislation Relevant to the Coastal and Nearshore Environment

Legislation	Intent
Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) (EPBC Act)	Provides for the protection of threatened and migratory species and their habitat listed as matters of national environmental significance (NES).
Environmental Protection Act 1986 (WA) (EP Act)	Provides for the prevention, control, and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement, and management of the environment in Western Australia (WA).
Wildlife Conservation Act 1950 (WA) (Wildlife Conservation Act)	Provides a legal framework to protect and manage flora and fauna in Western Australia.
Fish Resources Management Act 1994 (WA)	'To share and conserve the State's fish and other aquatic resources and their habitats for the benefit of present and future generations'.

10.2 Marine Disturbance Footprint

The GJVs intend to manage Fourth Train Proposal impacts to the marine environment within the framework of a Marine Disturbance Footprint (MDF). The MDF as it is currently defined applies during the construction of the Foundation Project and was assessed and approved through the Coastal and Marine Baseline State and Environmental Impact Reports (Chevron Australia 2011, 2011a, 2014). It includes the physical footprint of the facilities on the seabed, and the surrounding seabed expected to be disturbed by Foundation Project construction activities. The MDF limits the spatial area over which adverse impacts from these facilities are permitted to occur; material or serious environmental harm is not permitted outside this MDF. The MDF is shown in Figure 6-12 and Figure 6-13. Marine facilities in the MDF that are relevant to the Fourth Train Proposal are:

- Materials Offloading Facility
- LNG Jetty
- Offshore Feed Gas Pipeline System in State Waters and marine component of the shore crossing
- WAPET Landing marine upgrade.

The dimensions specified for the Foundation Project construction MDF are expected to be appropriate for the management of construction-related impacts for the Fourth Train Proposal. An MDF is proposed that applies to the Combined Gorgon Gas Development on Barrow Island, and it is proposed that this MDF is approved through an amendment to the Coastal and Marine Baseline State and Environmental Impact Report.

As the dimensions for the operations phase of the Foundation Project MDF have not yet been prescribed, it is not possible to assess how the operations phase MDF will be affected by the Fourth Train Proposal, nor is it possible to propose an operational MDF for the Combined Gorgon Gas Development. However, the expected areas of potential impact due to the Fourth Train Proposal, including the area of potential impact in addition to the Foundation Project construction and operations activities are assessed below. The GJVs propose that the Coastal and Marine Baseline State and Environmental Impact Reports (Chevron Australia 2011, 2011a, 2014) continue to set the Combined Gorgon Gas Development MDF.

10.3 Foreshore

10.3.1 Assessment Framework

10.3.1.1 Environmental Objective

The environmental objective established in this PER/Draft EIS for the foreshore is:

> *To maintain the integrity, ecological functions, and environmental values of the soil and landform of the coast.*

10.3.1.2 Relevant Policies, Plans, and Guidelines

Commonwealth, State, and local policy and framework documents relating to the foreshore are listed in Table 10-2.

Table 10-2: Policies, Plans, and Guidelines Relevant to the Foreshore

Policies, Plans, Guidelines	Intent
Western Australian State Planning Policy No. 2.6 – State Coastal Planning Policy (Western Australian Planning Commission 2013)	Outlines several objectives that need to be considered in the coastal planning process. Those relevant to development on Barrow Island are: ▪ Protection, conservation, and enhancement of coastal zone values, particularly in areas of landscape, biodiversity, and indigenous and cultural significance. ▪ Location of coastal development and facilities takes into account coastal processes, landform stability, coastal hazards, climate change and biophysical criteria.

Policies, Plans, Guidelines	Intent
Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007–2017 (DEC 2007)	Directs management of the Montebello Marine Park, Barrow Island Marine Park, and Barrow Island Marine Management Area to achieve the vision for the Montebello/Barrow Islands Marine Conservation Reserves: *'To conserve the marine flora and fauna, habitats and water quality of the Montebello/Barrow Islands area. The area will support commercial and recreational activities that are compatible with the maintenance of environmental quality and be valued as an important ecological, economic and social asset by the community.'* The management plan focuses on key ecological and social values, assesses risks to these values, and describes operational management objectives, targets, and strategies for the area.

10.3.2 Assessment and Mitigation of Potential Impacts

For the purposes of this assessment, 'foreshore' extends from the mean high water springs (the average spring highest tide level [MHWS]) to the backshore, which may be subject to infrequent inundation during extreme tides or weather events. The foreshore includes the beach areas where marine turtles typically nest (refer to Figure 10-1).

The North Whites Beach foreshore consists of a fragmented dune four to seven metres high, with sparsely scattered pioneer dune flora species. The sediments are largely coastal sands overlaying limestone and calcarenite; the main source of sand to the north-west coastline and intertidal zone is from creek discharges, which are irregular and typically occur after episodic rainfall events (Oceanica 2011). Sand movement from wind action is likely at the Fourth Train Proposal horizontal directional drilling site area as the dune area relief is low. The coastline to the south of North Whites Beach displays a well-developed foredune zone, with dune structures suggesting it is undergoing a slow erosive phase (Oceanica 2011). Further description of this coastal area can be found in Section 6.5. Refer to Section 9 for the assessment of the terrestrial environment, which includes the backshore area of North Whites Beach and beyond.

10.3.2.1 Spills and Leaks

Spills or leaks of hydrocarbons or hazardous materials have the potential to impact sediment quality in the foreshore area. The level of impact depends on the magnitude and type of spill or leak (i.e. condensate versus diesel) and weather conditions, with extreme conditions (such as high tides and/or high winds) more likely to generate spray that may reach areas above the MHWS.

Potential Impact on Foreshore from Spills and Leaks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Preparation and laying of Offshore Feed Gas Pipeline System (marine) Logistics vessel operations	Additional drilling activity on the west coast of Barrow Island under the shoreline. Additional marine vessel activities on the west coast and additional Offshore Feed Gas Pipeline System. Additional delivery of materials by marine vessels.	Construction: Low	Construction: Low
LNG and condensate vessel operations (including support vessels)	Additional marine vessels. Additional Offshore Feed Gas Pipeline System.	Operations: Low	Operations: Low

Potential Impact on Foreshore from Spills and Leaks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Operation and maintenance of Offshore Feed Gas Pipeline System Logistics vessel operations			

There is a potential for the foreshore on both the west and east coast of Barrow Island to be impacted by spills and leaks occurring offshore during construction or operations activities off the coast of Barrow Island.

10.3.2.1.1 Marine Horizontal Directional Drilling Activities – Frac-out

The components of the Feed Gas Pipeline System are planned to be installed in a series of holes beneath North Whites Beach using a horizontal directional drilling technique. A frac-out is caused when drilling fluid pressure exceeds ground strength, typically resulting in drilling cuttings and drilling fluid rupturing to the surface (ground or seabed) and collapse of the drill hole. A frac-out has the potential to cause sinkholes (a circular shaped hole at the land's surface) and alter beach morphology. Frac-outs can also introduce small amounts of drilling cuttings and associated drilling fluid to the foreshore environment.

A frac-out is not expected to occur in the foreshore area given the depth of the drilling bores beneath the foreshore at this location (approximately 10 m or more below the surface). The northern end of Whites Beach was selected for the site of horizontal directional drilling after the completion of geophysical surveys, which indicated that the rock appeared more competent and thus less prone to frac-out. No frac-outs have been experienced in the foreshore area during horizontal directional drilling for the Foundation Project.

10.3.2.1.2 Accidental or Unplanned Releases – Hydrocarbons

Potential impacts to the foreshore area from a spill or leak include reduced integrity of the sediment due to contamination, and reduced health of dune vegetation due to sublethal or lethal hydrocarbon toxicity. The potential for a spill or leak to impact areas above the MHWS and affect the foreshore area is only expected if a spill coincides with unusually high tides and/or storm surge, which are more likely during the cyclone season (November to April).

Based on oil spill modelling scenario results, the probability of any spill occurring as part of the Fourth Train Proposal that then makes contact with a nearshore area ranges from a 1 in 41 chance per year (a minor diesel refuelling incident) to a 1 in 9 259 000 chance per year (a major diesel spill at the Chandon gas field). The 'worst-case' potential impact from the Fourth Train Proposal to the Barrow Island foreshore area is contact from a bunker fuel oil spill off the east coast of Barrow Island, at a 1 in 121 000 chance per year. A full description of the model and its outputs is provided in Section 5.7.2.1.

A marine vessel refuelling incident during the summer 2.5 km to the west of Barrow Island could expose 6.8 km of shoreline on the west coast with a maximum volume of 0.1 m^3 of diesel. Under warm weather conditions rapid evaporation of the volatile component and dissolution of water-soluble fraction will result in a less toxic residue reaching foreshore areas than that initially released.

A diesel spill adjacent to the Materials Offloading Facility is predicted to reach some parts of the Barrow Island eastern shoreline, with prevailing wind-driven currents expected to push entrained diesel against the shore. The worst-case volume of diesel predicted to reach the shore was 0.5 m^3, with up to 22 km of shoreline affected.

Grounding of a condensate vessel adjacent to the LNG Jetty off the east coast of Barrow Island during the operations phase of the Fourth Train Proposal has the potential to result in the loss of condensate, bunker fuel oil, or crude oil into the marine environment. This is the 'worst-case' spill scenario modelled for the Montebello/Barrow/Lowendal Islands group, and could expose up to 51 km of shoreline to 47 m^3 of bunker fuel oil. Sediment contamination along the east coast of Barrow Island and the Lowendal Islands above the MHWS could occur; however, this is unlikely to occur.

An Offshore Feed Gas Pipeline System rupture (at either 14 km or 200 m west of Barrow Island) releasing condensate was predicted to contact the shorelines of the Montebello/ Barrow (west coast)/Lowendal Islands, with the highest probability of contact during the transition (October) season, affecting up to 31 km of shoreline with approximately 25 m^3 of condensate for a 14 km rupture; and up to 43.4 km of shoreline by approximately 158 m^3 of condensate for a rupture 200 m from the shoreline. The west coast of Barrow Island is likely to be most affected by a 200 m offshore rupture, while concentrations at the Montebello Islands were greatest for a 14 km rupture due to prevailing oceanographic conditions. Analysis of North West Shelf condensate has shown high evaporation rates. Its toxicity to biota decreases rapidly with the effects of evaporation. The effect of any stranded fresh condensate would be felt most acutely in the intertidal area (Section 10.4.2.3) and would be unlikely to affect areas much beyond the MHWS.

Although a spill has the potential to result in sediment quality consequences to the foreshore, the probability of this occurring is predicted to be very low. In addition, spill response measures will be put in place (as described in Section 5.7.3.2) to further reduce potential impacts. Impacts to the intertidal area are discussed in Section 10.4.2.4. Illustrative mitigation and management measures for potential impacts from spills and leaks are taken from Foundation Project Environmental Management Plans (EMPs) and are presented in Section 5.7.3 (for hydrocarbon and chemical spills and leaks) for assessment purposes.

The potential incremental impact on the foreshore from the Fourth Train Proposal due to spills and leaks during construction and operations is assessed as 'Low'. Although the severity of the consequence of a spill or leak can be major, the likelihood of the spill or leak occurring is low, and the likelihood of that spill or leak then impacting the foreshore area is also low.

The potential impact of spills and leaks from the Fourth Train Proposal on the foreshore area in addition to the approved Foundation Project is assessed as 'Low' for the construction and operations phases, which is the same as that predicted for the Foundation Project. Although there will be an increased likelihood of a spill or leak occurring during construction and operations activities due to the presence of additional marine vessels associated with the Fourth Train Proposal, the likelihood of the event occurring remains low. The level of consequence if a spill or leak event occurred was assessed to be the same.

10.3.3 Proposed Management

The GJVs consider that the potential impacts to the foreshore area by the Fourth Train Proposal can be effectively managed under the relevant Ministerial Conditions for the Foundation Project. No measures or controls additional or different to those required for the Foundation Project have been assessed as being necessary to manage the potential incremental or additional impacts to the foreshore from the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the various approved Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal horizontal directional drilling activities, locations, and potential impacts will also need to be prepared and approved, as described in Section 16.2.3.3. However, the GJVs anticipate that the mitigation and management measures included in the existing Foundation Project Horizontal Directional Drilling Management and Monitoring Plan will also apply to the Fourth Train Proposal and will prevent and manage any potential impact to the foreshore as a result of the Fourth Train Proposal.

The existing EMPs that are relevant to addressing potential impacts to the foreshore for the Fourth Train Proposal are:

- Horizontal Directional Drilling Management and Monitoring Plan
- Offshore Feed Gas Pipeline Installation Management Plan(or equivalent Environment Plan)
- Marine Environmental Quality Management Plan
- Coastal Stability Management Plan
- Post-Construction Rehabilitation Plan and associated sub-Plan

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

10.3.4 Predicted Environmental Outcome

A spill or leak has the potential to impact the foreshore if the spill or leak coincides with severe weather conditions, potentially impacting sediment quality on either the east or west coasts of Barrow Island (depending on the spill scenario); however, the likelihood of this event occurring is very low. No different impacts to the foreshore were identified.

The Fourth Train Proposal will result in additional construction activities, including at the horizontal directional drilling site, during which additional potential impacts may take place compared with the construction of the approved Foundation Project. The Fourth Train Proposal will also result in additional vessel movements during operations.

Potential impacts to the foreshore from spills and leaks are not predicted to impact the abundance, diversity, geographic distribution, and/or productivity of flora or fauna at species and/or ecosystem levels. The GJVs consider that the stressors to the foreshore area will be able to be adequately managed such that the impacts are environmentally acceptable and the environmental objective (Section 10.3.1.1) is met.

10.4 Seabed (Intertidal and Subtidal)

10.4.1 Assessment Framework

10.4.1.1 Environmental Objective

The environmental objective established in this PER/Draft EIS for the seabed is:

to maintain the integrity, ecological functions, and environmental values of the seabed

10.4.1.2 Relevant Policies, Plans, and Guidelines

Commonwealth, State, and local policy and framework documents relating to the seabed are listed in Table 10-3.

Table 10-3: Policies, Plans, and Guidelines Relevant to the Seabed

Policies, Plans, Guidelines	Intent
Western Australian State Planning Policy No. 2.6 – State Coastal Planning Policy (Western Australian Planning Commission 2013)	Sets several objectives that need to be considered in State Government decision-making, which are relevant to development on the coast (including Barrow Island): ▪ The proposed coastal development must provide for the protection, conservation, and enhancement of coastal zone values, particularly in areas of landscape, biodiversity, indigenous, and cultural significance ▪ The proposed location of coastal development and facilities takes into account coastal processes , landform stability, coastal hazards, climate change and biophysical criteria.
Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007–2017 (DEC 2007)	Establishes a target[1] in the Management Plan to maintain the geomorphology and sediment quality of the seabed in a natural state, except where some level of acceptable change is approved by the appropriate government regulatory authority. Sets ecological values for management. Ecological values relevant to the seabed include: ▪ a complex seabed topography consisting of subtidal and intertidal reefs, sheltered lagoons, channels, beaches, and cliffs ▪ generally pristine sediments, which is essential to the maintenance of healthy marine ecosystems ▪ rocky shores predominate and provide habitat for a variety of intertidal organisms.

1 *The target presented relates to 'unzoned areas of the marine management area' as defined in the Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007–2017. The area anticipated to be affected by Offshore Feed Gas Pipeline System activities on the west coast of Barrow Island falls into the unzoned area of the marine management area.*

10.4.2 Assessment and Mitigation of Potential Impacts

For the purposes of this assessment, the term 'seabed' refers to both the intertidal and the subtidal zone (refer to Figure 10-1). The scope of the impact assessment for the seabed environmental factor focused on determining any changes to seabed sediment characteristics (physical or chemical) and benthic landforms from the Fourth Train Proposal in waters under State jurisdiction.

Stressors identified as having the potential to impact the seabed in the coastal and nearshore environment (Chevron Australia 2012) were:

- discharges to sea
- seabed disturbance
- physical presence of infrastructure
- spills and leaks.

Spills and leaks have the potential to travel considerable distances under suitable metocean conditions. As such, potential impacts to the seabed in State Waters along the Pilbara coast have been included in the spills and leaks assessment (Section 10.4.2.3).

10.4.2.1 Discharges to Sea

Discharges to sea have the potential to impact the chemical or physical characteristics of the seabed by introducing contaminants or altering sediment characteristics by releasing finer or coarser particles. Accidental hydrocarbon spills and leaks are assessed separately under the spills and leaks stressor (Section 10.4.2.3).

Potential Impact on Seabed from Discharges to Sea			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities	Additional drilling cuttings and drilling fluids discharged to a new area of seabed off the west coast.	Construction: Medium	Construction: Medium
Operations: Trivial			

A range of discharges to sea may result from Fourth Train Proposal construction activities, including the release of drilling cuttings and drilling fluids, reject brine, hydrotest water, and marine vessel discharges. Increased operations phase discharges include deck drainage, treated effluent, and cooling water from vessels including additional LNG and condensate vessels and support vessel movements (Section 5.5). Except for the release of drilling cuttings and drilling fluids from horizontal directional drilling, all other discharges (e.g. hydrotest water, marine vessel discharges during either the construction or operations phases) are not anticipated to impact the seabed given the dispersive nature of the receiving marine environment and the low-toxicity, short-term nature, and spatial separation of the discharges. These planned discharges to sea are considered further under water quality in Section 10.5.2.1. Potential impacts from operations phase discharges to sea are assessed as 'Trivial' due to their low toxicity, localised nature, and the dissipative nature of the receiving environment.

The discharge of drilling cuttings and drilling fluid onto the seabed off the west coast of Barrow Island has the potential to alter seabed topography and sediment characteristics through smothering and the potential introduction of contaminants.

Sediment plume dispersion modelling completed for the Foundation Project predicted a localised change to the existing seabed profile and sediment character (less than 50 m from the horizontal directional drilling exit point), with a horizontal profile no higher than 15 cm (Section 5.5.3.2.2). Further dispersion of the material deposited from the horizontal directional drilling exit point will occur over time. Experienced gained from the Foundation Project found that the sediment dispersion plume was smaller than that predicted by the modelling, and that there was no detectable impact on benthic habitats. The volume of drilling cuttings from the Fourth Train Proposal is expected to be approximately half that of the Foundation Project horizontal directional drilling activities due to less holes being drilled. Nearly 90% of these cuttings are expected to range from coarse gravel to coarse sand, and as such settlement will be less than 50 m from the horizontal directional drilling exit point (Chevron Australia 2011b).

Drilling fluids anticipated for use in horizontal directional drilling are likely to be a combination of low-toxicity polymer drilling fluids or water-based fluids, therefore the discharge of drilling cuttings and drilling fluid is not expected to result in contamination of seabed sediments. Low-toxicity polymer drilling fluids or water-based fluids are commonly used in north-west Australia with no adverse impacts to sediment quality.

Illustrative measures to mitigate and manage discharges to sea are taken from Foundation Project EMPs and are described in Section 5.5.4 for assessment purposes.

The potential incremental impact on the seabed from the Fourth Train Proposal as a result of construction discharges to sea is assessed as 'Medium'. Discharges anticipated for the Fourth Train Proposal horizontal directional drilling activities were determined to be localised, but will impact a new area of seabed on the west coast of Barrow Island.

The potential impact of construction discharges to sea from the Fourth Train Proposal on the seabed in addition to the approved Foundation Project is assessed as 'Medium'. This assessment is the same as that predicted for the Foundation Project.

10.4.2.2 Seabed Disturbance

Seabed disturbance has the potential to change geomorphological features or seabed profiles (e.g. due to anchor scouring or trenching) and sediment characteristics (e.g. through sedimentation).

Potential Impact on Seabed from Seabed Disturbance			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Preparation and laying of Offshore Feed Gas Pipeline System (marine) Barge accommodation and barge laydown preparation and grounding (if required) Logistics vessel operations	New area of seabed for the marine exit point of the horizontal directional drilling holes. Additional marine vessels anchoring in a new geographic seabed area off the west coast of Barrow Island. Additional seabed preparation work off east coast of Barrow Island (i.e. re-profiling).	Construction: Low	Construction: Low
Operations Phase: Trivial			

Construction activities off the west coast of Barrow Island, such as horizontal directional drilling and preparation and laying of the offshore component of the Feed Gas Pipeline System, have the potential to result in seabed disturbance (Section 4.5). On the east coast, construction activities with the potential to result in seabed disturbance include seabed preparatory activities and placement of barge accommodation and barge laydown (if required) adjacent to the Materials Offloading Facility and/or WAPET Landing. Seabed disturbance during operations is not anticipated as condensate vessels will use existing moorings and the existing and approved designated Barrow Island Anchorage. Condensate vessels will moor at the LNG Jetty to gas up or cool down if required prior to commencing loading of LNG.

Seabed disturbance may occur at the horizontal directional drilling exit point, which is likely to be in an area of unconsolidated sediment beyond the limestone pavement off the west coast of Barrow Island. The horizontal directional drilling technique was chosen to reduce disturbance to the intertidal and shallow subtidal limestone pavement. Section 4.5.1.3 details the seabed profile changes associated with the placement of the Offshore Feed Gas Pipeline System.

The area of seabed potentially disturbed by the installation of the Fourth Train Proposal Feed Gas Pipeline System in State Waters will depend on the final spacing between the individual pipelines making up the Feed Gas Pipeline System (Section 4.3.4). Based on calculations at the time of submission of this document, direct seabed disturbance from preparation and laying activities will occur along the length of the Offshore Feed Gas Pipeline System (approximately 5 km long) affecting between approximately 0.27 and 0.32 km^2 of seabed, depending on the final pipeline route chosen. The Fourth Train Proposal base case is to not use trenching to stabilise the Feed Gas Pipeline within State Waters, similar to the approved Foundation Project. However, as a contingency, trenching may be required, in which case the excavated material will be placed adjacent to the trench to allow for natural dispersal. This has been included in the calculation for the total area of seabed disturbance.

Marine vessels involved in construction activities also have the potential to cause seabed disturbance through anchoring, dragging of anchor chains and the retrieval of anchors.

Frequent resetting of anchors along the length of the Offshore Feed Gas Pipeline System is required in shallow waters to ensure the accurate positioning of the Offshore Feed Gas Pipeline System. This may result in localised disturbance to small areas of limestone pavement; however, anchoring is anticipated to be undertaken within the MDF. Illustrative mitigation and management measures for anchoring are outlined in the approved Foundation Project Offshore Feed Gas Pipeline System Installation Management Plan (Table 10-4).

Re-profiling of the seabed prior to controlled barge grounding may be required off the east coast of Barrow Island during construction (Section 4.5.3.3 or Section 4.5.5). Potential impacts arising from re-profiling and the controlled grounding of barges are likely to be localised, and barges are only anticipated to remain in place for the construction of the Fourth Train Proposal.

Illustrative measures to mitigate and manage potential impacts for this stressor are taken from Foundation Project EMPs and are presented in Table 10-4 for assessment purposes.

Table 10-4: Illustrative Mitigation and Management Measures for Seabed Disturbance in the Coastal and Nearshore Environment

Approved Foundation Project EMP	Illustrative Measures
Offshore Feed Gas Pipeline Installation Management Plan	• Benthic disturbance is confined to the construction corridor in Commonwealth Waters • In State Waters, anchoring will be restricted to within the MDF as defined in Coastal and Marine Baseline State and Environmental Impact Report: Offshore Feed Gas Pipeline System and Marine Component of the Shore Crossing • For vessels that anchor, anchoring will be managed in accordance with maritime industry standard watchkeeping practices
Horizontal Directional Drilling Management and Monitoring Plan	Measures to be employed for mitigating direct disturbance impacts to marine habitats, and to ensure no detectable net mortality of coral assemblages include: • use of HDD technique to minimise disturbance to the nearshore environment at North Whites Beach • locating the shore crossing at North Whites Beach, out of sensitive coral habitats • detailed design and engineering of the anchor spread to minimise direct impacts to areas of conservation significance or environmental sensitivity • stabilisation of pipe tails through self weight in addition to supplementary stabilisation (such as clump weights) • all equipment on board vessels will be stowed securely to reduce the likelihood of solid objects falling overboard • water winning spread to be located out of sensitive areas (on bare rock where possible) and designed to be secure against movement in storm conditions. The Construction Contractor will develop an Anchor Management Plan, approved by the EPCM and/or Chevron Australia. The Plan will cover, in detail, aspects such as: required anchor spreads, the management of chain/wire drag and anchor movements, and the procedures for the deployment and retrieval of anchors.

Approved Foundation Project EMP	Illustrative Measures
Marine Facilities Construction Environmental Management Plan	• Locations of moorings will be selected to avoid impacts to coral assemblages, where practicable. • The location of moorings will be approved in consultation with the EPCM Contractor and Chevron Australia. • Construction Contractor will be provided with: ▪ boundaries of the MDF in a suitable format (i.e. GPS coordinates) ▪ locations of coral assemblages ▪ the latest revision of all relevant engineering drawings.

Construction of the Fourth Train Proposal will result in short-term and localised seabed disturbance. The potential incremental impacts of construction activities on the seabed from the Fourth Train Proposal seabed disturbance is assessed as 'Low'.

The potential impact of construction of the Fourth Train Proposal on the seabed in addition to the approved Foundation Project is assessed as 'Low'. This assessment is lower than that predicted for the Foundation Project, which was assessed as 'Low-Medium', based on Foundation Project experience showing a lower level of impact than predicted. Also, Fourth Train Proposal construction activities will be of a smaller scale and no dredging will be required, resulting in a lower predicted impact.

10.4.2.3 Physical Presence of Infrastructure

The physical presence of infrastructure in the marine environment has the potential to impact the seabed by introducing contaminants (through leaching) and/or changing seabed profiles and features as a result of alterations to marine sediment transport processes.

Potential Impact on Seabed from Physical Presence of infrastructure			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Preparation and laying of Offshore Feed Gas Pipeline System Barge accommodation and barge laydown preparation and grounding (if required)	Additional area of seabed off the west coast of Barrow Island replaced with an artificial substrate (Feed Gas Pipeline System). Additional temporary infrastructure (barge accommodation and barge laydown [if required]) on the east coast of Barrow Island.	Construction: Low	Construction: Low
Operations Phase: Trivial			

The Fourth Train Proposal Offshore Feed Gas Pipeline System route options include a Northern Route and a Southern Route (Section 4.3.4.1). The seabed substrate along both routes is similar in type, predominantly a limestone pavement, changing to more unconsolidated sediments as water depth increases.

The physical presence on the west coast of Barrow Island of the Fourth Train Proposal Feed Gas Pipeline System is additional to the two Foundation Project Feed Gas Pipeline Systems, and will result in the replacement of an additional area of seabed with an artificial substrate. On the east coast of Barrow Island, the Fourth Train Proposal may result in additional use (and possibly geographic areas of use) of marine infrastructure such as barge accommodation and barge laydown, if required to support the construction activities.

Stabilisation material such as rock will be placed over the Feed Gas Pipeline System to protect it against hydrodynamic forces as it approaches the shore on the west coast of Barrow Island. The height of the Offshore Feed Gas Pipeline System after rock stabilisation material is laid is not anticipated to be more than 1 m above the natural bathymetric profile; thus, the northerly longitudinal transfer of sediments on the west coast of Barrow Island is unlikely to be hindered by the presence of the structure. The barge accommodation and barge laydown (if required) adjacent to the Materials Offloading Facility and/or WAPET Landing is anticipated to be removed once it is no longer required to support construction activities.

Illustrative mitigation and management measures identified for the seabed are also applicable to Benthic Primary Producer Habitat (BPPH) due to the close association of BPPH with seabed substrate and habitat types, and are provided in Table 10-14.

The potential construction and operations phase incremental impacts on the seabed from the Fourth Train Proposal due to physical presence of infrastructure is assessed as 'Low'. The Fourth Train Proposal Offshore Feed Gas Pipeline System is not anticipated to alter the chemical characteristics of the seabed, and physical changes to the seabed substrate type have been reduced through the selection of horizontal directional drilling for the shore crossing.

The potential construction and operations impacts of the physical presence of infrastructure from the Fourth Train Proposal on the seabed in addition to the approved Foundation Project is assessed as 'Low'. This assessment is the same as that predicted for the Foundation Project.

10.4.2.4 Spills and Leaks

A spill or leak of hydrocarbon or hazardous material has the potential to cause contamination of seabed sediments. The magnitude of potential impact depends on the location of the spill or leak and its type (e.g. condensate versus diesel). When chemicals used for the treatment of spills and leaks contact the seabed, they also have the potential to impact seabed quality through changes to chemical and physical characteristics.

Potential Impact on Seabed from Spills and Leaks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Preparation and laying of Offshore Feed Gas Pipeline System (marine) Logistics vessel operations	Additional construction activities resulting in increased marine vessel activity involved in construction and logistics vessels delivering materials to Barrow Island.	Construction: Low	Construction: Low
LNG and condensate vessel operations (including support vessels) Operation and maintenance of Offshore Feed Gas Pipeline System Logistics vessel operations	Additional marine vessel product loading and support vessel activity. Additional infrastructure present off the west coast of Barrow Island.	Operations: Medium	Operations: Medium

There is a potential for the seabed on both the west and east coasts of Barrow Island to be impacted by spills and leaks associated with the construction and operation of the Fourth Train Proposal. Potential impact sources include frac-out at North Whites Beach and a hydrocarbon release.

Discharge of drilling fluids during a frac-out event has the potential to impact the seabed. Site selection process is a key control in reducing the likelihood of unplanned discharges to the marine environment as a result of frac-outs (Section 10.3.2.1.1). However, during Foundation

Project horizontal directional drilling, five Level 1 spills occurred (outside the foreshore area) as a result of frac-outs (Chevron Australia 2012a). Low-toxicity, water-based drilling fluid was used to minimise environmental impacts, and was an effective management measure (Chevron Australia 2012a). These low-toxicity drilling fluids will be used in Fourth Train Proposal horizontal directional drilling.

Based on hydrocarbon spill modelling, the annualised likelihood of a spill scenario occurring and making contact with the shoreline (including the area below the MHWS) was determined to be low. A full description of the model and its outputs is provided in Section 5.7.2.1. A description of the likely hydrocarbon volumes reaching the shore, and the shoreline locations affected is provided in Section 10.3.2.1. Although the potential consequence of such an event could be high, the likelihood of the event occurring is considered to be low.

Illustrative measures (including spill response measures) to mitigate and manage potential impacts from spills and leaks are taken from Foundation Project EMPs and Subsidiary Documents and are presented in Section 5.7.3 for assessment purposes.

The incremental impact on the seabed from the Fourth Train Proposal due to spills and leaks from construction activities is assessed as 'Low' and from the operations phase is assessed as 'Medium' due to the potential impact consequence of a bunker fuel oil spill on sediment quality in the intertidal area.

The potential impact of spills and leaks from the Fourth Train Proposal on the seabed in addition to the approved Foundation Project is assessed as 'Low' for construction and 'Medium' for the operations phase. The Fourth Train Proposal increases the likelihood of a spill or leak, although the consequence is predicted to be similar. The assessment for the operations phase is greater than that predicted for the Foundation Project, which was assessed as 'Low'. This is a consequence of a number of vessel accidents occurring in industry since the assessment for the Foundation Project was undertaken. Thus a bunker fuel oil spill is considered a 'remote' occurrence, rather than 'rare', although the consequence of the environmental harm remains similar.

10.4.3 Proposed Management

The GJVs consider that the potential impacts to the seabed by the Fourth Train Proposal can be effectively managed under the relevant Ministerial Conditions for the Foundation Project. No measures or controls additional to those required for the Foundation Project were assessed as necessary to manage the incremental or additional impacts to the seabed from the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the various approved Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal horizontal directional drilling activities, locations, and potential impacts will also need to be prepared and approved, as described in Section 16.2.3.3. However, the GJVs anticipate that the mitigation and management measures included in the existing Foundation Project Horizontal Directional Drilling Management and Monitoring Plan will also apply to the Fourth Train Proposal and will prevent and manage any potential impact to the seabed as a result of the Fourth Train Proposal.

The existing EMPs that are relevant to addressing potential impacts to the seabed for the Fourth Train Proposal are:

- Horizontal Directional Drilling Management and Monitoring Plan
- Marine Facilities Construction Environmental Management Plan
- Offshore Feed Gas Pipeline Installation Management Plan (or equivalent Environment Plan)
- Marine Environmental Quality Management Plan

- Reverse Osmosis Brine Disposal via Ocean Outfall Environmental Management and Monitoring Plan
- Solid and Liquid Waste Management Plan

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

10.4.4 Predicted Environmental Outcome

The seabed off the west coast of Barrow Island is dominated by a limestone pavement with sediments becoming progressively unconsolidated out to the State Waters boundary. The geophysical landscape of the seabed off the west coast of Barrow Island is widely represented throughout the Montebello/Barrow/Lowendal Island Region.

Potential incremental impacts to the seabed during both construction and operations activities are predicted to be short term and/or localised, except for potential impacts from a bunker fuel oil spill during operations, although it was recognised that the likelihood of such an event occurring would be remote. Potential impacts to the limestone pavement have been reduced by the selection of horizontal directional drilling as a technique for the shore crossing.

No different impacts to the seabed were identified for the Fourth Train Proposal to those identified for the Foundation Project.

The Fourth Train Proposal will result in additional construction activities, during which localised potential additional impacts to seabed may take place. The construction of the Fourth Train Proposal shore crossing will increase the area of seabed affected by the discharge of drilling cuttings and drilling fluids off the west coast of Barrow Island when compared to that assessed and approved for the Foundation Project. Construction of the Fourth Train Proposal also has the potential to increase the likelihood of a spill or leak as a result of the additional construction activities. During the operations phase, the additional presence of condensate and LNG vessels and infrastructure in the marine environment off the west coast of Barrow Island may result in potential additional impacts. However, these are similar to the impacts of the Foundation Project alone and are expected to be localised. Except for spills and leaks, the other stressors—seabed disturbance, discharges to sea, and physical presence of infrastructure—are localised, so are unlikely to interact to result in a greater impact on the seabed. Potential additive impacts are considered to be managed.

Potential impacts to the seabed are not predicted to impact the integrity of seabed sediments through alterations to chemical or physical characteristics, nor result in any changes to the transport of sediment in the coastal and nearshore environment. The GJVs consider that the stressors to seabed will be able to be adequately managed such that the impacts are environmentally acceptable and the environmental objective (Section 10.4.1.1) is met.

10.5 Marine Water Quality

10.5.1 Assessment Framework

10.5.1.1 Environmental Objective

The environmental objective established in this PER/Draft EIS for marine water quality is:

> *To maintain the quality of marine water so that existing and potential environmental values, including ecosystem functions and integrity of the seabed and the coast, are maintained.*

10.5.1.2 Relevant Policies, Plans, and Guidelines

Commonwealth, State, and local policy and framework documents relating to marine water quality are listed in Table 10-5.

Table 10-5: Policies, Plans, and Guidelines Relevant to Marine Water Quality

Policies, Plans, Guidelines	Intent
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000)	Provides water quality standards for marine waters and a guide for setting water quality objectives to sustain current or likely future environmental values for natural and semi-natural waters in Australia and New Zealand. Provides trigger values for a range of organic and inorganic compounds that, if exceeded, should be addressed.
National Water Quality Management Strategy - Water Quality Management (ANZECC and ARMCANZ 1994)	Aims to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development.
State Water Quality Management Strategy No. 6 (Government of Western Australia 2004)	Implements the National Water Quality Management Strategy and provides guidance to set environmental values and quality objectives for water quality management in Western Australia.
Pilbara Coastal Water Quality Project Consultation Outcomes – Environmental Values and Environmental Quality Objectives (Department of Environment 2006)	Provides Environmental Values and Environmental Quality Objectives to guide the management of coastal water quality in the Pilbara Region. The relevant environmental value 'Ecosystem Health' relates to an Environmental Quality Objective of *'maintenance of ecosystem integrity'*. The document sets out four levels of protection, each with an assigned environmental quality criterion.
Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007–2017 (DEC 2007)	Provides a vision for management of the Montebello/ Barrow Islands Marine Conservation Reserves: *'To conserve the marine flora and fauna, habitats and water quality of the Montebello/Barrow Islands area. The area will support commercial and recreational activities that are compatible with the maintenance of environmental quality and be valued as an important ecological, economic and social asset by the community.'* Implements the State Water Quality Management Strategy within these Reserves and sets ecological water quality values.
Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005–2015 (Department of Conservation and Land Management [CALM] 2005)	Provides a vision for the Montebello/Barrow Islands Marine Conservation Reserves: *'The water quality of the Ningaloo Marine Park and the Muiron Islands Marine Management Area to be in the same or better condition in 2015 than in 2005'*.

10.5.2 Assessment and Mitigation of Potential Impacts

The geographic scope of the marine water quality assessment included the nearshore waters surrounding Barrow Island and the Pilbara coast under State jurisdiction. State Waters surrounding Barrow Island are well-mixed, with waters on the west coast considered to have the highest clarity, progressively decreasing towards the south-eastern side of Barrow Island (DEC 2007). Although surface waters in the North-west Marine Region are considered nutrient-poor, water quality in the vicinity of Barrow Island is characterised by high concentrations of nutrients, and exceedances of ANZECC and ARMCANZ (2000) default trigger values for water quality have been observed (Section 6.4.4).

The waters surrounding Barrow Island (excluding the Barrow Island Port area) have been declared as marine parks or marine management areas under the *Conservation and Land Management Act 1984* (WA), and are managed by DPaW for the purpose of conservation. The management of the Barrow Island and Montebello Islands Marine Parks and Bandicoot Bay Conservation Area allow for no change from background contaminant levels as a result of human activity and are considered 'pristine' (DEC 2007). The general use area of the Barrow Island Marine Management Area is considered to have very low levels of contaminants, but allows for lower levels of ecological protection if approved by the appropriate government regulatory authority (DEC 2007).

Stressors identified to have the potential to result in impacts to marine water quality in the coastal and nearshore environment (Chevron Australia 2012) are:

- discharges to sea
- seabed disturbance
- spills and leaks.

Potential water quality impacts to Pilbara coastal waters were considered as part of the assessment of the spills and leaks stressor, as spills and leaks can travel considerable distances under suitable metocean conditions.

10.5.2.1 Discharges to Sea

Discharges to sea have the potential to impact water quality through localised increases in nutrient concentrations, and the introduction of contaminants such as suspended solids, grease, surfactants, and hydrocarbons. Impacts to water quality will depend on the exact nature of the discharge, its volume, duration of the release, and the nature of the receiving environment (currents, water depth, and existing water quality). Nutrient-rich discharges can result in eutrophication, while the discharge of deck wash can result in greases and hydrocarbons entering the marine environment. Increased sediment loads can increase turbidity levels, thus reducing light penetration. Accidental hydrocarbon spills and leaks are assessed under the spills and leaks stressor (Section 10.5.2.3).

Potential Impact on Water Quality from Discharges to Sea			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Preparation and laying of Offshore Feed Gas Pipeline System (marine) Offshore accommodation occupation Fourth Train Proposal construction at the Gas Treatment Plant Operation of reverse osmosis facilities Logistics vessel operations	Additional drilling cuttings and drilling fluids discharged into the marine environment. Additional hydrotest water and marine vessel discharges to the marine environment. Additional treated effluent. Additional hydrotest water. Additional usage of the reverse osmosis facility for construction of the Fourth Train Proposal.	Construction: Medium	Construction: Medium
LNG and condensate vessel operations (including support vessels) Logistics vessel operations Operation of reverse osmosis facilities	Additional frequency of marine vessel discharges. Additional reject brine from reverse osmosis facility.	Operations: Low	Operations: Low

A range of discharges to sea were identified for the construction of the Fourth Train Proposal (Section 5.5). These include drilling cuttings and drilling fluids, hydrotest water, reject brine from the reverse osmosis facilities, and marine vessel discharges including treated effluent from offshore accommodation (if required). Operations phase discharges to sea include additional marine vessel discharges and reject brine from the operation of the reverse osmosis facilities.

10.5.2.1.1 Marine Horizontal Directional Drilling – Drilling Cuttings and Drilling Fluids Discharge

Drilling cuttings and drilling fluids released at the horizontal directional drilling exit point will generate a sediment plume resulting in increased suspended sediment loads. Given the coarse nature of the discharge, it is expected that the plume will remain close to the seabed, causing minimal impacts to water clarity off the west coast of Barrow Island. The maximum suspended sediment load in the water is predicted to be approximately 12 mg/L within 25 m, reducing to 1 mg/L by 400 m from the discharge point (Chevron Australia 2011b). As a result, impacts to water quality are anticipated to be localised and short term, returning to background levels within 24 hours of the cessation of drilling.

Drilling fluids used for the Fourth Train Proposal are expected to be low-toxicity and water-based, similar to those used by the approved Foundation Project. Such fluids are commonly used in north-west Australia, and are non-toxic, biodegradable, and are not considered to have any long-term impact to marine water quality (Talabani *et al*. 1993). The potential impacts of discharges of drilling cuttings and drilling fluids on water quality from the Fourth Train Proposal are expected to be similar to those of the Foundation Project as the same method of installation and type of drilling fluid will be used. Observational monitoring of turbidity levels during the discharge of drilling cuttings from Foundation Project activities found the spatial area impacted appeared to be smaller than that predicted by the sediment dispersion modelling and was related to weather rather than drilling activities (Oceanica 2011; Asia-Pacific Applied Science Associates 2008). The volume discharged by the Foundation Project was found to have little to no detectable impacts on the receiving environment; therefore, potential impacts on water quality are not anticipated from the Fourth Train Proposal horizontal directional drilling activities.

10.5.2.1.2 Pre-commissioning – Hydrotest Water Discharge

Discharge to the marine environment is the final option on the hierarchy of disposal options for hydrotest waters from pre-commissioning (Section 5.5.4.2). Experience gained from the disposal of hydrotest water used in the approved Foundation Project will be used to develop the most suitable disposal options for the Fourth Train Proposal. As a worst-case scenario, disposal in shallow water has been assessed.

Hydrotest water will be generated from a number of activities during construction of the Fourth Train Proposal (Section 5.5.3.3), and the largest potential discharge affecting State Waters will be from the testing of the planned LNG Tank (if required) on the east coast of Barrow Island. Hydrotest water may contain a number of additives, such as biocide, leak detection dye, and oxygen scavengers, and when discharged has the potential to release contaminants into the marine environment. The Fourth Train Proposal intends to use similar chemicals and generate similar volumes of hydrotest water as the Foundation Project. In accordance with chemical selection criteria, the selected biocide will be readily biodegradable with no potential for bioaccumulation, and the oxygen scavenger will be of low toxicity. Any unreacted oxygen scavenger present in the hydrotest water will react with dissolved oxygen (DO) on release, potentially creating a localised low DO environment; however, rapid re-equalisation of DO is expected to occur, resulting in an incidental impact. Dye added to the hydrotest water is non-toxic at the concentrations used (Chevron Australia 2014a). Therefore, potential impacts to marine water quality from Fourth Train Proposal hydrotest water are not anticipated.

10.5.2.1.3 Operation of Reverse Osmosis Facilities – Reject Brine Discharge

The Fourth Train Proposal requires an extension to the duration of the Foundation Project temporary reverse osmosis facility (or a replacement facility with similar production capabilities) and the use of spare capacity in the permanent reverse osmosis facilities. This extension or replacement may be required for any part of Fourth Train Proposal construction. No increase in discharge volumes is anticipated above the current limit, but it is anticipated that there will be a period when the temporary facility (or replacement) will operate concurrently with the Foundation Project permanent reverse osmosis facility (Section 4.5.3.4.1). The discharge of reject brine may increase salinity concentrations and introduce contaminants, as the brine contains traces of antiscalant acids, coagulants, biocides, and alkaline or acidic cleaning chemicals. Heavy metals and nutrients already present in sea water may also become concentrated through the reverse osmosis process (RPS 2009).

The key aspects of water quality that have the potential to be impacted by the reject brine discharge are salinity, pH, temperature, and chemical toxicity. No heating of the intake water is required; therefore the reject brine is likely to be near ambient temperatures, and changes to water temperatures are not expected. Modelling for the Foundation Project predicted rapid dilution of salinity and chemicals to near ambient levels within 10 to 20 m of the outfall (RPS 2009), and that a minimum 40-fold dilution factor for the reject brine discharge could be achieved within the Zone of High Impact defined for the approved Foundation Project. A 10-fold dilution is expected to provide sufficient dilutions to achieve a 99% species protection level, and that salinity concentrations of the seawater/brine mixture were expected to remain within the natural range observed (Chevron Australia 2013). Reverse osmosis reject brine will be discharged in small volumes, undergo a high degree of mixing, and has a pH which is only marginally lower than ambient sea water (Chevron Australia 2013), as such changes to sea water pH are not expected.

Interaction between the two plumes (from the Foundation Project temporary and permanent reverse osmosis facilities) were modelled with the plume from a potential Foundation Project accommodation vessel located in the tug pen to consider the potential impact on water quality parameters. The spatial separation of the three facilities' discharge points (the temporary reverse osmosis facility discharge point on the south side of the Materials Offloading Facility, the permanent reverse osmosis discharge point on the north side of the Materials Offloading Facility in the tug harbour, and east of the tug pen for the accommodation vessel) will result in plumes that do not overlap (Figure 4-11 and Section 4.5.3.4.1). Brine dispersion modelling for the approved Foundation Project permanent reverse osmosis facility found that the discharge was unimpeded by the Materials Offloading Facility and predicted a minimum 100-fold dilution within 8 m of the discharge point (Chevron Australia 2013). As such, interaction between the discharge plumes is not expected, with no impact on the achievement of a 40-fold dilution factor within the Zone of High Impact defined for the approved Foundation Project.

10.5.2.1.4 Marine Vessel Discharges

The construction and operations phases of the Fourth Train Proposal will generate additional marine vessel discharges (Section 5.5.3.1). Discharges to sea such as greywater and treated effluent from marine vessels (Section 5.5) will be biodegradable, and are governed by State and Commonwealth legislation, and international obligations to further reduce potential impacts on water quality. Localised increases in nutrient concentrations may occur in the water column; however, such increases are likely to be small when compared to the total background turnover of nutrients in the coastal and nearshore marine environment. The concentrations of oil, grease, trace metals, and other contaminants from deck drainage that could potentially enter the marine environment are also expected to be low.

Additional effluent from the offshore accommodation (if required) will be treated using an appropriate sewage system that meets MARPOL standards. The discharge of treated effluent into coastal waters off the east coast of Barrow Island (Section 5.5) will result in the addition of some nutrients to the water column. The dynamic nature of the receiving environment off the east coast of Barrow Island will ensure rapid dissipation, dispersion, and dilution of the treated effluent.

The additional marine vessels used during the operations phase have the potential to introduce contaminants from the leaching of antifouling paints. As Australia is a signatory to the International Convention on the Control of Harmful Anti-fouling System on Ships (2001), the Commonwealth Department of Agriculture will require compliance with this Convention, reducing the potential risk of these antifouling compounds.

Given the dispersive nature of the receiving marine environment, and the predominantly low toxicity and spatial or temporal variability of most marine vessel discharges, concentrations of nutrients and contaminants are likely to be at low levels and rapidly diluted and dispersed by ambient currents. Detectable changes to background water quality from these discharges are not anticipated.

10.5.2.1.5 Illustrative Mitigation and Management Measures

Illustrative measures to mitigate and manage potential impacts for this stressor are taken from Foundation Project EMPs and are presented in Table 10-6 and further described in Section 5.5.4 for assessment purposes.

Table 10-6: Illustrative Mitigation and Management Measures for Discharges to Sea in the Coastal and Nearshore Environment

Approved Foundation Project EMP	Illustrative Measures
Offshore Feed Gas Pipeline Installation Management Plan	• Offshore discharge of greywater/treated sewage only when > 3 nm from land when vessel is moving, in accordance with MARPOL 73/78. • Wastes designated as hazardous or dangerous goods will be identified, packaged, segregated, handled, stored, transported, and tracked in accordance with MARPOL 73/78 and applicable International Maritime Dangerous Goods requirements. • Offshore discharge of food wastes macerated to <25 mm only when >3 nm from land when vessel is moving, in accordance with MARPOL 73/78. • Macerator maintained as per the Vessel's Preventative Maintenance Schedule. • Vessels have an IMO-approved Sewage Treatment Plant on board. • Vessels >400 GT will have an oil-water separator on board, hold a current International Oil Pollution Prevention (IOPP) certificate, and maintain an Oil Record Book, in accordance with MARPOL 73/78. • Hazardous chemicals and dangerous goods used during the pipeline installation activities are assessed and approved, according to the Hazardous Materials Approval Procedure (OE-03.16.13) or Chevron Australia-approved Contractor chemical approval process.
Horizontal Directional Drilling Management and Monitoring Plan	To mitigate potential impacts to the marine environment through a reduction in water quality, the following strategies will be implemented: • a chemical selection procedure will be used to ensure health, environment, and safety (HES) requirements are met and the least toxic option selected • only low-toxicity, water-based drilling fluid will be used • volumes of chemicals stored on vessels will be fit-for-purpose, and wherever possible, least-hazardous chemicals will be selected • drainage from below-deck work areas with potential for contamination (e.g. from oil or grease) will be treated in accordance with MARPOL 73/78 or stored for onshore disposal to actively manage oily water according to vessel International Oil Pollution Prevention (IOPP) Certification and relevant procedures • all bilge oil/water separators will be frequently checked, maintained, and monitored to ensure systems are efficient, fully operational, and discharging treated water at a concentration of less than 15 ppm.

Approved Foundation Project EMP	Illustrative Measures
Reverse Osmosis Brine Disposal via Ocean Outfall Environmental Management and Monitoring Plan	• Diffuser designed to achieve high mixing upon discharge. • System instrumentation and monitoring of pH and chemical concentrations. • Chemical selection process (As Low As Reasonably Practicable risk to personnel and the environment).

10.5.2.1.6 Discharges to Sea Summary

The potential construction incremental impacts on water quality from the Fourth Train Proposal due to discharges to sea is assessed as 'Medium' due to the known release of drilling cuttings and drilling fluids from horizontal directional drilling on the west coast and the extension of reject brine discharges off the east coast. Exceedances of the ANZECC and ARMCANZ (2000) guidelines may occur at the horizontal directional drilling exit point on the west coast of Barrow Island, but these will be short term and localised, with no long-term exceedance of these guidelines or the environmental quality criteria established for the Pilbara Region anticipated. Discharges of reject brine are low toxicity and will be rapidly diluted by the highly dispersive marine environment.

The incremental impact for the operations phase is assessed as 'Low' as discharges to sea from the additional LNG and condensate vessels frequenting the east coast of Barrow Island will be localised, of low toxicity, and readily dispersed in the receiving marine environment.

The Fourth Train Proposal additional to the approved Foundation Project will result in increases in discharges to sea off both the east and west coasts of Barrow Island. The potential impact of discharges to sea from the Fourth Train Proposal on water quality in addition to the approved Foundation Project is assessed as 'Medium' for construction, and 'Low' for the operations phase. This assessment is the same as that predicted for the construction and operations phases of the Foundation Project.

10.5.2.2 Seabed Disturbance

Physical disturbance of the seabed can result in the suspension of sediments into the water column, causing elevations in turbidity and reducing water quality. This increased sediment load will result in reduced light availability and may result in secondary impacts to marine biodiversity; these are discussed in Sections 10.6.2.5 and 10.7.2.2.

Potential Impact on Water Quality from Seabed Disturbance			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Preparation and laying of Offshore Feed Gas Pipeline System Barge accommodation and barge laydown preparation and grounding (if required)	Additional construction activities off the west coast of Barrow Island with additional marine exit points for horizontal drilling. Additional marine vessel activity off the west coast of Barrow Island in a new geographic area. Seabed preparation alongside the Materials Offloading Facility and/or WAPET Landing due to barge grounding.	Construction: Low	Construction: Low
Operations: Trivial			

Seabed disturbance on the west coast of Barrow Island from construction activities of the Fourth Train Proposal will be localised to the horizontal directional drilling breakout point and along the length of the Fourth Train Proposal Offshore Feed Gas Pipeline. Preparation work for the laying of the Fourth Train Proposal Offshore Feed Gas Pipeline System will result in seabed disturbance, and increased suspended sediment loads off the west coast of Barrow Island (Section 4.5.1.3). Marine vessels used for the preparation work, and laying and positioning of the Fourth Train Proposal Feed Gas Pipeline System on the seabed may also increase suspended sediment loads through the use of anchors or dynamic positioning systems; however, this suspension is considered trivial with regards to water quality impacts.

Increased suspended sediment levels generated by the breakout of the horizontal directional drilling and from marine vessel anchoring are expected to return to background levels within a 24 hours of cessation of these activities (Chevron Australia 2011b). As the west coast shows natural variability in turbidity levels due to weather conditions, these activities are not considered to pose different environmental conditions to those already experienced by the receiving marine environment.

Should trenching of the Fourth Train Proposal Offshore Feed Gas Pipeline System be required, a length of up to approximately 5 km of seabed is expected to be impacted in State Waters. This will result in increased suspended sediments in the water column. This may result in localised short-term exceedances of background or applicable ANZECC/ARMCANZ (2000) water quality guidelines.

On the east coast of Barrow Island, seabed preparation and the controlled grounding of an accommodation barge and barge laydown (if required) may result in seabed disturbance adjacent to the Materials Offloading Facility and/or WAPET Landing. Sediment suspension will be short term, returning to background levels quickly, and thus impacts on water quality parameters outside the Zone of High Impact defined for the approved Foundation Project are not expected.

Seabed disturbance is not expected during the operations phase as it is anticipated that Vessel Masters of condensate marine vessels will plan their journey to avoid waiting so as to avoid additional costs, and thus preventing seabed disturbance. An existing and approved designated Anchorage Area approximately 10 nm east of the Materials Offloading Facility and outside the Port limits can be used by condensate vessels, if required. In the unlikely event that an LNG vessel arrives prior to its allocated berthing time, anchorage will generally occur in deeper waters outside State Waters.

Should trenching of the Fourth Train Proposal Offshore Feed Gas Pipeline System be required, a length of up to approximately 5 km of seabed is expected to be impacted. Based on current calculations, direct seabed disturbance from preparation and pipe-laying activities will occur along the length of the Offshore Feed Gas Pipeline System, affecting between 0.23 and 0.27 km^2 (approximately) of seabed depending on the final pipeline route chosen. This will result in suspended sediments in the water column.

Experienced gained from the Wheatstone Project, which modelled the potential sediment plume generated from trenching activities in a similar sediment type [i.e. soft sediment] in State Waters off Onslow, found the Zone of High Impact to extend 525 m either side of the centre of the trunkline. Although the trenching proposed by the Fourth Train Proposal is smaller in scale, suspended sediment loads will be experienced and may result in localised short-term exceedances of background or applicable ANZECC/ARMCANZ (2000) water quality guidelines.

Illustrative measures to mitigate and manage potential impacts for this stressor are taken from Foundation Project EMPs and are presented in Table 10-7 for assessment purposes.

Table 10-7: Illustrative Mitigation and Management Measures for Seabed Disturbance in the Coastal and Nearshore Environment

Approved Foundation Project EMP	Illustrative Measures
Offshore Feed Gas Pipeline Installation Management Plan	• Disturbance will be confined to the construction corridors in Commonwealth Waters • In State Waters, anchoring will be restricted to within the MDF as defined in Coastal and Marine Baseline State and Environmental Impact Report: Offshore Feed Gas Pipeline System and Marine Component of the Shore Crossing
Horizontal Directional Drilling Management and Monitoring Plan	Measures to mitigate direct disturbance impacts to marine habitats, and to ensure no detectable net mortality of coral assemblages include: • use of horizontal directional drilling techniques to minimise disturbance to the nearshore environment at North Whites Beach • locating the shore crossing at North Whites Beach, out of sensitive coral habitats • guidewires may be installed to ensure correct alignment of holes and to reduce unnecessary disturbance from incorrect exit point location • detailed design and engineering of anchor spread to minimise direct impacts to areas of conservation significance or environmental sensitivity • designated anchoring exclusion zones and developing an internal Anchor Management Plan • stabilisation of pipe tails through self weight in addition to supplementary pipeline stabilisation (such as clump weights) • all equipment on board vessels will be stowed securely to reduce the likelihood of solid objects falling overboard. Dropped objects will be retrieved using the least-damaging methods • locating the water winning spread outside sensitive areas (on bare rock where possible) and designing it to be secure against movement in storm conditions • The Construction Contractor will develop an Anchor Management Plan, approved by the EPCM and/or Chevron Australia. The Plan will cover, in detail, aspects such as: details of required anchor spreads, details on the management of chain/wire drag and anchor movements, and details on the procedures for the deployment and retrieval of anchors.

The Fourth Train Proposal will result in an additional construction activities and thus seabed disturbance off the west coast of Barrow Island. This will have the potential to extend the duration of impact on water quality, specifically, increased suspended sediment loads. The potential incremental impact on water quality from the Fourth Train Proposal due to seabed disturbance is assessed as 'Low' for construction as the impacts are anticipated to be localised, short term, and confined to construction activities.

The potential impact of seabed disturbance on water quality during construction of the Fourth Train Proposal in addition to the approved Foundation Project is assessed as 'Low'. This assessment is the same as that predicted for the Foundation Project, which was assessed as 'Low', as there is no increase in the potential environmental consequence to marine water quality.

10.5.2.3 Spills and Leaks

A spill or leak of hydrocarbons or hazardous materials has the potential to reduce marine water quality. Hydrocarbons may impact water quality in the form of surface sheens or slicks, entrained oil in the water column, or dissolved aromatic hydrocarbons. The actual impact to water quality parameters of the receiving marine environment is highly dependent on a range of factors including the type of hydrocarbon, its specific physical/chemical properties and composition, its weathering process, prevailing conditions, the proximity of discharge from the waters being assessed, and the discharge volume. Chemicals used for the treatment of spills also have the potential to impact water quality by changing chemical and physical characteristics of the water body. Reductions in water quality may also result in secondary impacts to marine biodiversity; these are discussed in Sections 10.6 and 10.7.

Potential Impact on Water Quality from Spills and Leaks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Logistics vessel operations Preparation and laying of Offshore Feed Gas Pipeline System (marine)	Increased duration of marine vessel activities off the west coast of Barrow Island and logistics vessels delivering materials to Barrow Island.	Construction: Low	Construction: Low
LNG and condensate vessel operations (including support vessels) Logistics vessel operations Operation and maintenance of Offshore Feed Gas Pipeline System	Additional vessels for product loading and increased support vessel activity. Additional infrastructure present off the west coast of Barrow Island.	Operations: Low	Operations: Low

Water quality surrounding the Montebello/Barrow/Lowendal Islands has the potential to be impacted by a hydrocarbon spill or leak. The most likely sources of a spill or leak which would impact water quality are a vessel refuelling incident, a vessel grounding, a well blowout, or a pipeline rupture.

A potential release of diesel from a vessel refuelling incident would be expected to rapidly degrade in the marine environment off Barrow Island (RPS 2012). The extent of potential effects on water quality would depend on the location of the spill, with modelling indicating that a spill 10 km off the west coast of Barrow Island could extend as far as the Montebello Islands due to the predominant current direction. Approximately 40% of the diesel would be expected to have evaporated within the first 24 hours as the slick spreads out on the water's surface. Water quality would be expected to return to background levels within several days (Chevron Australia 2005).

In the unlikely event of a well blowout at the Chandon gas field or a grounded condensate vessel off the east coast of Barrow Island, the condensate released has the potential to impact water quality through the introduction of toxic aromatic compounds. Persistence of condensate in the marine environment is considered low in comparison to diesels and crude oils, as condensate spreads rapidly on the sea surface where it evaporates and dissipates. However, entrained condensate from a well blowout could travel considerable distances and will not evaporate until it comes into contact with the atmosphere, so extensive areas of marine water offshore may be exposed hydrocarbons, impacting water quality.

In the unlikely event of a pipeline rupture off the west coast of Barrow Island, condensate would be likely to weather rapidly due to the high-energy environment and shallow waters. Accordingly, long-term impacts to water quality would not be anticipated. Water quality parameters would be likely to return to background levels within a matter of days on cessation of the discharge.

If bunker fuel oil is released from a grounded vessel off the east coast of Barrow Island, it would have the potential to result in a solid residue forming near the surface of the water.

Bunker fuel oil would be likely to persist in coastal and nearshore waters off Barrow Island as discrete patches and tar balls, rather than forming slicks.

A full description of the model and its outputs is provided in Section 5.7.2.1.

Illustrative measures to mitigate and manage potential impacts for this stressor are taken from Foundation Project EMPs and are presented in Section 5.7.3 for assessment purposes.

The incremental impact on water quality from the Fourth Train Proposal due to spills and leaks from the construction and operations phases is assessed as 'Low'. Although there is the potential to impact water quality parameters, the likelihood of such an event occurring is remote. In addition, spill response measures including first-strike response will be in place as described in Section 5.7.3.2.

The potential impact of spills and leaks on water quality from the Fourth Train Proposal in addition to the approved Foundation Project is assessed as 'Low' for both the construction and operations phases. This assessment is the same as that predicted for the Foundation Project, which was assessed as 'Low'. It is recognised that there will be an increase in the likelihood of a spill or leak due to the additional marine vessels operating in the area during the construction and operations phases of the Fourth Train Proposal; however, the consequence of a spill was assessed to be the same.

10.5.3 Proposed Management

The GJVs consider that the potential impacts to water quality by the Fourth Train Proposal can be effectively managed under the relevant Ministerial Conditions for the Foundation Project. No measures or controls additional to those required for the Foundation Project were assessed as being necessary to manage the potential incremental or additional impacts to water quality from the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the various approved Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal horizontal directional drilling activities, locations, and potential impacts will also need to be prepared and approved, as described in Section 16.2.3.3. However, the GJVs anticipate that the mitigation and management measures included in the existing Foundation Project Horizontal Directional Drilling Management and Monitoring Plan will also apply to the Fourth Train Proposal and will prevent or manage any potential impact to marine water quality as a result of the Fourth Train Proposal.

The existing EMPs that are relevant to addressing potential impacts to water quality for the Fourth Train Proposal are:

- Long-term Marine Turtle Management Plan
- Marine Facilities Construction Environmental Management Plan
- Horizontal Directional Drilling Management and Monitoring Plan
- Offshore Feed Gas Pipeline Installation Management Plan (or equivalent Environment Plan)
- Marine Environmental Quality Management Plan
- Reverse Osmosis Brine Disposal via Ocean Outfall Environmental Management and Monitoring Plan
- Solid and Liquid Waste Management Plan.

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

10.5.4 Predicted Environmental Outcome

The nearshore area of the west coast of Barrow Island is a high-energy environment with regular sediment movement and high suspended sediment loads caused by episodic weather events. The east coast, although less exposed, has naturally higher suspended sediment loads (Chevron Australia 2008). Both the east and west coasts generally display nutrient and contaminant levels below ANZECC and ARMCANZ (2000) default trigger levels; although breaches have occurred, these are attributed to natural environmental conditions (RPS Bowman Bishaw Gorham 2007).

Potential incremental impacts to water quality during construction and operations are predicted to be short term and localised, except for potential impacts from spills and leaks from vessels. No different impacts were identified.

The Fourth Train Proposal will result in additional construction activities, during which localised potential additional impacts to marine water quality may take place. During construction and operations, potential additional impacts are similar to those of the Foundation Project alone and are expected to be localised.

Additive or synergistic impacts are not expected, given the localised nature of the potential impacts identified and the dispersive capacity of the receiving marine environment to dissipate any introductions of contaminants/sediments into the water column.

Potential impact to marine water quality are not anticipated to result in any long-term changes beyond natural variation, nor will any short-term changes impact marine ecosystem integrity. The GJVs consider that the stressors to water quality will be able to be adequately managed such that the impacts are environmentally acceptable and the environmental objective (Section 10.5.1.1) is met.

10.6 Marine Fauna

10.6.1 Assessment Framework

10.6.1.1 Environmental Objective

The environmental objectives established in this PER/Draft EIS for marine fauna are to:

> *maintain the abundance, diversity, geographic distribution, and productivity of marine fauna at species and ecosystems levels through the avoidance or management of adverse impacts and improvement in knowledge*
>
> *avoid, reduce, and/or mitigate against impacts on the ecological functions and environmental values of marine benthic habitats (except benthic primary producer habitats)*
>
> *protect Specially Protected (Threatened) Fauna consistent with the provisions of the Wildlife Conservation Act*
>
> *protect EPBC Act-listed threatened or migratory species.*

10.6.1.2 Relevant Policies, Plans, and Guidelines

Commonwealth, State, and local policy and framework documents relating to marine fauna are listed in Table 10-8.

Mobile marine fauna may not be sole residents of State Waters; they may also use the Commonwealth Marine Area. Sessile benthic marine fauna may also inhabit waters under either Commonwealth or State jurisdiction where suitable conditions exist. As such, relevant State and Commonwealth documents are listed in Table 10-8.

Table 10-8: Policies, Plans, and Guidelines Relevant to Marine Fauna

Policies, Plans, Guidelines	Intent
Commonwealth	
Recovery Plan for Marine Turtles in Australia (Environment Australia 2003)	Aims to reduce detrimental impacts on Australian populations of marine turtles and hence promote their recovery in the wild, and specifically to: • reduce mortality of marine turtles • develop programs and protocols to monitor marine turtle populations in Australia • manage factors affecting nesting • identify and protect habitats critical for their survival • communicate results with and educate stakeholders • support and maintain existing arrangements and develop collaborative programs with neighbouring countries.
The Action Plan for Australian Cetaceans (Environment Australia 1996)	Aims to provide more information on taxonomy, distribution, habitat preference, and diet in Australian waters for most of the fauna as well as identify threatening processes and priority actions, especially: • identify key habitats for endangered or vulnerable taxa • identify threatening processes • review current conservation research and management action • recommend future priorities • identify two or more flagship taxa • develop a list of relevant experts.
The Blue, Fin and Sei Whale Recovery Plan 2005–2010 (Department of the Environment and Heritage [DEH] 2005)	The objectives of the Plan are to recover populations of Blue, Fin, and Sei Whales using Australian waters so that the species can be considered secure in the wild, and maintain their protection from human threats.
Memorandum of Understanding on the Conservation and Management of Dugongs (*Dugong dugong*) and their Habitats throughout their Range, October 2007 (Convention on the Conservation of Migratory Species of Wild Animals 1979 2007)	Aims to facilitate national and trans boundary actions that will lead to the conservation of Dugong populations and their habitats. Australia is a signatory to this Memorandum of Understanding.
Humpback Whale Recovery Plan 2005–2010 (DEH 2005a)	The objectives of the Plan are to recover Humpback Whale populations using Australian waters so that the species is secure in the wild, ensure the distribution is similar to the pre-exploitation distribution, and maintain protection of the species from human threats.
Whale Shark (*Rhincodon typus*) Recovery Plan 2005–2010 (DEH 2005b)	To maintain existing levels of protection for the Whale Shark in Australia while working to increase the level of protection within the Indian Ocean and Southeast Asian region to enable population growth, so that the species can be removed from the threatened species list of the EPBC Act.

Policies, Plans, Guidelines	Intent
Australia's Biodiversity Conservation Strategy 2010–2020 – Consultation Draft (National Biodiversity Strategy Review Task Group 2009)	Provides a national direction for biodiversity conservation over the next decade, including a vision that 'Australia's biodiversity is healthy, resilient to climate change and valued for its essential contribution to our existence'.
Australia's Oceans Policy (Environment Australia 1998)	Provides the framework for integrated and ecosystem-based planning and management for all of Australia's marine jurisdictions. It includes a vision, a series of goals and principles, and policy guidance for a national Oceans Policy.
State	
Environmental Assessment Guidelines No. 5 – Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts November 2010 (Environmental Protection Authority [EPA] 2010)	Establishes a framework for protecting marine turtles from light impacts and provides a range of solutions, along with the key principles for lighting management.
Guidance for the Assessment of Environmental Factors: Environmental Noise Draft No. 8 May 2007 (EPA 2007)	Provides guidance to proponents submitting proposals for environmental impact assessment to: • protect the environment as defined by the *Environmental Protection Act 1986* (WA) • ensure noise emissions comply with the Environmental Protection (Noise) Regulations • in relation to noise impacts on fauna, the EPA recommends that a precautionary approach should be adopted by identifying at-risk populations, and conducting a risk assessment to estimate likelihood of possible adverse impacts.

10.6.2 Assessment and Mitigation of Potential Impacts

For the purposes of this assessment, marine fauna includes mobile species such as marine mammals, marine reptiles, fish, sharks, birds, and non-benthic primary producer habitats. BPPH, which include seagrass, mangrove, macroalgal, and coral assemblages are considered in Section 10.7.

The nearshore waters of Barrow Island are species-rich; typically with tropical or subtropical species. Barrow Island is noted for its importance in providing important and critical habitat to a number of migratory bird and marine turtle species (Section 6.6.2). A total of 153 coastal and marine species with statutory protection were identified as having the potential to occur in the Fourth Train Proposal Area (Appendix E2 [Conservation Significant Species Considered for Assessment in this PER/Draft EIS]).

Where scientific information was available on a species' critical or important habitat, as defined by the then Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC 2011), potential impacts to these habitats from the Fourth Train Proposal were also assessed. Important habitats are areas regularly used by birds as part of their migration pattern. Critical habitats are areas that marine fauna species rely on for activities such as feeding, breeding, courting, and nesting, and are also referred to as biologically important areas (BIAs).

Stressors identified to have the potential to impact marine fauna in the coastal and nearshore environment (Chevron Australia 2012) were:

- artificial light

- discharges to sea
- noise and vibration
- seabed disturbance
- physical interaction
- physical presence of infrastructure
- introduction and/or spread of Marine Pests (assessed in Section 12.3)
- spills and leaks.

The stressor 'atmospheric emissions (except dust)' has been included in this section due to stakeholder interest, but was assessed as 'Trivial'.

10.6.2.1 Atmospheric Emissions (except dust)

Atmospheric emissions have the potential to impact marine fauna through inhalation by surface-breathing species, through bioaccumulation of contaminants, and through alterations to their environment such as ocean acidification. Emissions of combustion products can contribute to a decline in local and/or regional air quality.

Atmospheric emissions from the Fourth Train Proposal in addition to the Foundation Project are expected to influence ground-level concentrations of atmospheric pollutants at Barrow Island and on the mainland. The key routine atmospheric emissions anticipated from the Fourth Train Proposal are expected to be combustion products from vessel engines during construction, and from power generation during operations. These are likely to include carbon dioxide, carbon monoxide, nitrogen oxides, sulfur dioxide, methane, and volatile organic compounds (VOCs). Section 5.2 contains a full discussion of atmospheric emissions over the life of the Fourth Train Proposal.

An assessment of criteria for critical deposition levels and loads in marine environments relevant to Barrow Island was undertaken using international guidelines, standards and peer-reviewed scientific literature for the Foundation Project Air Quality Management Plan (URS 2011, 2011a). In the absence of Australian ecosystem-specific criteria, impacts of atmospheric pollutants and air toxics on the marine fauna of Barrow Island were assessed with reference to National Environment Protection (Ambient Air Quality) Measure (NEPM) human exposure limits. These criteria provide the most conservative benchmark to assess potential impacts of air quality on marine ecosystems and their fauna.

It is predicted that the concentration of pollutants originating from the Fourth Train Proposal will be only marginally above that of the Foundation Project, and well below NEPM criteria (Table 5-1 and Table 5-2). As concentrations are expected to be below the critical levels and loads, potential impacts to marine fauna are not anticipated.

The potential incremental impact on marine fauna from the Fourth Train Proposal due to atmospheric emissions (except dust) from both the construction and operations activities is assessed as 'Trivial'.

10.6.2.2 Artificial Light

Natural light intensity varies from day to night and also according to lunar and seasonal cycles, and organisms have evolved to respond to these variations through movement, feeding, mating, seasonal breeding, migration, and dormancy. Artificial light spill has the potential to impact marine fauna that respond to direct light sources or to light glow, including plankton, pelagic fish, cetaceans, avifauna, and marine turtles. The impact of light emissions on marine fauna will depend on lighting design, and on the implementation of mitigation and management measures (e.g. wavelength, luminaire orientation, shielding, height, and operation/use).

Potential Impact on Marine Fauna from Artificial Light			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Preparation and laying of Offshore Feed Gas Pipeline System (marine) Fourth Train Proposal construction at the Gas Treatment Plant Barge accommodation and barge laydown and Floatel accommodation (if required) LNG Jetty alterations (if required) Logistics vessel operations	Additional artificial light on the west coast of Barrow Island from the horizontal directional drilling site and marine vessels associated with the preparation and laying of the Feed Gas Pipeline System on the west coast. Increased artificial light on the east coast of Barrow Island from construction of the fourth LNG Train. Increased artificial light from occupied accommodation Increased artificial light from any night construction activities by marine vessels involved in LNG Jetty alterations.	Construction: Medium	Construction: Medium
Operation of Fourth Train Proposal Gas Treatment Plant LNG and condensate vessel operations (and support vessels) Logistics vessel operations	Additional flaring during commissioning and during non-routine operation; additional operation and maintenance lighting and infrastructure to result in light reflection. Increased duration of artificial light from fourth LNG Train navigational and safety lighting on the LNG Jetty, increased frequency and duration of exposure of marine vessel lighting off the east coast of Barrow Island.	Operations: Medium	Operations: Medium

Marine species may be attracted or repelled by lighting from marine, marine vessels operating on either coast of Barrow Island, or onshore activities.

During the construction and operations phases, the Fourth Train Proposal will introduce lighting sources in addition to those of the approved Foundation Project. It is expected that offshore construction activities off the west coast of Barrow Island will occur 24 hours a day, seven days a week, and will require artificial lighting for safety and navigation purposes. Onshore construction is likely to use night construction selectively. Artificial light on the west coast of Barrow Island will be generated from the horizontal directional drilling site or offshore marine vessels. These construction activities are short term and no permanent lighting on the west coast during the operations phase is anticipated. Construction on the east coast will generate additional artificial light from activities such as LNG train construction, barge accommodation, barge laydown, and LNG Jetty alterations (if required) (Section 5.3.3.1).

The operations phase will introduce additional long-term light sources on the east coast of Barrow Island at the Gas Treatment Plant and offshore during LNG and condensate marine vessel loading. An increase in light intensity from the Gas Treatment Plant compared with that approved for the Foundation Project is not predicted due to refinements made to the lighting design of the Foundation Project, reducing the overall light emissions from those initially approved (Section 5.3.3.3). Boil-off gas flaring is predicted to increase by approximately 100 hours a year as a result of the Fourth Train Proposal, to approximately 390 hours a year for the Fourth Train Proposal in addition to the approved Foundation Project. Further details on additional light sources are outlined in Section 5.3.3. The additional condensate and LNG marine vessels and use of the Foundation Project infrastructure such as the LNG Jetty will also extend the duration of light emissions at the LNG Jetty.

10.6.2.2.1 Plankton and Fish

Plankton moves up and down the water column diurnally and this movement is governed by light availability. However, impacts to plankton abundance from additional light are not anticipated as plankton-feeding fish species are also attracted to light sources (Chevron Australia 2011b). Light may also provide opportunities for predatory birds, larger fish, or cetaceans to feed upon any fish present, although the increased predation is unlikely to impact their population viability as the lights on marine vessels will be temporarily present in any given area, and spatially variable in most cases, and thus are unlikely to be a long-term attraction source.

Impacts to pelagic fish were considered unlikely to occur at a level that will impact population dynamics or viability, although localised increases in abundance may be observed through opportunistic secondary predation.

10.6.2.2.2 Cetaceans

To date, there is little evidence that artificial light affects cetacean feeding, breeding, or migration as cetacean species predominantly use acoustic, not visual, cues (Simmonds *et al.* 2004). However, it is recognised that dolphins may feed opportunistically where night-time lighting sources exist (Chevron Australia 2011c).

10.6.2.2.3 Marine Avifauna

Light emissions are known to affect marine birds, potentially attracting migratory birds, causing disorientation and wasting the energy supplies required for migration. Light sources may alter foraging behaviour of some species or provide a competitive advantage to other species (e.g. Silver Gull [*Larus novaehollandiae*] that are known to predate on marine turtle hatchlings).

The west coast of Barrow Island does not provide important non-breeding habitat for migratory birds as much of the shoreline in the immediate vicinity of the horizontal directional drilling site area is rocky, with no intertidal mudflats, providing little opportunity for feeding. Bird abundance on the west coast is considered low, although a small number of birds are likely to use the area as seasonal roosts (Chevron Australia 2005). Any potential impact is expected to be short term, and unlikely to result in population-level impacts.

Rookeries for Bridled Terns (*Onychoprion anaethetus* [previously *S. anaethetus*]) and Wedge-tailed Shearwater (*Puffinus pacificus*) are located on Double Island. As Double Island is approximately 1.5 km off the east coast of Barrow Island, and approximately 5 km from the Gas Treatment Plant site, these rookeries are not anticipated to be impacted by construction or operations light emissions.

Bridled Terns and Wedge-tailed Shearwater populations have displayed variation that is considered to be within normal demographic variability during the construction of the Gorgon Foundation Project. No influence on mortality, breeding numbers, or breeding success has been identified for either species (Chevron Australia 2012a).

10.6.2.2.4 Marine Reptiles

Artificial light emissions including light glow are known to cause behavioural responses in both nesting marine turtles and hatchlings (Chevron Australia 2014b). Avoidance of well-lit beaches may result in turtles moving to less suitable beaches (Chevron Australia 2014b). However, while nesting females favour darker beaches to lay their clutch of eggs, nesting has been observed to continue in the presence of light (Pendoley 2005).

Hatchlings use visual cues to orientate towards the sea, moving away from dark horizons like dunes, and towards the lower and lighter horizon of the sea. Lighting adjacent to breeding beaches may cause hatchling misorientation (moving landward, increasing exposure to predation) and/or disorientation (crawling in circuitous paths). Hatchlings are attracted more to light with short wavelengths (300 to 500 nanometres: the blues, greens) than longer wavelengths (more than 500 nanometres: the oranges, yellows). However, hatchlings may be more attracted to longer wavelengths if these are at higher intensities (EPA 2010). The effect of artificial lighting can be high around a new moon when there is reduced celestial lighting (EPA 2010). Turtle hatchlings at sea may also be attracted to, and get trapped within, offshore artificial light emissions, which may result in exposure to increased predation, or may use valuable energy reserves. Turtle hatchlings at sea may be attracted to additional lighting on the LNG Jetty and from marine vessels at the jetty during LNG or condensate loading.

Flatback Turtles on the east coast of Barrow Island and, to a lesser extent, Green Turtles at Whites Beach on the west coast of Barrow Island, are considered the key species of concern for the impact assessment for the Fourth Train Proposal.

Green Turtles on the West Coast

On the west coast of Barrow Island, the horizontal directional drilling site area is approximately 60 m inland from the MHWS at North Whites Beach. Green Turtles nest near North Whites Beach, with the main Green Turtle nesting area (Whites Beach) approximately 0.5 km south of the horizontal directional drilling site area where the coastline is more conducive to beach crawls by the turtles. Night-time construction activities at the horizontal directional drilling site have the potential to attract hatchlings to construction light towers and reflective surfaces. In addition, night-time activities of pipe-lay marine vessels will also generate light sources, which have the potential to affect hatchlings moving into the water. There will be no permanent lighting on the west coast of Barrow Island once the Fourth Train Proposal construction activities are complete.

The Barrow Island Hatchling Orientation Monitoring Program monitors the spread and offset angle of newly emerged hatchlings. The results of the hatchling onshore (fan-angle) monitoring during season 2010–2011 suggested that artificial light from construction activities at the horizontal directional drilling site and offshore areas did not result in hatchling orientation varying beyond that observed from baseline levels (Chevron Australia 2011d). During the 2011–2012 season, no significant difference in spread angle or offset angle was identified compared to the combined baseline season's data from 2005–2010 (Pendoley Environmental 2012). Furthermore, beach surveillance to date of hatchling fan angles during the 2012–2013 hatchling season found no recurrent deviation in spread or offset angles at Whites Beach (Pendoley Environmental 2013). Therefore, impact on nesting turtles at Whites Beach is not anticipated.

Flatback Turtles on the East Coast

On the east coast of Barrow Island, adult marine turtles and hatchlings also have the potential to be impacted by artificial light emissions associated with the construction and operation of the Fourth Train Proposal. Lighting sources will be present on the east coast during operations, but at a level substantially less than that emitted during Fourth Train Proposal construction activities.

Light spill modelling was completed for the operations phase of the Fourth Train Proposal Gas Treatment Plant in addition to the approved Foundation Project Gas Treatment Plant to understand the light levels required for safe work practices while minimising environmental light spill (Section 5.3.3.3). The addition of the Fourth Train Proposal to the approved Foundation Project resulted in modelled light spill from the Gas Treatment Plant showed that under most circumstances, light spill to the beaches would be between the luminance level of a quarter moon and a moonless clear night (illuminances less than 10^{-3} lux). Planned LNG tank rooftop maintenance is not expected to occur at night; however, in the unlikely event that it is required, the model predicts that direct light spill of up to 2×10^{-3} lux will be received at Bivalve Beach.

Light emissions from the operational Combined Gorgon Gas Development Gas Treatment Plant are predicted to result in one to two orders of magnitudes less illuminance than that assessed and approved for the Foundation Project. This reduction in light emissions is due to subsequent changes in lighting design that have led to reductions in Gas Treatment Plant light level emissions, and that have refined the design of the light modelling (Section 5.3.3.3).

During the operations phase, the Fourth Train Proposal will result in approximately 70 additional LNG and condensate marine vessels each year, which will increase the duration of light emissions at the LNG Jetty (Section 5.3.3.2). Assuming 330 vessels a year are to be loaded for the Combined Gorgon Gas Development, light emissions are predicted to be generated for up to (approximately) 90 % of the year, which represents a worst-case scenario based on one vessel loading at a time, although in practical terms there is likely to be an overlap as the LNG Jetty has two loading berths. This is an increase of approximately 21% compared to the approved Foundation Project.

Marine Turtle Monitoring Approach

A range of studies into the effects of the construction of the Foundation Project on the marine turtles present in the area have been undertaken. These studies provide important information to assist in the assessment of likely impacts from the Fourth Train Proposal, and to manage Fourth Train Proposal impacts.

Experience to date from Foundation Project monitoring has shown that nesting Flatback Turtles returned in comparable numbers to Barrow Island beaches despite increases in light emissions during Foundation Project construction (Chevron Australia 2013a). There has been no evidence from turtle stranding data to suggest the Foundation Project construction is having an impact on the turtle population that nests on Barrow Island (Chevron Australia 2012a).

The Foundation Project is continuing to adopt the monitoring programs contained in the Long-term Marine Turtle Management Plan in response to risks to Flatback Turtles. A Flatback Turtle Hatchling Dispersal and Survivorship Program study during offshore migration from nesting beaches on the east coast of Barrow Island was undertaken during February 2011 and February 2012, to better understand the influence on hatchling dispersal of offshore light sources from structures and construction vessels (Pendoley Environmental 2012a). Monitoring of turtle hatchlings has not identified any mortality that is attributable to light emissions from the Foundation Project (Chevron Australia 2012a). The number of hatchlings observed at lit checkpoints has been small (less than 1%) compared to the total numbers estimated leaving the beaches either side of the causeway (Pendoley Environmental 2012). Onshore hatchling monitoring showed that there was no significant difference in offset angles compared to baseline angles (Pendoley Environmental 2012).

During construction of the Foundation Project, and based on the information to date, there has been no evidence from the turtle strandings data to suggest that Foundation Project construction is having a significant impact on the turtle population that nests on Barrow Island (Chevron Australia 2014b). Hatchlings have been found alive near worksites (primarily Materials Offloading Facility sites, where construction occurred near the water's edge); these hatchlings were captured (under licence) and released into the sea. A study to understand whether hatchlings in the water are attracted to construction lights found that a limited number of hatchlings were recorded away from nesting beaches or trapped in light emissions offshore during the 2012–2013 season, which is less than 1% of the overall numbers of emerging hatchlings at Barrow Island (Chevron Australia 2013a).

Monitoring of marine turtles will continue for the Fourth Train Proposal as part of the Long-term Marine Turtle Management Plan (Chevron Australia 2014b), with modifications to the monitoring programs in response to risks to marine turtles, where required, and in consultation with the Marine Turtle Expert Panel.

Even with the above design, management, and monitoring measures in place, a level of uncertainty remains in predicting the potential impacts to marine turtles from the Fourth Train Proposal. The Long-term Marine Turtle Management Plan (Chevron Australia 2014b) adopts an adaptive management framework to its monitoring and incident response approaches—tiered management triggers ('Alert', 'Review', 'Action') act as early warning signals to initiate defined actions to diagnose whether a deviation in a measured parameter is outside the bounds of natural variability, and to alert managers when action should be taken. As part of the Long-term Marine Turtle Management Plan (Chevron Australia 2014b), the GJVs propose to continue to monitor marine turtles in consultation with the Marine Turtle Expert Panel.

Marine Reptiles Summary

Foundation Project monitoring of adult nesters and hatchlings, based on the evidence available to date, and in consultation with the Marine Turtle Expert Panel, suggests the management and mitigation measures implemented through the Long-term Marine Turtle Management Plan (Chevron Australia 2014b) are appropriate to mitigate impacts to marine turtles from artificial light emissions.

Due to the conservative lighting design and informed by the construction monitoring to date and the adaptive management framework, population impacts to marine reptiles are not expected.

10.6.2.2.5 Illustrative Mitigation and Management Measures

The management of light emissions discussed in Section 5.3.4 takes into account a number of principles, which include reduction of environmental impacts, compliance with applicable legislation and standards, and maintenance of safety and reliability during both construction and operations (Chevron Australia 2014b).

As part of the Long-term Marine Turtle Management Plan (Chevron Australia 2014b), marine turtle data are collected to assess any long-term anthropogenic impact on the Barrow Island nesting population. The Long-term Marine Turtle Management Plan adopts an adaptive management framework to its monitoring and incident response approaches.

Illustrative measures to mitigate and manage potential impacts for this stressor are taken from Foundation Project EMPs and are presented in Table 10-9 for assessment purposes.

Table 10-9: Illustrative Mitigation and Management Measures for Artificial Light in the Coastal and Nearshore Environment

Approved Foundation Project EMP	Illustrative Measures
Long-term Marine Turtle Management Plan	Management preference will be: • Elimination: removing the stressor (e.g. removal/elimination of a light source, or its complete shielding) • Substitution: replacing a more hazardous characteristic of the stressor with a less hazardous one (e.g. change in spectral properties of lighting) • Reduction: reducing the amount/dose or duration of time that the stressor is active (e.g. reducing the amount of light escaping from a light source by shielding, shrouding, or screening) • Administrative Controls: These include operating procedures designed to restrict exposure to the stressor, or monitoring one or more of its properties, etc.

Approved Foundation Project EMP	Illustrative Measures
	The following administrative (operating) controls will be implemented during the onshore Construction Period, where practicable: • Lighting Management Procedure • Contractor Management: ▪ Where relevant, lighting management plans will be reviewed and approved by Chevron Australia prior to inclusion in contractor management plans. ▪ Regular worksite inspections will take place throughout the year to assess compliance with the Lighting Management Procedure, with targeted inspections during the marine turtle hatchling season (January to April). ▪ Chevron Australia inductions shall address the relevant lighting management strategies and measures outlined within the LTMTMP. • Timing of Construction Activities: ▪ Where practicable, night shift activities will be scheduled to avoid the marine turtle nesting and hatchling seasons.
	These mitigation strategies will be used to manage artificial light spill during marine construction activities, where practicable: • Outside artificial lighting on vessels will be kept to a minimum (i.e. navigational lights and necessary lighting as required for safety). • Lighting will be switched off when not in use and automatic timers/sensors will be installed where practicable. • Shielded light fittings, directed lights, and/or artificial or natural screens will be used where practicable. • Temporary artificial lighting will be mounted as low as practicable and focused on areas being worked on. • Where colour definition is not required for safety or operational purposes, lighting types that are least disruptive to turtles will be used. • Accommodation windows and portholes will have blinds or curtains fitted to block out artificial light emissions from vessels.
	The following administrative (operating) controls will be implemented during the Operations Phase, where practicable: • Routinely monitor light levels around the Plant and maintain luminaires commensurate with the maintenance factor specified. • Schedule major maintenance periods outside the marine turtle breeding season, where practicable. • At the Materials Offloading Facility: ▪ During loading/unloading operations, lighting is not intended to be permanently 'on', but will be sufficient to provide safe ingress and egress route access. ▪ Vessel and barge loading/unloading will be conducted during daylight hours where practicable. ▪ Regular vessel lighting inspections shall be conducted, with targeted inspections during the marine turtle hatchling season. • At the Jetty and on visiting LNG Vessels: ▪ During loading/unloading operations, lighting shall remain 'on'. At all other times, lights shall be turned 'off'. • Regular vessel lighting inspections shall be conducted, with targeted inspections during the marine turtle hatchling season.

Approved Foundation Project EMP	Illustrative Measures
	Operations Tugs and Support Vessels are intended to be fit-for-purpose, and the following engineering controls will be implemented during the operations phase, where practicable: • Light Location and Direction: ▪ Lights shall be directed solely onto work areas (i.e. use of spotlights instead of flood lights). ▪ Overboard lighting may be installed but will only be used when required (e.g. search light). ▪ Deck lights will be installed as low as practicable and directed away from the edge of the deck. ▪ Shielded light fittings and directional lights will be used to manage light spill. ▪ Downward-facing lights will be used to manage horizon glow. ▪ Recessed lighting will be used to prevent light spill overboard. ▪ Blanks on portholes will be used to manage light spill from cabins and internal work areas. ▪ Matt finish, or non-reflective paint surfaces will be used to prevent light reflection. • Acceptable Lighting Types (subject to operational safety requirements): ▪ Light types that are least disruptive to marine turtles will be used, including long-wavelength (reduced spectrum) and low wattage lights (e.g. yellow/orange lights rather than white lights). ▪ Alternatively, the use of yellow/orange filters on white lights may be acceptable.

10.6.2.2.6 Artificial Light Summary

Construction activities on the west coast of Barrow Island for the Fourth Train Proposal will generate short-term light emissions both onshore and nearshore. Light emissions from Fourth Train Proposal construction activities on the east coast, will result in long-term light emissions that have the potential to result in disturbances to nesting Flatback Turtles and their hatchlings; based on current evidence, impacts to population viability are not anticipated.

Based on current understanding of the known effects of light emissions on marine fauna, the potential incremental impact on marine fauna from the Fourth Train Proposal artificial light emissions is assessed as ‘Medium’ for both construction and operations. In accordance with Condition 16.1A of Statement No. 800, the specific requirements for Flatback Turtle monitoring at Barrow Island during the operations phase of the approved Foundation Project will be assessed in consultation with the Marine Turtle Expert Panel following the completion of the construction monitoring programs. The potential impact of artificial light from the Fourth Train Proposal on marine fauna in addition to the approved Foundation Project is assessed as the same as that predicted for the Foundation Project for construction and operations. This is based on the Foundation Project performance to date with successful lighting mitigation and management measures, and the completed monitoring results for marine turtles (nesting and hatchlings), which currently show no Project-attributable changes to nesting or hatchling behaviour outside normal inter-annual variations.

10.6.2.3 Discharges to Sea

Planned discharges to sea have the potential to result in direct impacts to marine fauna as a result of contact with undiluted toxic discharge, or indirect impacts as a result of changes to marine water quality. Direct impacts to mobile species can include injury and entanglement in putrescible wastes. Indirect impacts to marine fauna from reduced water quality may include metabolic impacts that can either be acute or chronic. Discharges can also deplete DO levels and introduce nutrients that can provide a competitive advantage to opportunistic species, ultimately altering species-richness and/or community structures. Accidental hydrocarbon spills and leaks are assessed under the spills and leaks stressor in Section 10.6.2.8.

Potential Impact on Marine Fauna from Discharges to Sea			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Logistics vessel operations Preparation and laying of Offshore Feed Gas Pipeline System (marine) Operation of reverse osmosis facilities	Additional drilling cuttings and drilling fluids discharged into the marine environment off the west coast of Barrow Island. Additional marine vessel discharges. Additional operation of reverse osmosis facility.	Construction: Low	Construction: Low
LNG and condensate vessel operations (and support vessels) Logistics vessel operations Operation of reverse osmosis facilities	Additional marine vessel discharges. Additional reject brine discharge.	Operations: Low	Operations: Low

Discharges to sea during the construction of the Fourth Train Proposal include the discharge of drilling cuttings and drilling fluids, hydrotest water, reject brine, marine vessel discharges, and additional treated effluent discharges from the Floatel and/or barge accommodation (if required) to be placed adjacent to the Materials Offloading Facility and/or WAPET Landing. Operations phase discharges include discharges from support vessels and additional LNG and condensate vessels.

10.6.2.3.1 Marine Horizontal Directional Drilling – Drilling Cuttings and Drilling Fluids Discharge

Drilling cuttings and drilling fluids released at the horizontal directional drilling exit point will generate a sediment plume resulting in increased suspended sediment loads, and are discussed in Section 10.5.2.1.1. Potential impacts to marine fauna may include behavioural responses by mobile species already present in the vicinity of the discharges, and physical impacts to infaunal/epifaunal benthic communities.

Any impacts to marine fauna are unlikely to result in population viability impacts to mobile species. Potential impacts to sessile benthic marine fauna from smothering/abrasion will be localised, within 25 m of the horizontal directional drilling exit point. Analysis of field survey data from the Foundation Project determined no significant impacts occurred to ecological elements including macroinvertebrate species composition and abundance as a result of horizontal directional drilling activities (Section 3.5.2.3).

10.6.2.3.2 Pre-commissioning – Hydrotest Water Discharge

Hydrotest water will be generated from a number of activities during construction of the Fourth Train Proposal, and effects on water quality are discussed in Section 10.5.2.1. Hydrotest water is likely to contain a biocide; however, impacts to fauna are anticipated to be limited to individuals present in the area at the time of the discharge, and acute toxicity effects to pelagic organisms are only likely in the immediate vicinity for a short duration (hours). Infaunal/epifaunal benthic species are more likely to be impacted as mobile species are likely to move away from the area.

The biocide used in hydrotest water is readily biodegradable with no potential for bioaccumulation in marine fauna, so is considered of low potential impact. The concentration of the dye used is non-toxic; and the oxygen scavenger present in hydrotest water is of low-toxicity and is not considered to pose an environmental risk (Chevron Australia 2011b).

10.6.2.3.3 Operation of Reverse Osmosis Facilities – Reject Brine Discharge

Reject brine impacts to water quality that may impact marine fauna are discussed in Section 10.5.2.1.3. Reject brine discharge has the potential to result in behavioural avoidance by mobile species in the area, and loss of benthic sessile fauna at the discharge point due to the introduction of contaminants.

Reject brine dispersion modelling completed as part of the assessment of the approved Foundation Project temporary reverse osmosis facilities predicted that a minimum 40-fold dilution factor for the reject brine discharge could be achieved in the Zone of High Impact. Modelling indicated that a 10-fold dilution is expected to provide a 99% species protection level, and that salinity concentrations of the seawater/brine mixture were expected to remain within the natural range observed (Chevron Australia 2013). The concurrent discharge of reject brine from the permanent and temporary (or replacement) reverse osmosis facilities is not anticipated to affect the current species protection level (99%) set for marine waters outside the Zone of High Impact. As such, impacts to sessile or mobile marine fauna from these reverse osmosis facilities are not anticipated.

10.6.2.3.4 Marine Vessel Discharges

Marine vessel discharges will occur during construction and operation of the Fourth Train Proposal, and their effect on water quality is discussed in Section 10.5.2.1.4. Elevated nutrient levels from marine discharges can cause algal blooms which may interfere with marine fauna through physical damage or depletion of DO; or cause mortality of sessile benthic species. However, such impacts are considered unlikely due to the small volume of discharges and the dispersive nature of the receiving marine environment.

The introduction of greases and oils to the marine environment from food waste or deck drainage has the potential to oil the feathers of birds floating on the surface or diving, reducing their fitness. Disposal of macerated food waste and the discharge of untreated effluent is prohibited within 3 nm of land under MARPOL Regulations, thus the likelihood of oil and grease concentrations at levels that may cause reductions in fitness is low.

Discharges are also likely to be episodic, spatially distributed, and short term, which will limit direct exposure of marine fauna to undiluted discharges (Section 10.5.2.1). Given the high-energy environment of the west coast of Barrow Island and the small number of marine construction vessels, rapid dispersion of discharges is anticipated, and any behavioural avoidance associated with such discharges is likely to be incidental and unlikely to have implications for marine fauna populations. The east coast is well-flushed and has the capacity to dissipate discharges rapidly from operational sources.

10.6.2.3.5 Illustrative Mitigation and Management Measures

Illustrative measures to mitigate and manage potential impacts for discharges to sea are discussed in Section 5.5.4. Illustrative measures to mitigate and manage potential impacts for this stressor are taken from Foundation Project EMPs and are presented in Table 10-6 for assessment purposes.

10.6.2.3.6 Discharges to Sea Summary

The potential incremental impact on marine fauna from the Fourth Train Proposal due to discharges to sea is assessed as 'Low' during both construction and operations. Any impact on marine fauna will be on an individual level rather than at a level that could affect population viability.

The Fourth Train Proposal additional to the approved Foundation Project will result in increases in discharges to sea, but these discharges will be spatially separated and temporally distributed. The potential impact of discharges to sea from the Fourth Train Proposal on marine fauna in addition to the approved Foundation Project is assessed as 'Low' for construction and operations. This assessment is lower than that predicted for the Foundation Project, which was assessed as 'Medium'. This reduction in potential impact is due to experience gained from the Foundation Project, which found the dispersion of drilling cuttings from horizontal directional drilling to be far more localised than predicted by the original plume modelling, with field surveys determining no impact to ecological elements (Section 3.5.2.3).

10.6.2.4 Noise and Vibration

Anthropogenic marine noise has the potential to impact marine fauna that rely on acoustic cues for feeding, communication, orientation, and navigation. The extent of impact depends on a number of variables, including the frequency range of the emitting noise and its intensity, the receiving environment (e.g. salinity, water depth, and seabed type), metocean conditions, characteristics and sensitivity of the organism, and its distance from the source. Terrestrial vibrations and onshore noise are also capable of affecting some marine fauna, particularly nesting marine turtles (Chevron Australia 2011e).

Potential Impact on Marine Fauna from Noise and Vibration			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Preparation and laying of Offshore Feed Gas Pipeline System (marine) Fourth Train Proposal construction at the Gas Treatment Plant Barge accommodation and barge laydown preparation and controlled grounding (if required) Logistics vessel operations	Additional noise and vibration from drilling generated on the west coast of Barrow Island. Additional noise from marine vessels associated with pipe-lay activities. Additional construction activities on the east coast of Barrow Island. Additional marine vessel movement associated with preparation and grounding.	Construction: Low	Construction: Low
LNG and condensate vessel operations (including support vessels) Logistics vessel operations Operation and maintenance of Offshore Feed Gas Pipeline System	Increased duration of noise from additional LNG and condensate vessels transiting to the east coast of Barrow Island. Increased noise associated with flow through the Offshore Feed Gas Pipeline System.	Operations: Low	Operations: Low

Marine fauna considered sensitive to underwater noise include cetaceans, fish, marine turtles, and seabirds. Effects on marine fauna are broadly grouped into masking, behavioural disturbance, and temporary or permanent hearing loss. Behavioural changes can range from mild responses to complete avoidance of an affected area, resulting in habitat displacement, and the noise levels that may induce a behavioural change vary between species.

Noise levels that may induce a behavioural change vary between species. Behavioural changes can range from mild behavioural responses to complete avoidance of an affected area (habitat displacement). There is limited empirical evidence for noise effects on marine populations, but research to date suggests that behavioural changes for cetaceans may commence when noise levels received by the species exceed 120–160 dB re 1µPa; exceed 170 dB re 1µPa for marine turtles; and exceed 90 dB re 1µPa for fish (Southall *et al.* 2007; Popper *et al.* 2003; Hastings *et al.* 1996; Bartol and Musick 2003).

Marine construction noise from the Fourth Train Proposal is likely to result in a mixture of broadband noises (Figure 10-3) from sources such as horizontal directional drilling activities and marine vessels. Additional construction activities on the west coast of Barrow Island will generate noise from installing and stabilising the pipeline off the coast, from helicopters used for personnel transfer to the installation vessels, and from marine vessels. Noise characteristics will depend on a range of factors including vessel engine size and the activity being undertaken. Construction noise and noise from medium-sized vessels is generally at frequencies between 20 and 1000 Hz.

Once the Fourth Train Proposal is in the operations phase, the flow of gas through the Offshore Feed Gas Pipeline System and marine vessel movements around the Barrow Island Port area are considered the main sources of anthropogenic marine noise. Commercial vessels in the operations phase are likely to generate low-frequency sounds with peak levels between 10 and 50 Hz (United Nations Environment Protection 2012).

10.6.2.4.1 Cetaceans

Changes to normal behaviours and avoidance of areas where noise is persistent have been observed in cetaceans, as well as short-term reductions in hearing sensitivity, physical injury of ear drums, and mortality (Oslo and Paris Convention for the Protection of the Marine Environment of the North East Atlantic [OSPAR] 2009).

The Offshore Feed Gas Pipeline System routes traverse a known Humpback Whale migration route, which has been identified by DotE as a BIA. Anecdotal evidence also suggests that sheltered waters west of Trimouille Island in the Montebello Island group are used as a resting point on their northerly migration (DEC 2007); and Flacourt Bay is used on their southerly migration, although neither are defined as BIAs for resting (Chevron Australia 2005).

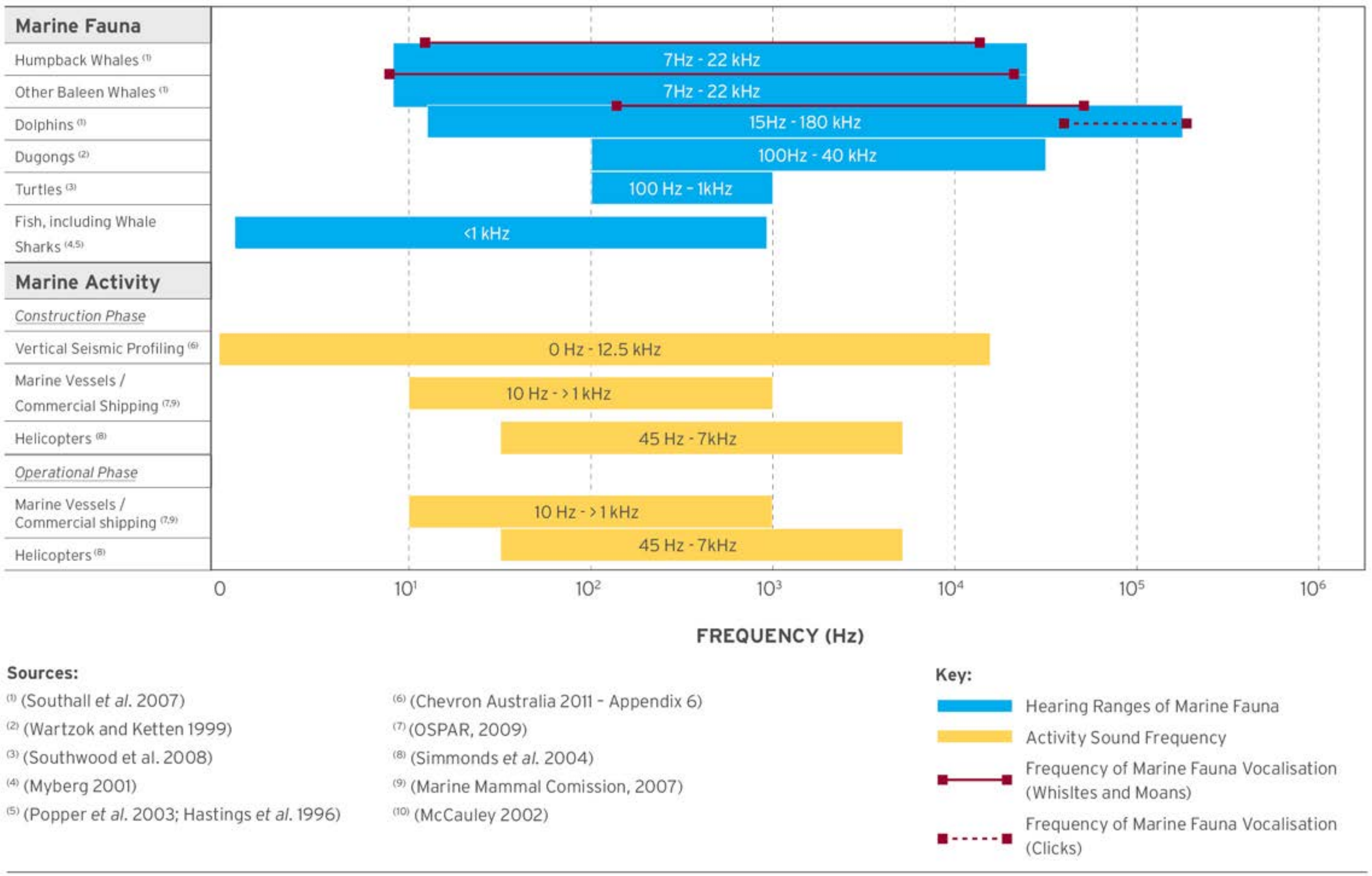

Figure 10-3: Generalised Noise Ranges for Construction and Operational Marine Activities Occurring in the Marine Nearshore Environment and Vocalisation and Hearing Ranges for a Number of Marine Fauna

Construction noise off the west coast of Barrow Island has the potential to temporarily mask cetacean vocalisation in the immediate area of installation activities during the migration period. Avoidance or behavioural changes in marine mammals may also occur where continuous industrial noise levels are above 120 dB re 1 µPa. These levels may be reached within 400 m of the pipe-lay operation and 160 m of trenching (Chevron Australia 2014a). Migrating Humpback Whales may modify their swimming direction to maintain distance from these activities; the consequences of these short-term changes in marine mammal behaviour may impact individual mammals but are not anticipated to have population effects given the short-term nature of the construction activities.

Noise generated by gas flow in the Offshore Feed Gas Pipeline System during the operations phase is low frequency (estimated at 90 dB re 1 µPA). At distances greater than 30 m from the pipeline, sound propagation will reduce sound levels to less than 75 dB (Glaholt *et al.* 2011). Baleen whales are likely to be exposed to very low intensity and low-frequency noise at their hearing threshold within this 30 m extent, but beyond it, noise levels will be no greater than ambient levels for a 'quiet ocean', with average noise levels of 75 dB re 1 µPA. Therefore, pipeline-generated noise is unlikely to compromise the ability of migrating Humpback Whales to communicate or forage.

10.6.2.4.2 Marine Reptiles

Marine turtles are sensitive to noise in the range of 100 to 1000 Hz, with greatest sensitivity between 200 to 400 Hz (Southwood *et al*. 2008). Anthropogenic marine noise may result in a change in mating and foraging behaviour of adult and juvenile marine turtles if threshold levels or frequencies are reached. This may include short-term avoidance of the area surrounding the horizontal directional drilling and offshore pipe-laying activities on the west coast.

Broadband ambient noise levels were observed to increase the most at Bivalve Beach and Terminal Beach (generally between 0700 and 1900 hours) during Foundation Project construction. The noise component audible to marine turtles increased marginally (1 to 2 dB) at these sites, with the likely sources being the movement of vehicles and activities at the Materials Offloading Facility. Whites Beach is considered a naturally noisy environment due to the exposed nature of the beach; however, monitoring has shown that narrow band ambient noise levels have not increased with the construction activities associated with the Foundation Project (SVT Engineering Consultants 2012).

Potential impacts are not anticipated to nesting marine turtles south of the horizontal directional drilling site area nor on the east coast of Barrow Island. Monitoring of turtle tracks on both the east and west coasts has also not shown any substantial changes to preferred nesting locations with the commencement of construction activities associated with the approved Foundation Project.

10.6.2.4.3 Fish

Fish are considered sensitive to marine noise as they use sound to communicate, locate prey and predators, and for orientation. Sharks rely heavily on sounds to detect prey (National Research Council [NRC] 2003), and there is general consensus that the smaller fish are more sensitive to lower frequencies. Schooling behavioural changes and area avoidance has been observed where high levels of underwater noise have been recorded (Simmonds and MacLennan 2005). However, fish are unlikely to suffer population impacts from noise if there is no perceived threat, as evidenced by the accumulation of fish adjacent to noisy artificial structures such as drilling rig platforms. Construction activities are unlikely to generate noise levels that will result in acute impacts to fish, but some area avoidance may occur on the west coast.

10.6.2.4.4 Marine Avifauna

Seabirds have the potential to be impacted by onshore noise emissions from horizontal directional drilling on the west coast of Barrow Island and the construction and operation of the Gas Treatment Plant on the east coast of Barrow Island (Section 5.4). North Whites Beach is not a favourable area for waders and shorebirds due to its rocky nature and lack of exposed mudflats, therefore impacts are not expected. The key mudflat area used by waders is Bandicoot Bay, located in the south-east of Barrow Island. Colonies of breeding seabirds are located on Double Island, approximately 5 km from the Gas Treatment Plant site. Noise generated from the Gas Treatment Plant during construction or operation is unlikely to impact population breeding success of these species. Aircraft noise is also considered unlikely to impact breeding seabirds, with Nicholson (2002) concluding that seabirds habituated to helicopters flying within 200 m of colonies at the Lowendal Islands.

10.6.2.4.5 Illustrative Mitigation and Management Measures

Noise and vibration emissions will be managed by the implementation of mitigation and management measures as identified in Section 5.4.4. Illustrative measures to mitigate and manage potential impacts for this stressor are taken from Foundation Project EMPs and are presented in Table 10-10 for assessment purposes.

Table 10-10: Illustrative Mitigation and Management Measures for Noise and Vibration in the Coastal and Nearshore Environment

Approved Foundation Project EMP	Illustrative Measures
Offshore Feed Gas Pipeline Installation Management Plan	• A caution zone will be established around observed cetaceans, with a radius of 150 m for a dolphin and 300 m for a whale in accordance with EPBC Regulations 2000 Division 8.1. • Dynamic Positioning systems will be maintained in accordance with the installation vessel’s preventive maintenance program to avoid excessive thruster noise.
Horizontal Directional Drilling Management and Monitoring Plan	To minimise disturbance to cetaceans (and possibly other marine fauna), all vessels associated with horizontal directional drilling activities will adhere to Part 8 of the Environment Protection and Biodiversity Conservation Regulations 2000 and the 2005 Australian National Guidelines for Whale and Dolphin Watching (DEH 2006) in regard to potential interaction with cetaceans, including: • Helicopter: maintaining helicopter height to higher than 1650 feet or outside a horizontal radius of 500 m of a cetacean.

10.6.2.4.6 Noise and Vibration Summary

The potential incremental impact on marine fauna from the Fourth Train Proposal due to noise and vibration generated during both construction and operations is assessed as ‘Low’. Onshore vibration is considered incidental, particularly for marine turtles and seabirds.

The Fourth Train Proposal will result in an increased duration of anthropogenic marine noise emitted into the marine environment during construction activities; however, construction noise will be short term and intermittent in nearshore waters off the west coast, as will marine vessel noise in the nearshore area. Onshore construction-generated noise is considered incidental. Marine noise resulting from the operations phase of the Fourth Train Proposal represents a small-scale increase in LNG and condensate vessels anticipated. The potential impact of noise and vibration from the Fourth Train Proposal on marine fauna in addition to the approved Foundation Project is assessed as ‘Low’ for both construction and operations. This assessment is lower than that predicted for Foundation Project construction, which was assessed as ‘Medium’. This reduced impact assessment outcome is due to the smaller scale of the Fourth Train Proposal construction activities when compared to the Foundation Project activities and the experience gained to date on construction activities.

10.6.2.5 Seabed Disturbance

Physical disturbance of the seabed can cause elevated suspended sediment loads that may result in behavioural or physiological changes to mobile species in the vicinity of the disturbance (e.g. marine turtles, cetaceans, Dugongs, fish avoiding the area) or smothering and/or abrasion of sessile benthic marine fauna and infaunal communities. Depending on the duration of the disturbance, benthic epifaunal/infaunal communities can be lost or degraded.

Potential Impact on Marine Fauna from Seabed Disturbance			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Logistics vessel operations Preparation and laying of Offshore Feed Gas Pipeline System (marine) Barge accommodation and barge laydown preparation and controlled grounding (if required)	Additional benthic habitat disturbed on the west coast of Barrow Island from the exit points of horizontal directional drilling. Additional marine vessels anchoring off the west coast of Barrow Island in a new geographic area. Seabed preparation off the east coast of Barrow Island prior to barge grounding.	Construction: Low	Construction: Low
Operations Phase: Trivial			

Behavioural changes and avoidance of areas by mobile species due to seabed disturbance may be of concern where the area to be disturbed is a key life stage area used for breeding, feeding, nesting, and/or resting; and/or where the behavioural change results in permanent avoidance.

The construction of the Fourth Train Proposal on the east coast may involve the controlled grounding of barge accommodation and barge laydown (if required) adjacent to the Materials Offloading Facility and/or WAPET Landing, which may generate seabed disturbance from ground preparatory works and placement of the barges. Sediment disturbance is likely to be highly localised, short term, and is expected to return to pre-construction concentrations within 24 hours after cessation of the works. Potential impacts to mobile marine fauna are considered unlikely.

Seabed disturbance on the west coast of Barrow Island from the preparation work and subsequent laying of the Offshore Feed Gas Pipeline System (Section 4.3.4) may increase suspended solid loads in the water column, causing short-term behavioural changes such as area avoidance by marine fauna. Marine fauna likely to be in the vicinity include marine turtles, pelagic fish, larger predatory fish, and marine mammals. Green Turtles use the limestone pavement to feed, court, and mate and limestone pavement is considered critical habitat for this species. The limestone pavement extends subtidally around much of Barrow Island and alternative feeding areas for marine turtles occur both north and south of the horizontal directional drilling exit point and Offshore Feed Gas Pipeline System route. Therefore, any impact to mobile marine fauna is likely to only be for the duration of the construction activities, with species returning to the area when activities cease and suspended solid levels return to background concentrations. In addition, the horizontal directional drilling technique has been selected to reduce direct impacts to the limestone pavement and the habitat this substrate supports.

Sessile benthic epifauna such as sea pens and sea fans have been observed in low densities off the west coast of Barrow Island beyond the limestone pavement; this area is dominated by macroalgal assemblages (Chevron Australia 2011a). Increased suspended solids from seabed disturbance have the potential to damage the delicate feeding apparatuses of these epifauna through abrasion and smothering, impacting on their health by inhibiting filter-feeding. However, given the low densities of the epifauna, any potential impact is likely to be highly localised and within the immediate vicinity of the Offshore Feed Gas Pipeline System. Sediment is anticipated to resettle to pre-construction concentrations within a few hours after the works are completed.

Seabed disturbance during the operations phase from marine vessels is not anticipated. An existing and approved designated Anchorage Area approximately 10 nm east of the Materials Offloading Facility and outside the Port limits can be used by condensate vessels, if required. If an LNG vessel arrives prior to its allocated berthing time, normally the vessel will remain offshore in deeper waters though it may occasionally use the designated Anchorage Area.

10.6.2.5.1 Illustrative Mitigation and Management Measures

Illustrative measures to mitigate and manage potential impacts from seabed disturbance are taken from Foundation Project EMPs and are presented in Table 10-4 and Table 10-7 for assessment purposes.

10.6.2.5.2 Seabed Disturbance Summary

The potential incremental impact on marine fauna from the Fourth Train Proposal due to seabed disturbance is assessed as ‘Trivial’ during operations, and as ‘Low’ during construction. Construction seabed disturbance will be short term and localised, and the habitats likely to be impacted are widely represented throughout the Montebello/Barrow/Lowendal Island region. The Fourth Train Proposal will result in additional seabed disturbance on the east and west coasts of Barrow Island, but the magnitude of disturbance is considerably less than that required for the Foundation Project, as a result of the smaller-scale activities of the Fourth Train Proposal and the absence of dredging. Seabed disturbance will be short term and localised and it is likely that mobile species in the area will display short-term behavioural responses. Sessile benthic epifauna and infaunal communities may be smothered or suffer abrasion in localised areas, but no long-term consequences to habitat viability from these small losses are anticipated. The loss of this habitat is also not expected to impact the marine fauna that feed on it (e.g. marine turtles).

The potential impact of seabed disturbance from the Fourth Train Proposal on marine fauna in addition to the approved Foundation Project is assessed as ‘Trivial’ for the operations phase and ‘Low’ for construction. This assessment is lower than that predicted for the Foundation Project construction, which was assessed as ‘Medium’, because the Fourth Train Proposal does not involve dredging, which was a substantial source of sediment suspension and plume development for the Foundation Project.

10.6.2.6 Physical Interaction

The physical interaction of marine vessels with mobile marine fauna has the potential to cause a range of impacts including injury or fatality through direct strike or entrapment, or behavioural responses due to disturbance. Species that spend extended periods of time at the water’s surface and/or are slow moving with limited capacity to rapidly alter course, are more vulnerable to impacts from physical interaction. Vessel speed is a key risk factor in marine fauna collisions—the higher the speed, the greater the risk.

Potential Impact on Marine Fauna from Physical Interaction			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Preparation and laying of Offshore Feed Gas Pipeline System (marine) LNG Jetty alterations Barge accommodation and barge laydown controlled grounding (if required) Logistics vessels operations	Additional construction activities resulting in presence of marine vessels associated with horizontal directional drilling and preparation and pipe-laying of the Feed Gas Pipeline System. Additional marine vessel movements associated with LNG Jetty alterations and barge grounding. Additional logistics vessels delivering construction materials to Materials Offloading Facility and vessel movements between Floatel and Barrow Island.	Construction: Medium	Construction: Medium
LNG and condensate vessel operations (including support vessels) Logistics vessel operations	Increased marine vessel movements within Barrow Island Port Area.	Operations: Medium	Operations: Medium

Slow-moving, surface-breathing marine fauna including marine turtles, cetaceans, and Dugongs, are at the greatest risk of physical interaction (predominantly vessel strike). Other marine fauna such as sharks (excluding Whale Sharks) and bony fish are considered less likely to be impacted by vessel strike as their time at the surface is limited, and they are fast-moving and able to change course rapidly.

To date, the Foundation Project has not recorded any vessel strike involving either Dugongs or cetaceans. Sixteen incidents relating to marine turtles were reported by the Foundation Project between 2009 and 2013 where the outcome was recorded as either 'not natural' or 'unknown', which may be attributable, or partially attributable, to Foundation Project vessel interactions. These incidents occurred off the east coast of Barrow Island, except for one off the west coast of Barrow Island during pipe-laying activities (Chevron Australia 2009, 2010, 2011d, 2012a).

East coast construction activities include marine vessel movements as part of the controlled grounding of barge accommodation and barge laydown (if required), movement of personnel between Floatel and Barrow Island, alterations to the topside of the LNG Jetty (if required), and delivery of materials by logistics vessels. The positioning of the barges will be at slow speeds and through the use of tug boats. However, logistics vessels may travel at higher speeds, posing a risk of physical interaction from vessel strike. Marine turtles, particularly Flatback Turtles, are the fauna most at risk off the east coast of Barrow Island.

West coast construction activities include marine vessel movements as part of the installation of the Offshore Feed Gas Pipeline System. These vessels are predominantly stationary to ensure the pipelines are positioned correctly, and any travel is for short distances at slow speeds to the next positioning point, generally less than 0.5 knots. The greatest risk to marine fauna is during transit where speeds are greater than 5 knots.

Green Turtles aggregate along the west coast for feeding and mating purposes, and may be at risk of physical interaction impacts on an individual level, but not a population level. Dugongs are unlikely to be involved in any physical interaction impacts off the west coast due to the lack of seagrass meadows in this area; their presence is likely to be transient, and they are timid animals, tending to avoid vessels and activity. Dolphins using shallow waters may be observed during construction activities; however, vessel strike incidents are not expected as they are able to rapidly change course. Humpback Whales on their northerly or southerly migrations may also be encountered, and behavioural change such as increased distance from vessels and shoreline may be observed.

Once the Fourth Train Proposal is in the operations phase, physical interaction may occur due to additional logistics vessels, and LNG and condensate vessels berthing at the LNG Jetty. Vessels will be escorted by tugs from the approved designated Anchorage Area, and then piloted by Barrow Island-based pilots to the Product Loading Facility. Operating procedures when in the vicinity of whales, dolphins, and Whale Sharks are outlined in a Notice to Mariners; these procedures include vessel speed restriction zones within Barrow Island Port limits.

10.6.2.6.1 Illustrative Mitigation and Management Measures

Illustrative measures to mitigate and manage potential impacts for this stressor are taken from Foundation Project EMPs and are presented in Table 10-11 for assessment purposes.

Table 10-11: Illustrative Mitigation and Management Measures for Physical Interaction in the Coastal and Nearshore Environment

Approved Foundation Project EMP	Illustrative Measures
Offshore Feed Gas Pipeline Installation Management Plan	▪ A caution zone will be established around observed cetaceans, with a radius of 150 m for a dolphin and 300 m for a whale in accordance with EPBC Regulations 2000 Division 8.1. ▪ If marine megafauna are spotted, vessels moving >6 knots will adjust their speed to <6 knots or adjust their direction to avoid impacting the animal, if safe to do so. ▪ Any detected injury or fatality attributed to the Gorgon Gas Development and Jansz Feed Gas Pipeline of any marine species (including marine turtles) listed as specially protected under the provisions of section 14 (2)(ba) of the Wildlife Conservation Act or the EPBC Act will be reported.
Horizontal Directional Drilling Management and Monitoring Plan	Specific controls to be implemented to prevent harm to, or fatalities of marine fauna include: ▪ Marine Fauna Observer program ▪ vessel speed management ▪ daily beach walks by trained project personnel during the turtle nesting season for detection and recording of any turtle nest sites within the immediate vicinity of the horizontal directional drilling worksite ▪ monitoring of known turtle nests in the vicinity of the horizontal directional drilling worksite during hatchling emergence season. If any impacts are observed, appropriate steps will be taken to eliminate the hazards, wherever practicable ▪ driving on the beach during the peak turtle nesting and hatching season (October to April) is prohibited, unless required under specific or unusual conditions (i.e. to move a guide wire or access a frac-out site). In these situations, it will be necessary to obtain an internal permit, which will require additional controls to be in place, and which will be determined on a case-by-case basis. Driving on the beach is to be avoided at all other times, where practicable ▪ marine construction works will generally occur only during the day shift (unless specifically required to complete individual tail pull-outs from time to time) ▪ fishing, hunting, surfing, and swimming are not permitted at any time in the waters surrounding Barrow Island.

Approved Foundation Project EMP	Illustrative Measures
	To reduce the risk of injury or fatality to marine fauna due to vessel strike, a trained Marine Fauna Observer will be on watch when all these conditions are in place: ▪ daylight hours; and ▪ vessel is moving (>5 knots); and ▪ vessel is close to shore (within 3 nm of the beach); and ▪ during times of high turtle activity (November to February).
	To minimise disturbance to cetaceans (and possibly other marine fauna), all vessels associated with horizontal directional drilling activities will adhere to Part 8 of the Environment Protection and Biodiversity Conservation Regulations 2000 and the 2005 Australian National Guidelines for Whale and Dolphin Watching (DEH 2006) in regard to potential interaction with cetaceans, including: ▪ ancillary/support vessel(s): maintaining position outside the caution zone of cetacean(s) under normal operating speed or withdrawing from a caution zone at a constant speed of less than 6 knots. The caution zone is defined as an area around the cetacean with a radius of 150 m for a dolphin and 300 m for a whale ▪ horizontal directional drilling vessel: no action as the horizontal directional drilling vessel is expected to be mostly stationary, hence unlikely to pose a collision risk for marine fauna
	Additional management measures to minimise disturbance to marine fauna include: ▪ Project personnel will not be permitted to intentionally feed, harass, capture, disturb, harm, or kill marine fauna. ▪ Whale, dolphin, Dugong, and marine turtle sightings by project vessels will be recorded during construction activities. If marine mammals are sighted, other vessels operating in the area will be notified by project vessels and the behaviour and direction of the marine mammals will be recorded and monitored. A fauna sighting report will be collated and forwarded to DotE annually.

10.6.2.6.2 Physical Interaction Summary

The potential incremental impact on marine fauna from the Fourth Train Proposal due to physical interaction from construction activities is considered 'Medium'. The potential incremental impact of the Fourth Train Proposal operations phase resulting from LNG and condensate vessels movements to and from the LNG Jetty on the east coast is assessed as 'Medium'.

Based on Foundation Project vessel strike data during construction, Fourth Train Proposal construction activities are not expected to increase the consequence of the potential impact to marine fauna from physical interaction. The consequence from the increase in the operations phase marine vessel movements is also assessed as the same as that of the Foundation Project. The potential impact of physical interaction from the Fourth Train Proposal on marine fauna in addition to the approved Foundation Project is assessed as 'Medium' for both construction and operations. This does not represent a change to the level of potential impact assessed for the approved Foundation Project.

10.6.2.7 Physical Presence of Infrastructure

The physical presence of infrastructure in the marine environment may create new habitat for sessile benthic marine fauna or result in habitat loss, which may have secondary implications for mobile marine fauna that rely on it. The presence of infrastructure can modify the behaviour of mobile species through attraction or repulsion, and may provide habitat that they can use for protection, feeding, or shelter. Congregations of fish are often found around permanent structures, and artificial structures commonly become colonised with ascidians, mussels, and encrusting organisms.

Potential Impact on Marine Fauna from Physical Presence of infrastructure			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Preparation and laying of Offshore Feed Gas Pipeline System (marine) Logistics vessel operations Barge accommodation and barge laydown preparation and grounding (if required)	Additional subtidal infrastructure present off the west coast of Barrow Island. Additional subtidal temporary infrastructure off the east coast of Barrow Island.	Construction: Low	Construction: Low
Operation of Offshore Feed Gas Pipeline System	Additional artificial structure present on the west coast of Barrow Island.	Operations: Low	Operations: Low

Fourth Train Proposal construction activities that have the potential to impact marine fauna include the Offshore Feed Gas Pipeline System off the west coast and the temporary presence of barge accommodation and barge laydown (if required) on the east coast of Barrow Island. Operations phase impacts relate to the presence of the Offshore Feed Gas Pipeline System.

The construction of the Offshore Feed Gas Pipeline System will replace a narrow corridor of seabed substrate from the horizontal directional drilling exit point out to the State Waters limit, permanently altering it to an artificial state. This will result in the loss of the existing benthic habitat, which is an area sparsely inhabited by sessile benthic marine fauna, including sea pens, sea cucumbers, and sea fans. Benthic epifaunal and infaunal species found in this area are considered widespread and common, and have not been noted as either critical or important habitat[10] to any species. In the longer term, the surface of the Fourth Train Proposal Offshore Feed Gas Pipeline System may provide suitable substrate for colonisation by epibenthic species that prefer hard substrates.

The presence of barge accommodation and laydown barges adjacent to the Materials Offloading Facility and/or WAPET Landing may attract marine fauna for shelter or potential food sources, but any attraction will be short term and during construction only.

Once operational, the physical presence of the Offshore Feed Gas Pipeline System off the west coast of Barrow Island is unlikely to have an impact on mobile marine fauna at a species or population level, as a result of causing behavioural responses or through loss of benthic habitat. Pelagic fish may be attracted to the pipeline structure and associated stabilisation materials, using it for shelter or as a food source once benthic communities establish on the artificial structure. Impacts at a population level from increased predation risks by larger fish or marine turtles are not anticipated.

Illustrative measures to mitigate and manage potential impacts to marine fauna from this stressor are taken from Foundation Project EMPs and are provided in Table 10-14 for assessment purposes.

The potential incremental impact on marine fauna from the Fourth Train Proposal due to physical presence of infrastructure is assessed as ‘Low’ for both construction and operations, given the limited number of structures to be placed in the coastal and nearshore environment.

[10] As defined by the SEWPaC Guidelines (2011)

The potential impact of physical presence of infrastructure during construction and operation of the Fourth Train Proposal on marine fauna in addition to the approved Foundation Project is assessed as 'Low'. This assessment is the same as that predicted for the Foundation Project.

10.6.2.8 Spills and Leaks

Spills and leaks of hydrocarbons or hazardous chemicals have the potential to impact marine fauna indirectly by reducing marine water quality or by direct exposure. The degree of impact to marine fauna will depend on various factors, including the time of exposure (i.e. immediately following the spill or a period after the release), the type of release, the location of the release and its proximity to sensitive marine areas, and the metocean conditions at the time. Different marine fauna species have different levels of sensitivity that should be considered when assessing the likely impact. Effects can occur at a community, population, or individual level, and result in lethal (acute) or sublethal (chronic) effects.

Potential Impact on Marine Fauna from Spills and Leaks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Logistics vessel operations Preparation and laying of Offshore Feed Gas Pipeline System (marine)	Additional marine vessel activities on the west coast of Barrow Island.	Construction: Medium	Construction: Medium
LNG and condensate vessel operations (including support vessels) Logistics vessel operations Operation and maintenance of Offshore Feed Gas Pipeline System	Additional marine vessels for product loading and increased support vessel activity. Additional infrastructure present off the west coast of Barrow Island.	Operations: Medium	Operations: Medium

Marine mammals, marine reptiles, and avifauna can be directly impacted by hydrocarbon spills and leaks through inhalation, ingestion, or physical contact. Inhalation of hydrocarbon vapours may affect the central nervous system, liver, and lungs; ingestion can damage the digestive tract of an animal. Vapours can also act as an irritant, reducing the animal's health and overall viability. The toxicity of hydrocarbon spills to marine fauna is generally a result of the dissolved aromatic component.

For heavier hydrocarbons, the surface slick thickness can be used to determine the likely risk of physical oiling of marine fauna at the water surface; this predominantly affects avifauna at risk of hypothermia from oiling of feathers, and surface-breathing marine mammals and reptiles. Few studies have been undertaken to assess the impact of entrained oil, and thus the threshold values selected are nominal and used to reflect increasing potential impact to marine life (RPS 2012). Exceedance of 1 g/m^2 is considered to give a 'perception' of environmental harm due to visibility, but is unlikely to result in an observable effect on marine organisms. Surface slick hydrocarbon concentrations above 10 g/m^2 are used as an indicator for moderate oiling, as these concentration levels have the potential to impact marine fauna and coat emergent habitat. However, direct environmental impact cannot be assumed from the exceedance of thresholds alone—a range of parameters including impact pathways, contact toxicity, receptor sensitivity, dosage, prevailing conditions at the time of spill, and specific chemical/physical composition affect the impact on marine fauna.

Hydrocarbon spill modelling was conducted for the Fourth Train Proposal. A full description of the model outputs is provided in Section 5.7.2.1. A description of the likely hydrocarbon volumes reaching the shore, and the shoreline locations affected is provided in

Section 10.3.2.1. The spill scenarios predicted to have the greatest potential impact were a bunker fuel oil spill off the east coast of Barrow Island and the rupture of the Offshore Feed Gas Pipeline System off the west coast.

10.6.2.8.1 Fish

Case studies offer no definitive evidence to suggest that hydrocarbon pollution has significant effects on fish populations in the open sea. Hydrocarbon-induced mortality of young fish is considered of little significance compared with larger losses each year through natural predation and targeted fishing. A wide variety of fish species occur in coastal and nearshore waters; these species have varying physiology, feeding behaviours, and habitats. No known aggregation areas for fish species have been identified in the Fourth Train Proposal Area. Therefore, impacts are not expected.

10.6.2.8.2 Cetaceans

Hydrocarbons are unlikely to adhere to a cetacean's smooth skin surface. However, cetaceans that surface within a spill may inhale vapours, with impacts as described above, and high doses may result in narcosis. Baleen whales such as Humpback Whales are considered more susceptible to harm from hydrocarbons as they filter large volumes of sea water and may ingest large volumes of hydrocarbons if they are swimming close to the water's surface. Humpback Whales have the potential to be impacted if a spill coincides with their annual migration north or south (Section 6.6.2.2.1).

10.6.2.8.3 Marine Reptiles

Documented evidence of impacts to marine turtles is limited, but are likely to occur in individuals that surface in the hydrocarbon slick, potentially causing eye, airway, and/or lung damage, which can cause inflammation and infection. Adult breeding females exposed to hydrocarbons may transfer hydrocarbons to eggs during the preparation and laying of eggs, which may impact embryo development, or result in mortality. Hatchlings exposed to hydrocarbons when emerging from the nest may suffer similar impacts as adult turtles. Fresh condensate also has the potential to damage the airways and/or eyes of marine turtles.

The heavy and persistent nature of bunker fuel has the potential to result in heavy oiling of intertidal areas and beach habitats (Section 10.4.2.3), affecting the nesting and reproductive success of Flatback Turtles through the oiling of eggs, which may inhibit development, and the reduced survival of hatchlings. The likelihood of such consequences occurring depends on the timing of the spill coincident with the breeding and nesting season. Flatback Turtle females nest once every two to five years, so in the event of hydrocarbon exposure, only a portion of the nesting population would be exposed. The worst-case scenario from modelling predicted a winter spill (May to September), which is outside the Flatback Turtle breeding season.

The modelled Offshore Feed Gas Pipeline System rupture was predicted to impact the west coast of Barrow Island, Lowendal Islands, and south-western sides of the Montebello Islands. A rupture from the Feed Gas Pipeline System 200 m west of Barrow Island predicted an exceedance of 10 ppb for dissolved aromatics during the summer, and hence the potential to directly impact breeding adult Green Turtles and hatchlings, and may impact their potential future breeding success. Green Turtle females nest once every two to five years, so in the event of hydrocarbon exposure, only a portion of the nesting population would be exposed. The evaporative nature of condensate will remove the volatile toxic components within a few days of cessation of the rupture.

A condensate release at the Chandon gas field was modelled to reach the Ningaloo Coast with entrained oil concentrations more than 100 ppb. The highest probability of contact was during October, which is during the nesting season for Flatback and Green Turtles and which therefore has the potential to affect nesting females at, or travelling to, natal beaches. Springtime spills and leaks could also coincide with the emergence of Hawksbill Turtle hatchlings in the area. A mean dissolved aromatic concentration of 6 ppb was predicted, well below the threshold for set for 99% species protection by ANZECC and ARMCANZ [2000] guidelines, and surface slick thickness was not predicted to be above the threshold concentration. Thresholds of more than 100 ppb for dissolved aromatics are generally exceeded before narcosis will be observed. As Flatback, Green, and Hawksbill Turtles all exhibit cyclical nesting patterns, only a portion of a nesting population would be exposed in the event of a hydrocarbon spill or leak. For further discussion on the Ningaloo Coast, see Section 13.2.

Population-level impacts to marine turtles are not expected as the likelihood of a major spill event is low.

10.6.2.8.4 Marine Avifauna

Impacts to diving seabirds, surface feeders and shorebirds may include oiling of feathers and ingestion of hydrocarbons while preening, feeding, or resting. Mortality is usually due to loss of feather waterproofing, which can result in drowning or hypothermia. The digestion or absorption of hydrocarbon through food contamination or direct physical contact can lead to damage to the digestive tract and other organs, and impairment of mobility (National Oceanic and Atmospheric Administration [NOAA] 2010). Reductions in reproductive success have also been recorded in birds as a result of hydrocarbon spills, and longer-term impacts to a population will depend on the number of young non-breeding birds affected.

The modelled Offshore Feed Gas Pipeline System rupture was predicted to impact the west coast of Barrow Island, Lowendal Islands, and south-western sides of the Montebello Islands. Fresh condensate is considered highly toxic and inhaled vapours will damage the airways and/or eyes of marine fauna exposed to these vapours. Avifauna are considered particularly vulnerable at all life stages, both in the water and onshore. However, the annualised probability of this event is predicted to be only 1 in 36 000.

Population-level impacts to avifauna from a condensate rupture or diesel spill off the west coast is unlikely as bird count data on Barrow Island suggests that two-thirds of birds present are located in the south and south-east in the Bandicoot Bay Conservation Area, which is not predicted to be affected by any spills off the west coast of Barrow Island.

10.6.2.8.5 Illustrative Mitigation and Management Measures

Illustrative measures to mitigate and manage potential impacts for spills and leaks are taken from Foundation Project EMPs and are presented in Section 5.7.3 for assessment purposes.

10.6.2.8.6 Spills and Leaks Summary

The Fourth Train Proposal will increase the likelihood of a spill or leak due to the additional construction activities on both the west and east coasts of Barrow Island, increased support vessel usage and additional LNG and condensate vessels that will frequent the Barrow Port area during the operations phase. Based on an assessment of severity of the consequence (while recognising that the likelihood of an event is very low), the potential incremental impact on marine fauna from the Fourth Train Proposal due to spills and leaks during the construction and operations phases is assessed as ‘Medium’.

The potential impact of spills and leaks from the Fourth Train Proposal on marine fauna in addition to the approved Foundation Project is assessed as ‘Medium’ for both the construction and operations phases. This assessment is the same as that predicted for the Foundation Project. It is recognised that there will be an increase in the likelihood of a spill or leak due to the additional marine vessels operating in the area during the construction and operations phases of the Fourth Train Proposal; however, the consequence of a spill was assessed to be the same.

10.6.3 Conservation-significant Species

Conservation-significant marine species that could be impacted by the Fourth Train Proposal were identified from Commonwealth and State legislation (Section 2); full descriptions of these marine species and their habitats can be found in the Environmental and Social Baseline (Section 6.6.2). To ensure a focused assessment, data were gathered and analysed on each species to determine if they were likely, possible, or unlikely to be present in the Fourth Train Proposal Area. This determination was based on several factors including species' geographic range, presence of critical or important habitat, abundance, and regularity of occurrence. This screening process was undertaken to identify those species where the potential existed for a population-level impact due to their presence in the area, or the presence of critical or important habitat (Appendix E2 [Conservation Significant Species Considered for Assessment in this PER/Draft EIS]).

Species that were deemed unlikely to be present in the Fourth Train Proposal Area were screened out from further species assessment. Species which were assessed as possibly present were considered in the general assessment of potential impacts on marine fauna and their habitats, as described in Section 10.6.2. Conservation-significant marine fauna that were likely to be in the vicinity of the Fourth Train Proposal are discussed in the subsections below. Habitats identified as important to conservation-significant marine fauna in the Fourth Train Proposal Area were:

- marine turtle feeding grounds for juveniles and adults:
  - shallow, subtidal, limestone pavement reef with macroalgal assemblages used by adult Green Turtles
  - subtidal pavement with filter-feeding assemblages, such as soft-bodied sea pens and sea cucumbers, used by Flatback Turtles
- marine turtle nesting and internesting grounds:
  - high-energy, deep, steeply sloped, sandy unobstructed foreshore used for nesting by Green Turtles
  - deep, sandy, low-sloped beaches with wide shallow intertidal zones used for nesting by Flatback Turtles
  - small, shallow beaches characterised by coarse-grained sand or coral grit interspersed with rocks and beach wrack for nesting by Hawksbill Turtles
- shallow seagrass meadow used by Dugongs for feeding
- extensive tidal mudflats for use by feeding shorebirds.

Except for a small number of cetacean species identified in the Fourth Train Proposal Area (Blue Whale, Southern Right Whale, Humpback Whale, and Sperm Whale), cetacean aggregations are likely to vary spatially and temporally in response to oceanographic and bathymetric parameters, and ecological processes that affect prey concentrations. BIAs identified in the vicinity of the Fourth Train Proposal Area are outlined in Section 6.6.2.

Table 10-12: Conservation-significant Marine Fauna Species Likely within the Fourth Train Proposal Area within State Waters

Species	Scientific Name	Commonwealth Protection[1]	State Protection[2, 3]
Marine Reptiles			
Green Turtle	*Chelonia mydas*	V	Sch 1[2]
Flatback Turtle	*Natator depressus*	V	Sch 1[2]
Hawksbill Turtle	*Eretmochelys imbricate*	V	Sch 1[2]

Species	Scientific Name	Commonwealth Protection[1]	State Protection[2, 3]
Marine Mammals			
Blue Whale *	*Balaenoptera musculus*	E, M	Sch 1[2]
Humpback Whale	*Megaptera novaeangliae*	V	Sch 1[2]
Sperm Whale *	*Physeter macrocephalus*	M	P4[3]
Australian Snubfin Dolphin	*Orcaella heinsohni*	M	P4[3]
Indo-Pacific Humpback Dolphin	*Sousa chinensis*	M	P4[3]
Dugong	*Dugong dugon*	M	Sch 4[2]
Avifauna			
Wedge-tailed Shearwater	*Puffinus pacificus*	M, Marine	Sch 3[2]
Bridled Tern	*Onychoprion anaethetus* (previously *Sterna anaethetus)*	M, Marine	Sch 3[2]

Notes:

1 Status under the EPBC Act: V = Vulnerable; E = Endangered; CE = Critically Endangered; M = Migratory (matters of NES)

2 Status under the Wildlife Conservation Act: Sch 1 = Schedule 1: Fauna that is rare or is likely to become extinct; Sch 4 = Schedule 4: Other specially protected fauna

3 DPaW Current Threatened and Priority Fauna Ranking: P4 = Priority Four: rare or near threatened taxa or taxa requiring monitoring

** Discussed in Section 13 given its oceanic, offshore nature in the Fourth Train Proposal Area*

Source: EPBC Act Protected Matters Interactive Search Tool (14 January 2008), coordinate area search

10.6.3.1 Green Turtles, Flatback Turtles and Hawksbill Turtles

Barrow Island and its surrounding waters are noted for their importance to Green Turtles, Flatback Turtles, and to a lesser extent Hawksbill Turtles. Internesting habitat data suggests that Green Turtles prefer the north-west, north, and north-east coasts of Barrow Island, while Flatback Turtles spend time off the east coast of Barrow Island and in shallow nearshore waters off the adjacent mainland coast. Internesting habitat of the Hawksbill Turtle was found to be the north-east of Barrow Island (Chevron Australia 2014b).

Stressors identified to have the potential to impact marine turtles in the coastal and nearshore environment are:

- artificial light (Section 10.6.2.2)
- discharges to sea (Sections 10.5.2.1 and 10.6.2.3)
- noise and vibration (Section 10.6.2.4)
- seabed disturbance (Sections 10.5.2.2 and 10.6.2.5)
- physical interaction (Section 10.6.2.6)
- spills and leaks (Sections 10.5.2.3 and 10.6.2.8).

Analysis of multiple stressors related to the Foundation Project horizontal directional drilling and Offshore Feed Gas Pipeline System construction activities undertaken for the Long-term Marine Turtle Management Plan was used to aid the assessment of the Fourth Train Proposal on marine turtles (Chevron Australia 2014b). The assessment considered each marine turtle species and what stage of their life cycle had the potential to be impacted by stressors generated by these activities.

Potential impacts were identified for adult nesting or mating Green Turtles and their hatchlings on the west coast, and adult nesting or mating Flatback Turtles and their hatchlings on the east coast.

Artificial Light

Light spill from additional lighting on the east coast from Fourth Train Proposal construction activities is likely to be the primary stressor on the east coast affecting nesting Flatback Turtles and their hatchlings. Additional lighting from the construction of Fourth Train Proposal Gas Treatment Plant has the potential to affect breeding Flatback Turtle females returning to natal beaches for egg laying and also the potential to disorient hatchlings as they emerge and move towards the ocean. Once the Fourth Train Proposal moves into the operations phase, additional offshore and onshore artificial lighting on the east coast will continue to have the potential to impact Flatback Turtle nesting and hatchlings through disorientation and attraction, resulting in dehydration risk and increased predation risk.

Marine turtle observations to date as part of the Long-term Marine Turtle Management Plan (Chevron Australia 2014b) have not shown any statistical change in the proportional use of natal beaches within 2 km of the Gas Treatment Plant since the commencement of Foundation Project construction (Chevron Australia 2013a). Studies in the 2011–2012 season of turtle hatchling movements offshore from the east coast found water currents are an overriding factor in the movement of hatchlings out of nearshore coastal waters. A study to understand whether hatchlings in the water are attracted to construction lights found that a limited number of hatchlings were recorded away from nesting beaches or trapped in light emissions offshore; however, this is less than 1% of the overall numbers of emerging hatchlings at Barrow Island (Chevron Australia 2013a).

Discharges to Sea

Discharges to sea generated from the Fourth Train Proposal during both the construction and operations phases are likely to dissipate quickly in the receiving environment and are unlikely to impact marine turtles, unless individuals are in the immediate vicinity of the discharge. Where marine turtles are present, behavioural responses, such as moving out of the immediate area into alternative habitat may occur, but discharges are not likely to cause impacts on the health of the individual.

Noise and Vibration

Adult Green Turtles are known to use the nearshore area off North Whites Beach for courting and mating activities as well as feeding on macroalgae or invertebrates on the limestone pavement. Juveniles also feed in the area. Noise generated from marine vessel thrusters associated with pipe-lay and horizontal direction drilling activities may result in behavioural responses such as short-term avoidance of the limestone pavement in the vicinity of the noise source in favour of limestone pavement to the north and south.

Seabed Disturbance

Seabed disturbance associated with construction activities off the west coast of Barrow Island is likely to be localised and short term, although behavioural avoidance of the nearby area may be observed in individuals. The extensive nature of the limestone pavement covered with macroalgae assemblages on the west coast suggests suitable habitat exists elsewhere for Green Turtles when construction is underway, and therefore population impacts are unlikely. No impact to this species at either a population level from loss of habitat, or loss of individuals due to direct impact is expected.

Physical Interaction

Physical interaction of marine vessels with marine turtles has the potential to occur during both construction and operations activities of the Fourth Train Proposal. Marine turtle fatalities have been recorded during the construction of the Foundation Project; however, some of the causes of these mortalities remain unknown. Impacts are not anticipated at a population viability level from the Fourth Train Proposal given the smaller marine vessel fleet associated with the construction and operations, although individual impacts may be observed with the increase in vessel movements in the area.

Spills and Leaks

Spills and leaks have the potential to have consequences to marine turtles if they coincide with the breeding season and impact natal beaches. However, the likelihood of such an event occurring is 'Low'. Green, Hawksbill, and Flatback Turtle females nest once every two to five years, so in the event of hydrocarbon exposure, only a portion of the nesting population would be exposed.

Marine Reptiles Summary

Additive impacts are not expected off the west coast of Barrow Island, as North Whites Beach is not heavily used as a natal beach by Green Turtles and suitable foraging and courting areas over the limestone platform exist elsewhere. The short-term displacement of any foraging/courting animals in the nearshore area may reduce their exposure to stressors associated with localised seabed disturbance, discharges to sea, and physical interaction, which could otherwise result in additive stress/impacts to the species.

Interactions of the identified stressors that could result in an additive impact to marine turtles on the east coast of Barrow Island are artificial light and physical interaction. This additive impact has the potential to affect nesting turtles and hatchling orientation, as well as foraging turtles. However, as the Long-term Marine Turtle Management Plan (Chevron Australia 2014b) has shown no statistically significant change in turtle sightings off the east coast as a result of Foundation Project construction, the Fourth Train Proposal is not anticipated to increase the consequence of impact from that assessed for the Foundation Project.

10.6.3.2 Marine Mammals

10.6.3.2.1 Cetaceans – Blue Whales, Humpback Whales, Sperm Whales, Australian Snubfin Dolphin, and Indo-Pacific Humpback Dolphin.

While whale species may occur in the Pilbara Region, many are likely to be transient or migratory rather than resident. This is also likely to be the case for most dolphin species recorded, except Indo-Pacific Humpback Dolphins and Bottle-nosed Dolphins, which are regularly sighted in coastal and nearshore waters on both the east and west coasts of Barrow Island, and which both have resident populations in the shallow waters of the Barrow Island area.

Potential stressors identified from the assessment that have the potential to impact the identified cetaceans or their biologically important areas in the coastal and nearshore environment are:

- discharges to sea (Sections 10.5.2.1 and 10.6.2.3)
- noise and vibration (Section 10.6.2.4)
- physical interaction (Section 10.6.2.6)
- seabed disturbance (Sections 10.5.2.2 and 10.6.2.5)
- spills and leaks (Sections 10.5.2.3 and 10.6.2.8).

Discharges to Sea

Discharges to sea are likely to be highly localised and short term and will dissipate quickly into the receiving nearshore environment and are not anticipated to have an impact that will result in any change to population viability of cetaceans in the Fourth Train Proposal Area.

Noise and Vibration

Individuals may show signs of behavioural response to anthropogenic marine noise generated as part of the Fourth Train Proposal, but their response will be highly variable and based on a range of internal and external factors such as species, age, and distance from the noise source. Behavioural responses, such as moving away from an area, require energy that may have been spent acquiring food or enhancing reproduction (NRC 2003), but only repetitive behavioural change has the potential to cause cumulative stress. Of the species identified, the Humpback Whale has the greatest potential to be impacted in the coastal and nearshore environment during its southerly or northerly migration as a result of anthropogenic marine noise associated with construction activities occurring off the west coast of Barrow Island (Section 10.6.2.4). During the Humpback Whale migration, individuals travelling alone or in short-term aggregations may show behavioural avoidance of the noise source (Section 10.6.2.4).

Shipping noise generates lower frequencies than those used by dolphins for communication. As such, behavioural impacts may be observed, but are not anticipated to affect the viability of dolphin populations found in the local vicinity of Barrow Island.

Physical Interaction

The potential for physical interaction between vessels and cetaceans exists during the construction and operation of the Fourth Train Proposal as a result of additional vessel movements. Off the west coast, potential physical interaction will only occur during construction activities, while off the east coast the potential for physical interaction will occur during the construction and operations phases. To date, there has been no physical interaction from vessel strike with cetaceans associated with the Foundation Project.

Seabed Disturbance

Seabed disturbance is not anticipated to impact cetaceans as sediment suspension resulting from Fourth Train Proposal construction activities is likely to quickly dissipate into the nearshore marine environment once the activity ceases.

Spills and Leaks

Humpback Whales are considered particularly sensitive to spills and leaks due to their feeding mechanism of straining large quantities of sea water. The consequence of a spill during the migration season (north or south) has the potential to be substantial due to the ingestion of hydrocarbons; however, the likelihood of this event occurring during the migration season is ‘low’, and spill modelling suggests the movement of the slick is unlikely to be in the main migratory path for this species. Potential impacts to cetaceans from spills and leaks are described in Section 10.6.2.8.

Cetaceans Summary

Of the above stressors identified, additive impacts are not anticipated to occur on cetaceans within coastal and nearshore waters due to the temporal and spatial separation of activities. Discharges to sea, physical interaction, and seabed disturbance off the west coast will be highly localised and short term. Noise from construction activities will be intermittent, and the likelihood of a spill is considered ‘Low’. Potential impacts identified from the marine fauna assessment that may interfere with breeding, feeding, migration, or resting behaviours are unlikely at a population level.

10.6.3.2.2 Dugongs

Dugongs are found in the shallow warm waters of the Montebello/Lowendal Islands, and seagrass beds around the Lowendal Islands provide Dugong feeding habitat (DEC 2007). Marine fauna observations as part of the Foundation Project have regularly recorded Dugongs off both the east and west coasts of Barrow Island. Aerial and tagging surveys are currently being completed by Chevron Australia and its Joint Venture Partners for the Wheatstone Project as part of their Dugong Research Project. Results from the first phase of the project suggest the south-east area off Barrow Island is an area with a high probability of Dugong sightings, although they are likely to be transient in the area.

The lack of well-developed seagrass habitat in the Fourth Train Proposal Area indicates that stressors are more likely to impact individual animals rather than their benthic habitat. Stressors identified that have the potential to impact marine fauna and that are relevant to Dugongs are:

- discharges to sea (Sections 10.5.2.1 and 10.6.2.3)
- noise and vibration (Section 10.6.2.4)
- seabed disturbance (Sections 10.5.2.2 and 10.6.2.5)
- physical interaction (Section 10.6.2.6)
- spills and leaks (Sections 10.5.2.3 and 10.6.2.8).

Discharges to Sea

Discharges to sea resulting from the Fourth Train Proposal are expected to be localised and to rapidly dissipate into the receiving marine environment. Potential impacts on Dugongs are not anticipated other than the possibility of nuisance disturbance resulting in Dugongs temporarily seeking alternative areas.

Noise and Vibration

Anthropogenic marine noise has the potential to impact Dugongs given its potential to travel large distances, potentially impacting Dugongs further afield at the Montebello and Lowendal Islands. Anthropogenic marine noise generated during construction activities will be intermittent and short term. Such noise has the potential to result in nuisance disturbance to Dugongs, but it is unlikely to impact sufficient numbers of individuals to result in population-level changes. The operations phase will also result in an increase in the number of vessels moving to and from the east coast of Barrow Island. The level of anthropogenic marine noise generated from these vessels will not increase, but they will add to the duration of anthropogenic marine noise experienced.

Seabed Disturbance

Seabed disturbance resulting from the Fourth Train Proposal will be highly localised and well outside the critical habitats identified for the Dugong. Impacts are not anticipated as disturbance to the seabed will be short term, although some behavioural avoidance of the area may occur by Dugongs transiting through the waters off the west coast.

Physical Interaction

As slow-moving surface-breathing animals, Dugongs tend to rest at the surface between dives, making them susceptible to vessel strike (Department of Environment [n.d.]). Hodgson and Marsh (2006) found that reaction times of Dugongs do not change in accordance with the speed of an approaching vessel; thus faster-moving marine vessels provide less time for the animal to alter course, and so have a greater probability of causing Dugong mortality due to the force of impact and higher probability of contact. Vessel strike during the construction of the Fourth Train Proposal is not expected as marine vessels involved in construction activities will be operating at low speeds or will be stationary in most instances. To date, there have been no observed vessel strikes on Dugongs off either the east or west coasts of Barrow Island during the construction phase of the Foundation Project.

The increase in movement of LNG and condensate vessels in the operations phase as a result of the Fourth Train Proposal is not expected to increase the potential incidence of physical interaction with Dugongs. Condensate and LNG vessels moving within Port limits will be piloted into the LNG Jetty using tugs, which will be operated at low speeds. In addition, MFOs are required to be on board vessels within the limits of the Port of Barrow Island to minimise the potential impact of marine activities on key marine fauna. Thus, no increased possibility of vessel strike with Dugongs is anticipated.

Spills and Leaks

A large spill or leak has the potential for consequences to Dugongs which are similar to cetaceans. However, the likelihood of such a high consequence spill event occurring is rare (Section 10.6.2.8).

Dugongs Summary

The additive impact of the identified stressors within the Fourth Train Proposal Area is unlikely to increase the potential impact to Dugongs due to the temporal and spatial separation of activities, and their transient presence in the Fourth Train Proposal Area. Observations of Dugong behaviour suggest they are timid and will avoid areas where activities are occurring, and, given the number of Dugongs observed within the Fourth Train Proposal Area and the small likelihood that more than one stressor will act on an individual simultaneously, there are unlikely to be impacts on Dugong population viability. The Fourth Train Proposal is not expected to degrade or reduce seagrass habitat during either construction or operations.

10.6.3.3 Wedge-tailed Shearwaters and Bridled Terns

Double Island, 1.5 km off the east coast of Barrow Island, is a regionally significant rookery for Bridled Terns (*Onychoprion anaethetus*) and a locally significant rookery for Wedge-tailed Shearwaters (*Puffinus pacificus*).

Potential stressors originating from the Fourth Train Proposal that are relevant to Wedge-tailed Shearwaters and Bridled Terns were identified as:

- artificial light (Section 10.6.2.2)
- spills and leaks (Sections 10.5.2.3 and 10.6.2.8).

Artificial Light

Although the Wedge-tailed Shearwater rookery is small compared to other rookeries in the region (Chevron Australia 2005), fledging Wedge-tailed Shearwaters have been documented as being attracted to the night lighting of the Gas Treatment Plant on nearby Varanus Island (Nicholson 2002). Therefore, individuals of this species have the potential to be impacted by artificial lighting associated with the construction and operation of the facilities on the east coast of Barrow Island.

Although the Fourth Train Proposal will add to light emitted on the east coast during the construction and operations phases, light spill modelling concluded that the operational Fourth Train Proposal would result in a ‘negligible’ contribution to the light spill assessed and approved for the Foundation Project (Section 5.3.3), and as such, long-term impacts to avifauna are not expected to be any different to those already assessed and approved for the operation of the Foundation Project.

Spills and Leaks

As described in Section 10.6.2.8, avifauna have the potential to be impacted by spills and leaks, with surface-feeding birds such as shearwaters and terns considered to be at risk due to their feeding behaviour, which includes diving/foraging for food in both coastal and offshore environments. However, the potential of a spill or leak to impact breeding areas on Double Island is unlikely as burrows and nest areas for Bridled Terns and Wedge-tailed Shearwater are situated across the top of Double Island, away from foreshore areas (Chevron Australia 2005).

If adult seabirds are oiled from a spill or leak event, juveniles that are still dependent on food from their parents may also be impacted through subsequent loss of food supply or ingestion of contaminated food. However, the wide availability of foraging habitat for adult birds and the tendency of these species to feed in small groups is likely to reduce the potential for impacts at the local population level from isolated spills and leaks. Any impacts to individuals would not be anticipated to affect the wider population of either Wedge-tailed Shearwaters or Bridled Terns, as their distribution range extends far beyond the Fourth Train Proposal Area.

Marine Avifauna Summary

The potential additive impacts on conservation-significant marine avifauna as a result of the Fourth Train Proposal are not predicted to change from that assessed and approved for the Foundation Project. The Fourth Train Proposal is unlikely to increase the potential impact to either marine avifauna species.

10.6.4 Proposed Management

The GJVs consider that the potential impacts to marine fauna by the Fourth Train Proposal can be effectively managed under the relevant Ministerial Conditions for the Foundation Project. No measures or controls additional to those required for the Foundation Project were assessed as being necessary to manage the incremental or additional potential impacts to marine fauna from the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the various approved Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal horizontal directional drilling activities, locations, and potential impacts will also need to be prepared and approved, as described in Section 16.2.3.3. However, the GJVs anticipate that the mitigation and management measures included in the existing Foundation Project Horizontal Directional Drilling Management and Monitoring Plan will also apply to the Fourth Train Proposal and will prevent and manage any potential impact to marine fauna as a result of the Fourth Train Proposal.

The existing EMPs that are relevant to addressing potential impacts to marine fauna for the Fourth Train Proposal are:

- Long-term Marine Turtle Management Plan
- Marine Facilities Construction Environmental Management Plan
- Horizontal Directional Drilling Management and Monitoring Plan
- Offshore Feed Gas Pipeline Installation Management System (or equivalent Environment Plan)
- Marine Environmental Quality Management Plan
- Solid and Liquid Waste Management Plan
- Reverse Osmosis Brine Disposal via Ocean Outfall Environmental Management and Monitoring Plan.

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

10.6.5 Predicted Environmental Outcome

The Montebello/Barrow/Lowendal Islands group is noted for its importance to marine biodiversity with species-richness typical of the wider region. The islands are of regional importance for turtle breeding; Barrow Island for Green Turtles and Flatback Turtles, and the Montebello Islands for Hawksbill Turtles. A Humpback Whale migration route passes close to the west coast of Barrow Island, with sightings of Humpback Whales also recorded on the east coast.

Construction impacts are anticipated to be short term and localised. Artificial light has the potential to impact up to three breeding seasons for marine turtles during construction off the west coast of Barrow Island (if the Control Umbilical is constructed before the other components of the Feed Gas Pipeline System). The Fourth Train Proposal will result in additional artificial light emissions over the longer term from the Gas Treatment Plant on the east coast, which will add to light glow levels. The increase is considered to result in light glow that is equivalent of a moonless clear night sky with airglow, but is still less than the light emissions assessed and approved for the Foundation Project. A spill or leak from the Fourth Train Proposal could result in severe impacts to marine fauna or critical/important habitat; however, the likelihood of a spill or leak occurring that could result in such impacts is predicted to be very low. In addition, first-strike spill response procedures will be in place.

When added to the approved Foundation Project, the assessment of impact on marine fauna has remained the same for all stressors. The Fourth Train Proposal will result in additional construction activities on the east coast of Barrow Island, during which time additional impacts to marine fauna may take place. Of the stressors discussed, the potential exists for physical interaction and artificial light on the east coast of Barrow Island to cause a greater additive impact than when considered separately, given both have the potential to impact marine turtles, however, significant environmental impacts are not predicted.

With mitigation and management measures in place, the Fourth Train Proposal is not anticipated to affect the abundance, diversity, or geographic distribution of marine fauna found within or adjacent to the Fourth Train Proposal Area. Impacts to the functional ability of non-benthic primary producer habitats are not predicted, nor are potential impacts expected to the population viability of those marine species specifically protected by State or Commonwealth legislation.

The GJVs consider that the stressors to marine fauna will be able to be adequately managed such that the impacts are environmentally acceptable and the environmental objective (Section 10.6.1.1) is met.

10.7 Benthic Primary Producer Habitats

10.7.1 Assessment Framework

10.7.1.1 Environmental Objective

The environmental objectives established in this PER/Draft EIS for BPPH is:

> *To maintain the abundance, diversity, geographical distribution, ecological function, and productivity of mangroves, marine macrophytes (seagrass, macroalgae), and corals through avoidance or management of adverse impacts and improvement in knowledge.*

10.7.1.2 Relevant Policies, Plans, and Guidelines

Commonwealth, State, and local government policy and framework documents relating to BPPH are listed in Table 10-13.

Table 10-13: Policies, Plans, and Guidelines Relevant to BPPH

Policies, Plans, Guidelines	Intent
Guidance for the Assessment of Environmental Factors: Guidance Statement for Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline No. 1 April 2001 (EPA 2001)	Provides guidance on how to demonstrate that a proposal will not adversely affect mangrove habitats, the ecological function of these areas, or the maintenance of ecological processes that sustain them.

Policies, Plans, Guidelines	Intent
Environmental Assessment Guidelines No. 3 – Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment December 2009 (EPA 2009)	• Requires proposals to demonstrate: ▪ consideration of options to avoid damage or loss of BPPH ▪ design that minimises damage or loss of BPPH ▪ best practice in design, construction methods, and environmental management aimed at minimising indirect impacts ▪ consideration of an environmental offset where substantial cumulative losses of BPPH have already occurred ▪ risk to ecosystem integrity within a management unit is not substantial. • Includes quantitative cumulative loss guidelines for BPPH within defined local assessment units for six categories of ecological protection. Assessment of the Fourth Train Proposal falls within Category C (non-designated areas) which outlines a maximum 2% damage/cumulative loss guideline.
Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007–2017 (DEC 2007)	Outlines a vision and series of objectives, targets, and ecological and social values for the sustainable management of the area, while protecting and conserving its biodiversity.
Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005–2015 (CALM 2005)	Vision for the Ningaloo Marine Park and Muiron Islands Marine Management Area: *'The marine flora and fauna [and] habitats … of the Ningaloo Marine Park and the Muiron Islands Marine Management Area will be in the same or better condition in 2015 than in the year 2005.'*

10.7.2 Assessment and Mitigation of Potential Impacts

BPPH generally only occurs in intertidal and subtidal areas within the photic zone, which roughly corresponds to water depths less than 40 m. Seagrass, macroalgae, coral, and mangrove-dominated communities are the predominant BPPHs found in marine waters surrounding Barrow Island and off the Pilbara coast (Chevron Australia 2005).

The dominant ecological unit potentially impacted by the Fourth Train Proposal on both the east and west coasts of Barrow Island are macroalgae assemblages on limestone pavement, as depicted in Figure 6-12 and Figure 6-13. This habitat is considered extensive and widespread around Barrow Island. It is home to a range of invertebrate life and provides a food source to a range of marine fauna found in these coastal waters (Chevron Australia 2011). Further description of the BPPH of Barrow Island can be found in Section 6.6.1.

Stressors identified to have the potential to impact on BPPH in the coastal and nearshore environment (Chevron Australia 2012) are:

- discharges to sea
- seabed disturbance
- physical presence of infrastructure
- introduction and/or spread of Marine Pests (assessed in Section 12.3)
- spills and leaks.

Except for spills and leaks, no stressors were identified to have the potential to impact BPPH found in Barrow Island or Pilbara coastal waters.

10.7.2.1 Discharges to Sea

Potential impacts to BPPH from discharges to sea can be from both the introduction of chemical contaminants and/or due to the physical characteristics of the discharge which can result in smothering or abrasion. Effects can include mortality or reduced health of BPPH. Accidental hydrocarbon spills and leaks are assessed under the spills and leaks stressor (Section 10.7.2.4). Indirect impacts to BPPH that may result from adverse changes to water quality are discussed in Section 10.5.

Potential Impact on BPPH from Discharges to Sea			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Logistics vessel operations Preparation and laying of Offshore Feed Gas Pipeline System (marine) Offshore accommodation occupation Fourth Train Proposal construction at the Gas Treatment Plant Operation of reverse osmosis facilities	Additional drilling cuttings and drilling fluids discharged to a new area of seabed off the west coast of Barrow Island. Additional marine vessel discharges. Additional treated effluent. Additional operation of reverse osmosis facilities.	Construction: Low	Construction: Low
LNG and condensate vessels operations (including support vessels) Logistics vessel operations Operation of reverse osmosis facilities	Additional frequency of marine vessel discharges. Additional reject brine discharge.	Operations: Low	Operations: Low

A range of discharges to sea have been identified for the construction of the Fourth Train Proposal that have the potential to impact BPPH (predominantly macroalgal assemblages). These include the release of drilling cuttings and drilling fluids, treated effluent from the barge and/or Floatel accommodation, reject brine, and marine vessel discharges. Operations phase discharges include additional marine vessel discharges in the Barrow Island Port area.

10.7.2.1.1 Marine Horizontal Directional Drilling – Drilling Cuttings and Drilling Fluids Discharge

The selection of the horizontal directional drilling technique for the Fourth Train Proposal reduces the potential impact to macroalgal BPPH as drilling will occur beneath the limestone pavement, but it will result in the discharge of drilling cuttings and drilling fluids at the exit point. Macroalgal assemblages are likely to be present at low densities in this area. Toxicity impacts to either algal or invertebrate species associated with the BPPH community are not anticipated as the drilling fluid to be used has a low aquatic toxicity (Section 5.5.3.2). The volume of discharged drilling cuttings and drilling fluids is expected to be half that discharged from the horizontal directional drilling exit point of the Foundation Project, which showed little or no detectable impact on the receiving marine environment. As such, it is anticipated that Fourth Train Proposal horizontal directional drilling activities are unlikely to result in any long-term impacts to BPPH.

10.7.2.1.2 Pre-commissioning – Hydrotest Water Discharge

Discharge to the marine environment is the final option on the hierarchy of disposal options for hydrotest waters from pre-commissioning (Section 5.5.4.2). Hydrotest water will be generated from a number of activities during construction of the Fourth Train Proposal (Section 5.5.3.3); this hydrotest water may contain a number of additives, such as biocide, leak detection dye, and oxygen scavengers. The largest potential hydrotest water discharge affecting State Waters will be from testing the planned LNG Tank (if required) on the east coast of Barrow Island. The discharge of hydrotest water has the potential to release contaminants into the marine environment, potentially affecting BPPH.

The biocide used in hydrotest water is readily biodegradable and has no potential for bioaccumulation, so is considered of low potential impact; the concentration of dye used is non-toxic; and the oxygen scavenger present in the hydrotest water is of low-toxicity and not considered to pose an environmental risk (Chevron Australia 2011b).

10.7.2.1.3 Operation of Reverse Osmosis Facilities – Reject Brine Discharge

The Fourth Train Proposal requires an extension to the operation of the temporary reverse osmosis facility (or similar). Reject brine from the operation of the reverse osmosis facilities (Section 4.7.2.2.1) has the potential to impact BPPH in the immediate vicinity of the discharge point by introducing chemicals or changing salinity levels beyond those found naturally and thus impacting BPPH health. Heavy metals present in sea water become concentrated in reject brine during the reverse osmosis process, and chemical compounds are added to the intake water; biocide additives being the most toxic. Exposure to biocides may result in acute or chronic toxicity, although there is limited information on these impacts to the marine ecosystem.

Macroalgal assemblages and isolated coral community outcrops are located in the vicinity of the reject brine outfall off the east coast of Barrow Island. Previous research for the Foundation Project predicted rapid dilution of salinity and chemicals to near ambient levels within 10 to 20 m of the outfall (RPS 2009). A 40-fold dilution was determined to provide sufficient dilution to ensure 99% species protection (Chevron Australia 2013), and reject brine dispersion modelling completed for the Foundation Project temporary and permanent reverse osmosis facilities predicted this to be achieved within the Foundation Project Zone of High Impact. Therefore, impacts to BPPH beyond the Zone of High Impact are not anticipated.

10.7.2.1.4 Marine Vessel Discharges

Marine vessel discharges will occur during both construction and operations activities of the Fourth Train Proposal (Section 10.5.2.1.4). These discharges have the potential to impact BPPH through localised increases in nutrient concentrations and other contaminants. Impacts from additional nutrient inputs include algal blooms and increased turbidity, causing reductions in light penetration. Reduced light availability can prevent BPPH from producing energy, reducing growth rates and health, and potentially resulting in mortality.

Additional effluent from the barge and/or Floatel accommodation (if required) will be treated using an appropriate sewage system that meets MARPOL standards. This will result in the addition of nutrients to the water column (Section 10.5.2); however, the dynamic nature of the receiving environment off the east coast of Barrow Island will ensure rapid dispersion, and dilution. The east coast of Barrow Island is considered well-flushed and impacts on BPPH are not anticipated beyond the Zone of High Impact defined for the approved Foundation Project.

Contaminants from marine vessel discharges are not expected to be in high enough concentrations to impact BPPH through chronic or acute toxicity. Given the localised nature of the actual discharges, their low toxicity, and the dispersive receiving environment, potential impacts to BPPH are unlikely, and, if they do occur, will be highly localised.

10.7.2.1.5 Illustrative Mitigation and Management Measures

Illustrative mitigation and management measures for the potential impacts of discharges to sea are outlined in Section 5.5.4. Mitigation and management measures identified for water quality and provided in Table 10-6 are also relevant to BPPH.

10.7.2.1.6 Discharges to Sea Summary

The potential incremental impact on BPPH from the Fourth Train Proposal due to discharges to sea during the construction and operations phases is assessed as 'Low'. This is due to the dispersive receiving marine environment and the type of discharges to sea anticipated.

The potential impact of discharges to sea from the Fourth Train Proposal on BPPH in addition to the approved Foundation Project is assessed as 'Low' for both construction and operations. This assessment is lower than the impact predicted for the Foundation Project, which was assessed as 'Medium'. This difference is due to results of Foundation Project monitoring, which have not identified any adverse impacts on BPPH outside the existing MDF, or any significant difference between benthic percentage cover and macroalgal biomass between sites within the Foundation Project MDF and reference sites at a distance from it (Oceanica 2011). It is anticipated that the Fourth Train Proposal will have similar types of discharges to sea, but at reduced volumes.

Data collected from fortnightly ocean outfall monitoring between July 2011 and July 2013 indicated that the brine was consistently achieving the target dilution level (i.e. 40 fold dilution). As this data validated the brine dilution modelling for the temporary reverse osmosis outfall and confirmed that the constructed outfall achieves 40 fold dilution, in September 2013 DPaW approved the cessation of ocean outfall monitoring of the temporary reverse osmosis facility.

10.7.2.2 Seabed Disturbance

Activities that result in seabed disturbance can cause smothering, scouring, or abrasion of BPPH, which can result in total loss or degradation of the BPPH. Recovery from such disturbances is possible, but depends on the sensitivity of the BPPH and the duration and level of exposure.

Potential Impact on BPPH from Seabed Disturbance			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Preparation and laying of Offshore Feed Gas Pipeline System (marine) Barge accommodation and barge laydown grounding (if required)	Additional construction activities in a new geographic area off the west coast of Barrow Island. Additional marine vessel anchoring off the west coast of Barrow Island. Additional seabed disturbance alongside the Materials Offloading Facility and/or WAPET Landing due to barge grounding.	Construction: Low	Construction: Low
Operations: Trivial			

The construction of the Fourth Train Proposal is likely to result in seabed disturbance off the west coast of Barrow Island at the horizontal directional drilling exit point and along the Offshore Feed Gas Pipeline System route. Seabed disturbance is also likely off the east coast of Barrow Island during controlled grounding of barge accommodation and barge laydown areas (if required) (Section4.5). Once Fourth Train Proposal construction activities are completed, impacts to BPPH have been assessed as 'Trivial' due to the use of the existing and approved designated Anchorage Area and moorings off the east coast of Barrow Island.

Disturbance of the seabed, as assessed in Section 10.4.2.2, will also have the potential to impact any BPPH present on the substrate. The horizontal directional drilling exit into the marine environment may result in the sediment smothering BPPH, specifically macroalgal communities. As the exit point is beyond the main limestone pavement and the use of horizontal directional drilling for the shore crossing reduces potential impacts to BPPH on the west coast, direct disturbance will be limited to the area of the exit point. The main benthic habitat present beyond the limestone pavement is soft sediment with sparse sessile taxa.

Marine vessels may be required to anchor close to shore behind the horizontal directional drilling exit point to assist with pulling pipelines through into the marine environment, which may result in highly localised scouring of macroalgae. Macroalgae is likely to recolonise these areas in the short term, with no long-term impacts expected on macroalgae coverage in the Management Unit 1 area (MU1), as established by the EPA for BPPH (EPA 2009).

Experience gained from pre- and post-development monitoring the Foundation Project horizontal directional drilling activity has found that the benthic percentage cover and macroalgal biomass are not significantly different between sites within the Foundation Project MDF and reference sites at a distance from it (Oceanica 2011).

Frequent anchoring and use of dynamic positioning on the west coast of Barrow Island will also be required along the length of the Offshore Feed Gas Pipeline System during pipeline installation to ensure accurate positioning, and will result in the disturbance and potential displacement of benthic habitat. The dominant habitat present in this area is sediment with sparse sessile taxa, but may contain low density/scattered patches of BPPH (predominantly macroalgae) that are not well-developed assemblages.

If trenching of the Offshore Feed Gas Pipeline System is required within State Waters, a length of up to approximately 5 km of subtidal habitat is expected to be impacted. Based on current calculations, direct seabed disturbance from preparation and pipe-laying activities will occur along the length of the Offshore Feed Gas Pipeline System affecting between approximately 0.23 and 0.27 km^2 of subtidal habitat depending on the final pipeline route chosen. BPPH is not anticipated to be impacted (except for sparse low density patches) given the predominant habitat is 'soft sediment with sparse sessile taxa'.

Potential impacts to BPPH that could affect the abundance, diversity, distribution, ecological function or productivity of the wider BPPH (predominantly macroalgal assemblages) are not anticipated.

10.7.2.2.1 Illustrative Mitigation and Management Measures

Illustrative mitigation and management measures for potential impacts for this stressor are taken from Foundation Project EMPs and are presented in Table 10-4 for assessment purposes. These measures may include setting anchoring safety zones if these are considered necessary to protect sensitive BPPH. Where practicable, the use of dynamic positioning systems is preferred to anchoring as dynamic positioning is a short-term activity in which suspended solids rapidly disperse and resettle on the seabed, whereas anchoring has the potential to result in greater impacts to the seabed through scouring.

10.7.2.2.2 Seabed Disturbance Summary

Construction impacts to BPPH will be short term and localised. The potential incremental impact on BPPH from the Fourth Train Proposal due to seabed disturbance during construction has been assessed as 'Low'.

The potential impact of seabed disturbance from the Fourth Train Proposal on BPPH in addition to the approved Foundation Project is assessed as 'Low' for construction. This assessment is lower than that predicted for the Foundation Project, which was assessed as 'Medium'. The predicted impact for the Fourth Train Proposal is lower due to Foundation Project experience on impacts from horizontal directional drilling and the smaller scale of the Fourth Train Proposal.

10.7.2.3 Physical Presence of infrastructure

The physical presence of infrastructure in the marine environment may result in a permanent change that often results in the displacement of habitat. Artificial structures provide hard substrates, attracting species preferring these substrates for attachment, and will result in a change to community composition when constructed on soft sediment habitats. Depending on the location and size of the infrastructure, its physical presence can result in the isolation of BPPH or may reduce the size of the habitat below the minimum habitat 'patch' size required for the community to be self-sustaining.

Potential Impact on BPPH from Physical Presence of infrastructure			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Preparation and laying of Offshore Feed Gas Pipeline System (marine) Logistics vessel operations Barge accommodation and barge laydown preparation and grounding (if required)	Additional marine vessel anchoring in front of the horizontal directional drilling marine exit point. Additional subsea infrastructure.	Construction: Low	Construction: Low
Operation of the Offshore Feed Gas Pipeline System	Additional subsea infrastructure off the west coast of Barrow Island.	Operations: Low	Operations: Low

The physical presence of infrastructure off the west coast of Barrow Island has the potential to impact BPPH, predominantly macroalgal assemblages on the limestone pavement. On the east coast, the controlled grounding of barge accommodation and barge laydown (if required) may be adjacent to either the Materials Offloading Facility and/or WAPET Landing where low densities of interspersed macroalgal communities may be present. The presence of this additional infrastructure will temporarily prevent the re-establishment of macroalgal-dominated habitat until this infrastructure is removed at the completion of construction activities, when it is anticipated that it will be refloated and removed from site.

The installation of the Fourth Train Proposal Offshore Feed Gas Pipeline System will result in the alteration of benthic habitat. The use of the horizontal directional drilling technique will reduce the potential loss of macroalgal assemblages on the west coast, with the seabed exit point located beyond the main limestone pavement feature within the soft sediment with sparse sessile taxa. Small localised patches of macroalgal communities may exist along the Offshore Feed Gas Pipeline System route and may be lost as a result. The presence of the Feed Gas Pipeline System itself provides a hard substrate, which may provide colonising opportunities for macroalgal species. As such, it is anticipated that in the longer term this structure may provide additional BPPH on the west coast of Barrow Island. The presence of the Offshore Feed Gas Pipeline System will not isolate any existing BPPH as the marine area is considered well-connected, with spores dispersed by ocean currents (Chevron Australia 2011a).

Illustrative measures to mitigate and manage potential impacts for this stressor are taken from Foundation Project EMPs and are presented in Table 10-14 for assessment purposes.

Table 10-14: Illustrative Mitigation and Management Measures for Physical Presence of Infrastructure in the Coastal and Nearshore Environment

Approved Foundation Project EMP	Illustrative Measures
Horizontal Directional Drilling Management and Monitoring Plan	Measures to mitigate direct disturbance impacts to marine habitats and to ensure no detectable net mortality of coral assemblages, include: ▪ locating the shore crossing at North Whites Beach, outside sensitive coral habitat ▪ installing guide wires, if required, to ensure correct alignment of holes and to reduce unnecessary disturbance from incorrect exit point location ▪ locating the water winning spread outside sensitive areas (on bare rock where possible) and designing it to be secure against movement in storm conditions. Discharge of sand and other solids from the water intake during the filter cleaning process will be flushed out with water and at a water depth of approximately 12 m.
Marine Facilities Construction Environmental Management Plan	Establish mooring locations to avoid unnecessary vessel anchoring to minimise impacts to coral assemblages.

The potential incremental impact to BPPH from the Fourth Train Proposal due to physical presence of infrastructure is assessed as ‘Low’ for construction and operations. The predominant loss will be to ‘soft sediment with sparse sessile taxa’ habitat, which may contain small patches of BPPH.

The potential impact of physical presence of infrastructure during construction and operations of the Fourth Train Proposal on BPPH in addition to the approved Foundation Project is assessed as ‘Low’. This does not represent a change to the level of potential impact assessed for the approved Foundation Project. The permanent loss of BPPH when the Fourth Train Proposal in addition to the approved Foundation Project is expected to below the 2% loss/damage criteria established for defined local assessment units, in this case MU1, as established by the EPA for BPPH (EPA 2009).

10.7.2.4 Spills and Leaks

A spill or leak of hydrocarbon or hazardous material has the potential to expose BPPH to toxic compounds. The level of impact depends on the magnitude of the spill, the spill or leak hydrocarbon type (condensate versus heavy fuel oil), metocean conditions, timing in relation to biological events, and species composition. Intertidal and shallow BPPH are more vulnerable to potential impact, with deeper subtidal communities buffered to some degree by the water above them, although certain metocean conditions can result in hydrocarbons dispersing through the water column. Potential impacts may include changes in species abundance and/or community structure, with more tolerant species having an advantage and sensitive species being lost. Heavy hydrocarbons can smother BPPH in the intertidal zone, interfering with its capacity to produce energy and impacting BPPH health, potentially resulting in mortality. Aromatic hydrocarbons can also cause acute or chronic toxicity impacts on the health and functioning of BPPH. Chemicals used for the treatment of spills also have the potential to impact BPPH with the dissolution of toxic components.

Potential Impact on BPPH from Spills and Leaks			
Activities	**Change Introduced by Fourth Train Proposal**	**Incremental Impact**	**Additional Impact**
Marine horizontal directional drilling activities Preparation and laying of Offshore Feed Gas Pipeline System (marine)	Increased marine vessel activities off the west coast and logistics vessels delivering materials to Barrow Island.	Construction: Low	Construction: Low
LNG and condensate vessel operations (including supply vessels) Logistics vessel operations Operation and maintenance of Offshore Feed Gas Pipeline System	Additional marine vessel for product loading and increased support vessel activity. Additional infrastructure present off the west coast of Barrow Island.	Operations: Medium	Operations: Medium

Intertidal and shallow subtidal areas of BPPH surrounding the Montebello/Barrow/Lowendal Islands are particularly sensitive to spills and leaks as oils tend to concentrate along the high water mark. Wave-sheltered habitats that are not well-flushed by tidal movements are likely to have longer-term impacts.

Mangrove communities are likely to be the most sensitive to a spill or leak, and to be impacted long term. Short-term impacts on mangroves include defoliation and mortality, while some long-term impacts can include seed failure due to toxicity. Corals, seagrasses, and macroalgae are considered less susceptible as these habitats are less exposed to the sea surface.

An Offshore Feed Gas Pipeline System rupture (modelled at 200 m or 14 km west of Barrow Island) during the summer has the potential to result in dissolved aromatic hydrocarbon contact with the shoreline in concentrations exceeding 10 ppb in the shallow water habitats off the west coast of Barrow Island, the south-western side of the Montebello Islands, and the limestone pavement between. The probability of a pipeline rupture releasing condensate 200 m west of Barrow Island was calculated to be a 1 in 36 000 chance per year event, and for a rupture 14 km off the west coast of Barrow Island the probability was calculated to be a 1 in 102 000 chance per year event.

It was estimated that a shoreline area of up to 43 km for the 200 m rupture (and 23 km for a rupture 14 km offshore) could be affected with 158 m^3 of condensate (or 27 m^3 for the 14 km scenario). Maximum concentrations for dissolved aromatics were predicted to be well above the 500 ppb ANZECC and ARMCANZ (2000) guideline levels. Biggada Reef, coral reefs to the west of Hermite Island, and on the western ledge of the limestone pavement between Barrow and Montebello Islands all have the potential to be impacted. Given the shallow depth of the release, condensate is predicted to rapidly rise to the surface where it will spread and evaporate. Potential impacts relate to the toxicity effects to reproduction, and/or sublethal toxicity effects due to accumulation of compounds in the tissue.

A diesel fuel spill of 2.5 m^3 from a marine vessel during the construction of the Fourth Train Proposal Offshore Feed Gas Pipeline System has the potential to affect shallow subtidal reefs between Barrow and Lowendal Islands. Diesel toxicity to BPPH is related to the less volatile components, which tend to physically entrain in the upper water column in the presence of moderate winds (i.e. greater than 12 knots). The modelled maximum concentration of entrained hydrocarbons predicted within the water column did not exceed the ANZECC and ARMCANZ (2000) guideline threshold of 500 ppb for BTEX, which affords 99% species protection.

The grounding of a condensate vessel adjacent to Town Point during the operations phase has the potential to result in the loss of condensate and/or bunker fuel oil into the marine environment. Based on probability calculations, the risk of a grounding releasing bunker fuel oil in the vicinity of the Barrow Island Port area was determined to be a 1 in 121 000 chance per year event. A bunker fuel oil spill has the potential to impact BPPH in the intertidal areas at Barrow Island, with contact also predicted at the Montebello and Lowendal Islands. Physical and chemical contamination of the intertidal and shallow subtidal areas (up to 47 m^3 affecting up to 51 km of coastline) was predicted, which may have physical smothering and sublethal/lethal consequences. Given the persistence of bunker fuel oil and its tendency to result in sediment contamination, BPPH may display reduced health through the presence of hydrocarbon compounds.

A well blowout at Chandon has the potential to affect the Muiron Islands (noted for their exceptional reef life including coral species) with entrained oil exceedances of 500 ppb and dissolved aromatics exceedances of 5 ppb. However, the probability of this event occurring is extremely low, and should it occur the likelihood of this outcome is also low. If condensate did reach the Muiron Islands, it is predicted to have weathered in the open ocean for at least 14 days, reducing its potential for impact.

Illustrative mitigation and management measures for potential impacts from spills and leaks are taken from Foundation Project EMPs and are presented in Section 5.7.3 for assessment purposes. In addition, spill response measures will be applied.

The potential incremental impact on BPPH from the Fourth Train Proposal due to spills and leaks is assessed as ‘Low’ for construction and as ‘Medium’ during the operations phase due to the potential consequence of a bunker fuel oil spill.

The potential impact of spills and leaks on BPPH from construction of the Fourth Train Proposal in addition to the approved Foundation Project is assessed as ‘Low’. The potential impact of spills and leaks from the Fourth Train Proposal on BPPH during the operations phase in addition to the approved Foundation Project is assessed as ‘Medium’. This assessment is the same as that predicted for the Foundation Project. Although there will be a minor increase in the likelihood of a spill or leak due to the additional marine vessels operating in the area of the Fourth Train Proposal, the consequence to BPPH from a spill remains the same.

10.7.3 Proposed Management

The GJVs consider that the potential impacts to BPPH from the Fourth Train Proposal can be effectively managed under the relevant Ministerial Conditions for the Foundation Project. No measures or controls additional to those required for the Foundation Project were assessed as being necessary to manage the incremental or additional potential impacts to BPPH from the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the various approved Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal horizontal directional drilling activities, locations, and potential impacts will also need to be prepared and approved, as described in Section 16.2.3.3. However, the GJVs anticipate that the mitigation and management measures included in the existing Foundation Project Horizontal Directional Drilling Management and Monitoring Plan will also apply to the Fourth Train Proposal and will prevent and manage any potential impact to BPPH as a result of the Fourth Train Proposal.

The existing EMPs that are relevant to addressing potential impacts to BPPH for the Fourth Train Proposal are:

- Horizontal Directional Drilling Management and Monitoring Plan
- Marine Facilities Construction Environmental Management Plan
- Offshore Feed Gas Pipeline Installation Management Plan (or equivalent Environment Plan)
- Marine Environmental Quality Management Plan

- Solid and Liquid Waste Management Plan
- Reverse Osmosis Brine Disposal via Ocean Outfall Environmental Management and Monitoring Plan.

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

10.7.4 Predicted Environmental Outcome

BPPH present within the Fourth Train Proposal Area is predominantly macroalgae assemblages on a limestone pavement. This habitat type is considered widespread and extensive, surrounding much of Barrow Island. Beyond the limestone pavement, soft sediment dominated by sessile taxa is predominant, with only patches of BPPH likely.

The incremental impact to BPPH from construction and operations stressors are all assessed as ‘Low’ except for spills and leaks for the operations phase, which is assessed as ‘Medium’ due to the potential consequence of a bunker fuel oil spill on BPPH in the intertidal area. All construction impacts are likely to be short term and localised, and unlikely to result in habitat distribution change, although some small localised degradation or loss may occur. The selection of horizontal directional drilling as a technique for the shore crossing on the west coast will significantly reduce potential impact to BPPH. On the east coast of Barrow Island, disturbance to BPPH will be contained within the existing MDF as defined for the approved Foundation Project.

No different impacts to BPPH were identified from the Fourth Train Proposal to those identified from the Foundation Project. Fourth Train Proposal impacts on BPPH in addition to the approved Foundation Project is reduced for all stressors, except for spills and leaks during the operations phase, which remains the same. Although the consequence of a spill or leak on BPPH has the potential to cause widespread environmental impact, there are mitigation and management measures in place to prevent and respond to spills. The downgrading of stressors from that assessed as part of the Foundation Project was due to the lack of BPPH within the Fourth Train Proposal Area and the results of Foundation Project monitoring of the horizontal directional drilling program.

Additive potential impacts from all stressors identified from the Fourth Train Proposal on BPPH are not anticipated given the localised nature of the predicted potential impacts.

Predicted impacts from the Fourth Train Proposal are not expected to alter BPPH abundance, diversity, distribution, or to disrupt habitat functioning. The GJVs consider that the stressors to BPPH will be able to be adequately managed such that the impacts are environmentally acceptable and the environmental objective (Section 10.7.1.1) is met.

10.8 Conservation Areas

10.8.1 Assessment Framework

10.8.1.1 Environmental Objective

The environmental objective established in this PER/Draft EIS for the conservation areas is:

> *To protect the environmental values of areas identified as having significant environmental attributes.*

10.8.1.2 Relevant Policies, Plans, and Guidelines

Commonwealth, State, and local policy and framework documents relating to conservation areas are listed in Table 10-15

Table 10-15: Policies, Plans, and Guidelines Relevant to Conservation Areas

Policies, Plans, Guidelines	Intent
Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007–2017 (DEC 2007)	Aims to facilitate the conservation of the marine biodiversity of the area and to ensure that the existing and future pressures on the reserves are managed within an ecologically sustainable framework. Provides ecological values and social values for management of the Reserves, and mechanisms for the community and visitors to actively participate in day-to-day management.
National Representative System of Marine Protected Areas (Department of Environment [n.d.])	Aims to establish a comprehensive, adequate, and representative system of protected marine areas with the primary goal to contribute to the long-term ecological viability of marine and estuarine systems, to maintain ecological processes and systems, and to protect Australia's biological diversity at all levels.

10.8.2 Assessment and Mitigation of Potential Impacts

The Montebello/Barrow Islands Marine Conservation Reserves includes the Montebello Islands Marine Park, Barrow Island Marine Park, and Barrow Island Marine Management Area (Section 6.7.1 and Figure 6-27)[11]. These marine and coastal environments are protected in recognition of their importance to marine biodiversity. All Fourth Train Proposal activities and infrastructure in State Waters are either in the 'general use zone' of the Barrow Island Management Area or within the Barrow Island Port area, which is outside the Barrow Island Marine Management Area.

A number of ecological and social values have been determined for the Montebello/Barrow Islands Marine Conservation Reserves to aid their management. The ecological values relate to physical, geological, chemical, and biological characteristics that assure the protection of marine biodiversity and ecosystem integrity (Table 6-12), and align with the environmental objective established in Section 10.8.1.1. Section 14.4 discusses the potential impacts of the Fourth Train Proposal on the Montebello/Barrow Islands Marine Conservation Reserves from a social perspective.

Stressors that are relevant to the assessment of potential impacts on the conservation values of the protected areas are:

- artificial light
- discharges to sea
- noise and vibration
- seabed disturbance
- physical interaction
- physical presence of infrastructure
- introduction/spread of Marine Pests (assessed in Section 12)
- spills and leaks.

Full descriptions of the potential impacts of each of these stressors on the environmental factors that are also relevant to the ecological values of Montebello/Barrow Islands Marine Conservation Reserves are discussed in Sections 10.3 to 10.7.

Activities off the west coast of Barrow Island are approximately 5 km away from the northern boundary of the Barrow Island Marine Park sanctuary zone. Bandicoot Bay Conservation Area

[11] Although intertidal areas are vested as part of the terrestrial Barrow Island Reserve, an assessment of potential impacts is included in this section as the intertidal area falls within the coastal and nearshore definition used in this PER/draft EIS. Section 9 provides the impact assessment on the Barrow Island Reserve.

within the Barrow Island Marine Management Area is approximately 15 km from key construction and operations activities, and the Montebello Island Marine Park is approximately 15 km north of the Fourth Train Proposal activities.

Selection of the Offshore Feed Gas Pipeline System route and the use of the horizontal directional drilling technique reduces the potential impacts on several of the ecological values of the Montebello/Barrow Islands Marine Conservation Reserves (for example, the selection of the shore crossing site at North Whites Beach reduces potential impacts to Green Turtle nesting sites [Section 10.6.3.1] as well as feeding and internesting areas [Sections 10.4.2.2 and 10.7.2.2]).

Except for spills and leaks, physical presence of infrastructure, and artificial light, impacts from Fourth Train Proposal activities are anticipated to be short term. The physical presence of the Offshore Feed Gas Pipeline System will result in the permanent removal of benthic habitat, but this is within the 'general use' area, and is well below the threshold loss value set for the MU1 management area, as defined by the EPA for BPPH (EPA 2009). Spills and leaks from the Fourth Train Proposal could extend throughout the Barrow Island Marine Management Area, affecting the Reserves and the Bandicoot Bay Conservation Area. However, although the Fourth Train Proposal will result in an incremental increase in the risk of a spill occurring compared to that assessed for the Foundation Project (associated with the increase in spill and leak sources such as additional LNG and condensate vessel movements), the likely consequences remain the same. In most potential leak or spill scenarios, the hydrocarbon compound is likely to be light, volatile, and typically non-persistent diesel or condensate. Potential consequences are anticipated to be short term and the likelihood of such events occurring is considered to be low. The risk to the environment is considered acceptable given the response mechanisms in place in the event of a spill (Section 5.7.3.2).

The operations phase will result in longer-term artificial light emissions to the east coast from onshore components of the Fourth Train Proposal and offshore from increased LNG and condensate vessel movements to and from Barrow Island. Refer to Sections 10.6.2.2 and 10.6.2.6 for more details.

Illustrative measures to mitigate and manage potential impacts for these stressors are taken from Foundation Project EMPs and are also presented in Sections 10.3 to 10.7 for assessment purposes. The Fourth Train Proposal will result in additional construction activities on both the west and east coasts of Barrow Island and additional marine vessel movements during the operations phase. However, there is no change to the consequence of potential impacts, and the ecological values established for Montebello/Barrow Islands Conservation Reserves are anticipated to be maintained.

10.8.3 Proposed Management

The proposed management framework for potential impacts on conservation areas is described in Sections 10.3.3, 10.4.3, 10.5.3, 10.6.3, and 10.7.3.

10.8.4 Predicted Environmental Outcome

The marine and coastal environments of the Montebello/Barrow Islands Marine Conservation Reserves are considered a unique combination of offshore islands with significant conservation value. The Reserves are managed to protect their environmental values, marine biodiversity and ecosystem integrity.

Potential incremental impacts of the Fourth Train Proposal are largely predicted to be localised or short term, and are not predicted to compromise the ecological values established for the Reserves. Potential incremental impacts are evaluated to be of no greater scale than those predicted for the Foundation Project.

The Fourth Train Proposal will extend the duration and the area potentially impacted by construction activities beyond that assessed for the approved Foundation Project. However, construction activities on both the east and west coasts of Barrow Island are likely to be localised and short term, and impacts on the Reserves are not anticipated. The increased area potentially affected by these activities remains within the Barrow Island Marine Management Area general use zone and presents no greater threat to the ecological values potentially impacted compared to that assessed for the Foundation Project.

Once operational, the Fourth Train Proposal will generate additional shipping activity off the east coast of Barrow Island. However, this incremental increase in shipping is not predicted to result in any different impacts or to change the level of impact determined for the Foundation Project on individual receptors.

The stressors that have the potential to impact the ecological values of marine and coastal environments of the Montebello/Barrow Islands Marine Conservation Reserves, when considered additively, are not expected to contradict efforts to manage the Reserves as set out in the Montebello/Barrow Conservation Reserve Management Plan and it is anticipated that ecological values will be maintained.

Given the management measures that will be put in place to mitigate potential impacts from the Fourth Train Proposal, impacts to the ecological values established for the Montebello/Barrow Islands Marine Conservation Reserves are not anticipated. The GJVs consider that the stressors will be able to be adequately managed such that the potential impacts on the Conservation Areas are environmentally acceptable and the environmental objective (Section 10.8.1.1) is met.

10.9 Potential Impacts during Decommissioning

The future decommissioning of the Fourth Train Proposal has the potential to result in impacts on the coastal and nearshore environment. Section 4.8 outlines current industry practice in decommissioning, noting that prior to decommissioning taking place there will be advances in technology and information, as well as potential changes to decommissioning procedures and regulatory requirements. Decommissioning will be undertaken in a safe and environmentally responsible manner in accordance with the legislative requirements at the time.

The actual methodology employed will be determined at the time of decommissioning to assess the best available option, taking into account relevant safety and environmental issues, economic analysis, and practicability.

Assuming current practices and technologies, decommissioning is predicted to result in impacts that are similar to the construction of the Fourth Train Proposal; these potential impacts are from:

- artificial light
- discharges to sea
- noise and vibration
- physical interaction
- spills and leaks.

The following Foundation Project EMPs address potential impacts from decommissioning of the Fourth Train Proposal:

- Decommissioning and Closure Plan
- Project Site Rehabilitation Plan.

Depending on the timing of the Fourth Train Proposal in relation to the approved Foundation Project, these EMPs may be submitted for approval for the Combined Gorgon Gas Development. However, if these EMPs have already been approved for the Foundation Project, they will be revised to incorporate the Fourth Train Proposal.

It is anticipated that any potential impacts resulting from decommissioning activities will be managed and mitigated to ensure the environmental objectives identified for each environmental factor are met, enabling the development areas to be returned to Commonwealth or State agencies in an appropriate condition.

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11. Greenhouse Gas Emissions and Energy Management

Greenhouse gas emissions will be produced during the construction, commissioning, operation, and decommissioning of the Fourth Train Proposal; these emissions are mostly related to the combustion of natural gas within the Gas Treatment Plant during operations.

This Section of the PER/Draft EIS outlines:

- the Commonwealth and Western Australian State Government policy and regulatory framework that establishes the governments' expectations regarding the management of greenhouse gas emissions and energy efficiency under which the Fourth Train Proposal will operate
- the anticipated greenhouse gas emissions from the Fourth Train Proposal, as outlined in Section 4. Where appropriate, emissions estimates are provided for both the Fourth Train Proposal and the impacts of the Fourth Train Proposal when added to the Foundation Project
- the impact of the Fourth Train Proposal on global greenhouse gas emissions relative to competing fuels for base load power generation
- the measures the GJVs have adopted to reduce the Fourth Train Proposal's greenhouse gas emissions and to maximise energy efficiency during both the design and operation of the Proposal
- a benchmark comparison against a number of other LNG projects focusing on the adoption of technologies being deployed to reduce emissions and maximise energy efficiency.

11.1 Assessment Framework or Policy

11.1.1 Management Objective

In the Environmental Scoping Document prepared for the Public Environmental Review for the Gorgon Gas Development, Fourth Train Proposal, a management objective '*To reduce emissions to levels as low as reasonably practicable on an ongoing basis and consider offsets to further reduce cumulative emissions'* was proposed for greenhouse emissions (Chevron Australia 2012).

Since the release of the Scoping Document, significant changes have been made to both Commonwealth and State policy on the management and regulation of greenhouse gas emissions. Consistent with these policy changes the GJVs consider the appropriate objective to guide the management of greenhouse gas emissions from the Fourth Train Proposal to be:

> *To manage greenhouse gas emissions on an ongoing basis guided by economic incentives to reduce emissions provided by Commonwealth Government policy, while managing health, safety, environment, and operability requirements through all phases of the Fourth Train Proposal.*

In common with most major energy companies, Chevron Australia applies a price to future greenhouse gas emissions in its business plan and as an aid to capital project decision making. This internal emissions price forecast is designed to reflect the cost of greenhouse emissions regulation over the anticipated operating life of a project.

An outline of current government policies and programs that impact the management of greenhouse gas emissions and energy efficiency is provided in the following sections.

11.1.2 Commonwealth Legislation and Policy

Reflecting the complex issues involved with reducing global greenhouse emissions, Commonwealth Government policy in this area has changed significantly over the last few years. This change will likely continue during the period when the approval of the Fourth Train Proposal is being considered.

At the time of writing this document, Commonwealth Government regulation has been implemented through the following national legislation:

- *Energy Efficiency Opportunities Act 2006* (Cth) (EEO Act)
- *National Greenhouse and Energy Reporting Act 2007* (Cth) (NGER Act)
- *Clean Energy Act 2012* (Cth) (Clean Energy Act) and associated Acts (carbon pricing scheme)

With the election of the Liberal/National Party Coalition Government in September 2013, it is anticipated the carbon pricing scheme will be replaced with the Coalition's Direct Action Plan's Emissions Reduction Fund (ERF) in late 2014.

The Commonwealth Government has also announced financial savings from the administration of the Energy Efficiency Opportunities Program and stated the program will not continue in its current form in the longer term (Department of Industry 2014). However, the Department of Industry has reminded liable companies that the legislation remains in place and companies need to continue to comply with the legislation and regulations for the time being. The Government has also stated that it is 'investigating how to build on Australian industry's experience of energy efficiency' and 'through the Energy White Paper process, the government is consulting on how to optimise energy efficiency policy as part of the overall energy policy mix'.

The NGER Act is expected to remain as Australia's national scheme for the reporting of greenhouse gas emissions, energy use, and energy production and is anticipated to underpin several key elements of the ERF.

The National regulatory regime (Section 11.1.2) also provides a framework for the ongoing monitoring, investigation, review, and reporting of greenhouse gas emissions and abatement measures.

11.1.2.1 Carbon Pricing Scheme

From 1 July 2012, the Clean Energy Act (and changes to liquid fuel taxation arrangements and excise on synthetic gases) established a price on greenhouse gas emissions. Most greenhouse gas emissions from the Fourth Train Proposal would be directly covered by the Clean Energy Act.

The Bill to repeal the Clean Energy Act is currently before Parliament and was passed by the House of Representatives in November 2013. The Bill has been debated in the Senate and was voted down during March 2014. It is considered likely the Senate will pass the repeal Bill during the third quarter of 2014.

11.1.2.2 Direct Action Plan and the Emissions Reduction Fund

The Government has proposed a Direct Action Plan (Liberal National Coalition n.d.) as an alternative to the Clean Energy Act as the principle policy to meet a 5% emissions reduction target by 2020. The Direct Action Plan comprises proposals to:

- establish an ERF to support carbon dioxide emissions reduction activity by business and industry
- invest AU$100 million each year for an additional one million solar energy homes by 2020
- establish 125 mid-scale solar projects in schools and communities and 25 geothermal or tidal power 'micro' projects in suitable towns

- plant an additional 20 million trees in available public spaces.

Of relevance to the management of greenhouse gas emissions from the Fourth Train Proposal is the proposed establishment of the ERF. A Green Paper on the design of the ERF was released in December 2013 with a White Paper released in April 2014 (DotE 2013, 2014).

In the Foreword to the Green Paper, the Minister for the Environment stated:

> *The Government's Plan for a Cleaner Environment will reduce Australia's greenhouse gas emissions by creating positive incentives to adopt better technologies and practices to reduce emissions. It will provide a lasting and stable policy framework for investment, underpinned by strong partnerships with businesses and the community.*

The ERF is proposed to comprise three fundamental elements:

- building upon the existing Carbon Farming Initiative, a process for crediting emissions reductions
- a process for the Government to purchase emissions reductions
- a mechanism to 'safeguard the value of funds expended under the ERF and provide businesses with a stable and predictable policy landscape in which to make new investments'.

The reporting arrangements under the NGER Act are proposed to underpin key elements of the ERF.

The DotE established a number of stakeholder groups to solicit input into the detailed design of the ERF, including:

- an Expert Reference Group comprising leading industry and academic experts, to guide the overall design of the ERF
- Technical Working Groups to assist in developing methodologies for estimating and crediting emissions reductions in key sectors of the economy. The methodologies will include rules for determining additionality, identifying eligible abatement projects, and measuring their results. Priority has been given to developing methodologies in the following sectors:
  - facilities reporting under the NGER Act
  - coal fugitive emissions
  - building energy efficiency
  - industrial energy efficiency
  - transport
  - waste
- a Stakeholder Reference Group on the operational design of the Safeguard Mechanism.

The Government has indicated its intent to have the crediting and purchasing components of the ERF operational on 1 July 2014. The Safeguarding Mechanism is proposed to commence in mid-2015, allowing time for further consultation on complex design issues.

11.1.2.3 National Greenhouse and Energy Reporting Act 2007

In 2007, the Commonwealth Government introduced the NGER Act, which mandates the national reporting of greenhouse gas emissions, energy production, and energy use. Prior to the introduction of the NGER Act, the Council of Australian Governments (COAG) agreed that data reported under the NGER Act would satisfy all greenhouse and energy reporting requirements of all State, Territory, and Commonwealth Government programs (COAG 2006). This is reflected in the Objects of the NGER Act, which state:

'The object of this Act is to introduce a single national reporting framework for the reporting and dissemination of information related to greenhouse gas emissions, greenhouse gas projects, energy consumption and energy production of corporations to:

a) underpin the introduction of an emissions trading scheme in the future; and

b) inform government policy formulation and the Australian public; and

c) meet Australia's international reporting obligations; and

d) assist Commonwealth, State and Territory government programs and activities; and

e) avoid the duplication of similar reporting requirements in the States and Territories.'

If the Fourth Train Proposal is approved, the greenhouse gas emissions, energy use, and energy production from the Proposal will be reported in accordance with Chevron Australia's obligations under the NGER Act.

11.1.2.4 Regulation of Greenhouse Gas Emissions Under the EPBC Act

While greenhouse gas emissions are not listed as a matter of National Environmental Significance under the EPBC Act, historically the Commonwealth Minister for the Environment has imposed conditions regulating greenhouse gas emissions on a number of proposed projects with planned emissions in the Commonwealth Marine Area.

In October 2012 the Minister for the Environment wrote to the owners of several projects subject to these conditions indicating that, with their consent, he would remove these conditions as the projects would now be operating under the Clean Energy Act (Minister for Sustainability, Environment, Water, Population and Communities 2012). This offer has been accepted by at least one proponent, as evidenced by the issuing of a revocation of conditions relating to the requirement for a Greenhouse Gas Management and Abatement Strategy for the Wheatstone Project (EPBC Reference: 2008/4469).

Given the use of subsea development infrastructure, routine operation of the Fourth Train Proposal in the offshore Commonwealth Marine Area is not anticipated to result in significant greenhouse gas emissions.

11.1.3 Western Australian Legislation and Policy

In October 2012 the State Government released its climate change strategy, 'Adapting to our Changing Climate' (DEC 2012), which establishes that regulation of greenhouse gas emissions is viewed by the State Government as a matter for the Commonwealth Government:

'The Western Australian Government's view is that decisions on the design, implementation and timing of the regulation of greenhouse gas emissions, and support for new low emissions technology, are primarily matters for the Australian Government and Federal Parliament'.

This reaffirms previous statements by the Western Australian Premier and Minister for the Environment (Minister for Environment 2010; Premier of Western Australia 2010) and marks a shift from State regulation to national regulation.

The policy strategy identifies Adaptation Planning as the primary role for the State Government and proposes 'complementary action', which assists the national mitigation effort in areas such as:

- supporting energy efficiency in the residential, industrial, and commercial sectors
- improving building energy and water efficiency
- ensuring that price signals for consumers are transparent to drive efficient energy use

- supporting the transition from coal to gas by enhancing the availability of gas in the domestic market
- supporting alternative forms of transport and fuel (DEC 2012).

11.1.3.1 Environmental Protection Act

Prior to the release of the 'Adapting to our Changing Climate' policy statement (DEC 2012), the State Government had historically regulated greenhouse gas emissions by imposing conditions on the approval of large energy projects under the *Environmental Protection Act 1986* (WA) (EP Act). The form of these conditions has evolved over time and generally required the development of a greenhouse gas management or abatement program and, in certain cases, an investment in greenhouse gas offsets.

The recommendations of the Western Australian EPA and its Guidance Statement No. 12 Greenhouse Gas Emissions (EPA 2002) on minimising greenhouse gas emissions played an important role in determining the nature of these conditions. At the time of writing this PER/Draft EIS, the EPA's position on the regulation of greenhouse gas emissions was under review. The EPA website currently states:

> 'At the time of writing this Guidance Statement the State Government was developing a State Greenhouse Strategy which will set the wider policy context for greenhouse gas management. This Guidance Statement will be reviewed when the new Government Policy is announced' (EPA 2014).

Since the release of the 'Adapting to our Changing Climate' policy statement, several major projects have either been approved or had their approval conditions varied to give effect to the State Government's policy. The approval (Ministerial Implementation Statement No. 917) of the Strategic Proposal to develop the Browse LNG Precinct and the variation to conditions (Ministerial Implementation Statement No. 922) imposed on the Wheatstone Project, only impose conditions on these projects related to the reporting of greenhouse gas emissions.

11.2 Greenhouse Gas Emissions

The discussion in the remainder of this Section has been provided to meet the requirements of the Tailored Guidelines and Environmental Scoping Document, noting that both the Commonwealth and State Governments' preference is for the national regulation of greenhouse gas emissions outside the environmental approval process.

11.2.1 Construction and Commissioning Phases

Greenhouse gas emissions from construction activities related to the Fourth Train Proposal will be dominated by two sources:

- emissions related to electricity generation
- diesel fuel used to operate various plant infrastructure and equipment.

With respect to the Fourth Train Proposal construction activities on Barrow Island, it is anticipated that electricity will be supplied from the existing approved Foundation Project temporary power stations and/or available capacity from the approved Foundation Project's Gas Turbine Generators.

Greenhouse gas emissions from diesel fuel use during Fourth Train Proposal construction activities are predicted to originate primarily from the approved Foundation Project temporary power stations. Other minor emissions sources will include construction equipment, vehicles and marine vessels.

During commissioning of the Fourth Train Proposal, flaring of process gas and venting of reservoir CO_2 are expected to occur as the LNG train and associated infrastructure is brought on line. Approximately 1.5 million tonnes of CO_2-e are predicted to be produced by the commissioning of the Fourth Train Proposal Gas Treatment Plant. The commissioning of the Fourth Train Proposal in addition to the approved Foundation Project is predicted to result in approximately 6 million tonnes of CO_2-e.

Emissions associated with the drilling and completion of wells and installation of the offshore infrastructure (including the pipelines) in the Commonwealth Marine Area is discussed in Section 11.2.3]

11.2.2 Operations Phase

11.2.2.1 Methodology and Assumptions

Greenhouse gas emissions estimates provided in this PER/Draft EIS are based on the current design status of the Fourth Train Proposal as documented in Section 4; note that where options are included in the Fourth Train Proposal, the worst-case option related to greenhouse gas emissions has been used.

The emissions estimates contained in this PER/Draft EIS have been prepared consistent with the methodologies currently prescribed by the NGER Act and its supporting regulations, determinations, and technical guidelines.

Emissions of methane (CH_4) and nitrous oxide (N_2O) have a higher global warming potential than carbon dioxide (CO_2) and have been converted to carbon dioxide equivalent (CO_2-e) using global warming potentials, as described in Part 2 of the National Greenhouse and Energy Reporting Act Regulations 2008 (Cth). In this PER/Draft EIS, a reference to a tonne of greenhouse gases should be read as a tonne of CO_2-e.

Key considerations for the estimation of greenhouse gas emissions are:

- The State Ministerial Conditions for the Foundation Project require that 'all practicable means are taken to inject underground all reservoir carbon dioxide removed during gas processing operations on Barrow Island and ensure that calculated on a 5-year rolling average, at least 80 percent of reservoir carbon dioxide removed during gas processing operations on Barrow Island and that would be otherwise be vented to the atmosphere is injected.' For the purposes of this PER/Draft EIS, it is assumed that 20% of the reservoir CO_2 is vented to the atmosphere rather than injected.
- Emissions estimations are based on the Gas Treatment Plant operating approximately 342 days per year.
- All power generation turbines are operated at the load required for the Fourth Train Proposal, as outlined in Section 4.4.4.4. Emissions estimations are based on the current understanding of the nominal design under International Organization for Standardization (ISO) conditions and are subject to change.
- During detailed design, energy efficiency improvements and operational procedures to reduce energy use may be identified; however, no allowance has been made for these.

Emissions estimations are based on the Gas Treatment Plant operating under steady state conditions. Therefore, the emissions estimated in this section may vary from actual daily, weekly, monthly, or annual emissions. It is assumed that all three trains in the Foundation Project are operating.

The Fourth Train Proposal is an 'integrated development' with the approved Foundation Project. As a result, the maximum annual production rate of reservoir CO_2 expected for the approved Foundation Project will alter from the predictions in the PER (Chevron Australia 2008) and Greenhouse Gas Abatement Program (Chevron Australia 2009). Therefore, the incremental maximum annual production rate of reservoir CO_2 associated with the Fourth Train Proposal is defined as the expected maximum annual rate of reservoir CO_2 for the 'integrated development' less the maximum annual rate of reservoir CO_2 approved for the Foundation Project.

11.2.2.2 *Predicted Emissions*

Greenhouse gas emissions during operation of the Fourth Train Proposal will be predominantly from combustion sources used to supply energy for LNG production. Greenhouse gas emissions of combustion products will increase as a result of the extra energy requirements of the Fourth Train Proposal over that of the approved Foundation Project.

As the gas fields being developed as part of the Fourth Train Proposal have a lower concentration of reservoir CO_2 compared with those supplying the Foundation Project, comparatively less energy is required to extract this reservoir CO_2 during the gas processing operations and to inject it into the Dupuy Formation. This results in a modest improvement in the greenhouse gas emissions intensity of the Fourth Train Proposal compared with the Foundation Project.

Table 11-1 documents the anticipated greenhouse gas emission during operation of the Fourth Train Proposal and the overall level of greenhouse gas emissions from the combined Fourth Train Proposal and Foundation Project. The Fourth Train Proposal is anticipated to emit approximately 1.6 MTPA of CO_2-e. The anticipated greenhouse gas emissions from the Fourth Train Proposal combined with the approved Foundation Project are estimated at approximately 7.6 MTPA CO_2-e.

Table 11-1: Estimated Annual Greenhouse Gas Emissions from the Operation of the Fourth Train Proposal

Emissions Source	Fourth Train Proposal	Fourth Train Proposal in Addition to the Foundation Project
	CO_2-e Tonnes Per Annum	CO_2-e Tonnes Per Annum
Gas Turbine Drivers	840 000	3 370 000
Gas Turbine Generators	680 000	3 240 000
Heating Medium Heaters	50 000	60 000
Non-routine Flaring	7000	30 000
Routine Flaring (pilot and purge)	12 000	83 000
Fugitive Emissions	6000	23 000
Reservoir CO_2 Vented [1]	20 000	870 000
Diesel Consumption [2]	4000	16 000
Total	**1 619 000**	**7 692 000**

Notes:

1 *Based on venting 20% of the maximum annual average reservoir CO_2 and 80% being injected (over a five-year rolling average). The calculations are based on the Fourth Train Proposal known gas resources at the time of submission of the PER/Draft EIS.*

2 *Includes diesel equipment such as firewater pumps, emergency diesel generators, vehicles, tugs, and pilot boats.*

Not all emissions from the Gas Turbine Generators listed in Table 11-1 are associated with LNG production. Approximately 9000 tonnes per annum of CO_2-e are associated with Fourth Train Proposal infrastructure electricity consumption (i.e. offshore facilities and Butler Park [Construction Village]). Of the estimated 680 000 tonnes of CO_2-e per annum from the Gas Turbine Generators, approximately 70 000 tonnes per annum of CO_2-e are associated with domestic gas production and approximately 140 000 tonnes per annum of CO_2-e with electricity consumption to provide support infrastructure on Barrow Island.

During operations, no perfluorocarbons are planned to be used in the Gas Treatment Plant. Hydrofluorocarbons will be used in the heating, ventilation, and air conditioning systems, and sulfur hexafluoride will be used in limited quantities in some electrical switch gear. However, both these uses are for closed systems, with minimal emissions during normal operating conditions. Operating and maintenance procedures for heating, ventilation, and air conditioning systems will aim to prevent loss of hydrofluorocarbons during refrigerant change-out.

Refer to Section 11.3 for the proposed management of greenhouse gas emissions.

11.2.2.3 Decommissioning Phase

While it is not possible to accurately predict the greenhouse gas emission rates of decommissioning activities at this stage, it is anticipated emissions arising from sources such as generators and shutdown flaring would not be significant, compared to the operations phase, and the duration would be temporary.

11.2.3 Greenhouse Gas Emissions in Commonwealth Marine Area

As a result of the proposal to use subsea infrastructure for the development of the gas fields, the greenhouse gas emissions predicted from the implementation of the Fourth Train Proposal within the Commonwealth Marine Area will predominately occur during the construction phase, with relatively low levels of emissions during the operations phase. Activities that are likely to generate greenhouse gases in the Commonwealth Marine Area may include:

- drilling and completions, including well drilling and vessel support
- well testing, including well clean-up (i.e. flaring)
- Feed Gas Pipeline System construction including:
  - installation of Feed Gas Pipeline System, intrafield flowline, and subsea infrastructure
  - operation of marine support vessels
  - helicopter transfers
  - scarp trenching
  - commissioning support.

The primary source of emissions will be from diesel engines, with the greenhouse gas emissions being composed of CO_2, N_2O, and CH_4. Synthetic greenhouse gases, including hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are commonly used as refrigerants and are not expected to be used in significant quantities during normal operations of the Fourth Train Proposal in Commonwealth Marine Area, thus emissions are not expected; therefore, these synthetic greenhouse gases are not included in the estimates. Table 11-2 lists the predicted greenhouse gas emissions produced in the Commonwealth Marine Area during construction.

Table 11-2: Greenhouse Gas Emissions Produced in the Commonwealth Marine Area during Construction of the Fourth Train Proposal

Activity	Greenhouse Gas Type (tonnes)			CO_2-e (tonnes)
	N_2O	CO_2	CH_4	
Drilling and completions	5	190 000	6	191 777
Well testing	4	94 000	1120	118 677
Feed Gas Pipeline System Construction	6	204 000	8	206 028
Total	**13**	**488 000**	**1134**	**516 482**

Greenhouse gas emissions during the operation of the Fourth Train Proposal in the Commonwealth Marine Area are expected to be significantly less than during the construction period. The use of subsea infrastructure to gather the gas and transport it to Barrow Island eliminates the need for a surface platform, which is typically the main greenhouse gas emissions source from offshore gas production operations. Greenhouse gas emissions will be produced during the operations phase as a result of non-routine offshore operations (such as well workovers and maintenance activities).

11.2.4 Impact on Global Greenhouse Gas Emissions

11.2.4.1 Global Emissions

To assess the potential impact on global greenhouse gas emissions, the full emissions life cycle should be considered. This comprises the quantity of greenhouse gas emissions associated with the extraction, processing, transportation, and end use of the supplied energy. For this assessment it is assumed that the LNG supplied from the Fourth Train Proposal will be used to generate electricity (using combined cycle gas turbines) in markets in East Asia. This results in annual life cycle emissions of 15.3 MTPA of CO_2-e. This estimate comprises approximately:

- 1.6 MTPA from the production and processing of natural gas into LNG by the Fourth Train Proposal
- 0.7 MTPA from the transportation of the produced LNG to markets in East Asia
- 13 MTPA from the end use of the supplied LNG, in this case to generate electricity using combined cycle technology.

These life cycle emissions need to be considered in the context of the life cycle emissions from the use of other fuels with which LNG from the Fourth Train Proposal will compete to supply energy into these markets.

Figure 11-1 shows the life cycle annual greenhouse gas emissions resulting from a range of electric power generation technologies using both LNG from the Fourth Train Proposal and Australian export-quality black coal. The graph shows the emissions associated with the generation of 35 million MW hours of electricity, which is approximately the amount of electricity that can be generated from 5 million tonnes of LNG using combined cycle power generation technology. For each power generation technology, the emissions associated with the production of the relevant fuel in Australia, the transportation of that fuel, and its consumption in East Asia, are shown.

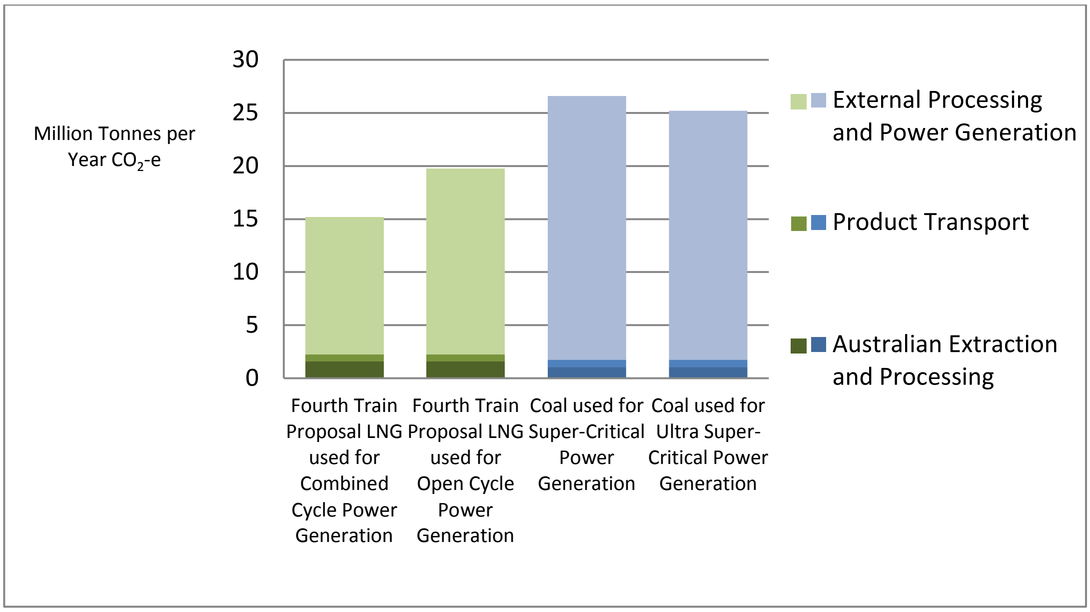

Figure 11-1: Annual Lifecycle Greenhouse Gas Emissions for the Fourth Train Proposal and Alternative Fuels for to Generate 35 million MW Hours of Electricity

Figure 11-1 shows that the generation of electricity using LNG from the Fourth Train Proposal results in between 10 and 12 MTPA fewer greenhouse gas emissions per year compared to using Australian export-quality coal to generate a comparable amount of electricity. This life cycle emissions benefit increases if lower quality coal is used as the alternative fuel.

11.2.4.2 Australian and Western Australian Emissions

Table 11-3 shows the estimated annual greenhouse gas emissions from operation of the Fourth Train Proposal relative to Australia's and Western Australia's greenhouse gas emissions. The Fourth Train Proposal may increase national and State greenhouse gas emissions by 0.3% and 2% respectively, relative to 2010–2011 emissions data (Department of Climate Change and Energy Efficiency 2013).

Table 11-3: Predicted Greenhouse Gas Emissions Relative to Australian and Western Australian 2010–2011 Emissions

	Australia	Western Australia
2010–2011 greenhouse gas emissions (excluding changes from land use and forestry) (million tonnes CO_2-e)	551.4	84.0
Estimated annual average emissions from the Fourth Train Proposal (CO_2-e MTPA)	1.570	1.570
Increase in greenhouse gas emissions relative to emissions in 2009	0.28%	1.87%

11.3 Proposed Greenhouse Gas Emissions and Energy Efficiency Management Measures

The National regulatory regime (Section 11.1.2), provides a framework for the ongoing monitoring, investigation, review, and reporting of greenhouse gas emissions and abatement measures.

The GJVs have adopted a range of measures to reduce greenhouse gas emissions and to maximise energy efficiency from the Fourth Train Proposal. This section discusses the major emissions sources and measures taken to reduce greenhouse gas emissions from those sources.

11.3.1 Gas Turbine Drivers and Gas Turbine Generators

Gas turbines are required to supply mechanical energy to the liquefaction compressors and to generate electrical energy; these are the two largest energy demanding activities within the Fourth Train Proposal during its operations phase. Options to supply this energy include various types of gas turbines or, in the case of gas turbine drivers, electric motors, or a combination of both. Most modern LNG projects around the world use gas turbines as these are best suited to delivering the energy required, as well as providing the required operability and reliability expected.

As described in Section 4.4, the Fourth Train Proposal will use two industrial gas turbines, each of approximately 80 MW nominal capacities to drive the liquefaction compressors.

To avoid any unnecessary shutdown of the Gas Treatment Plant, the Foundation Project incorporates an electrical power station based on an N+1 operating philosophy. While the five Gas Turbine Generators installed for the Foundation Project are capable of meeting the anticipated electrical demand for the Foundation Project, an additional 116 MW (nominal) Gas Turbine Generator (Table 4-7) is required to maintain the N+1 operating philosophy.

11.3.1.1 Gas Turbine Selection

A range of aero-derivative gas turbine models were assessed for use on the Fourth Train Proposal. While aero-derivative gas turbines offer high thermal efficiencies (energy output per unit of fuel input), limitations that required consideration include:

- The large capacity of the proposed LNG train, which delivers increased thermal efficiency, exceeds the operating range of available aero-derivative gas turbines. To use aero-derivate gas turbines, additional units, gearboxes, and potentially changes to the process configuration would be required. This not only has land take implications, but also reduces process efficiency and decreases reliability.
- Aero-derivative gas turbines are not able to use fuel gas that has high nitrogen content. Fuel gas for aero-derivative models would also need to be supplied at a higher pressure than is currently available for the Foundation Project; therefore, additional fuel treatment and gas compression facilities would need to be installed, creating additional land take implications.
- The ability for industrial gas turbines to burn fuel gas higher in nitrogen avoids the need for the venting of nitrogen-rich gas, which is common for LNG projects using aero-derivative gas turbines. While nitrogen is inert, these nitrogen-rich gas streams contain varying concentrations of methane and other hydrocarbons. Where these gas streams are not used as fuel, the gas stream is often incinerated to oxidise these other gases prior to venting. The use of industrial gas turbines in the Fourth Train Proposal enables a waste gas stream that would otherwise be vented to be used as fuel and thus put to a beneficial use.
- In conjunction with the gas turbine, each of the liquefaction compressors is also equipped with a large electric ‘helper motor’, which ensures the power requirements of the compressor are closely matched to the output of the gas turbine, thus ensuring the gas turbine can be continually operated at its maximum efficiency.
- To further reduce the greenhouse gas emissions from the Fourth Train Proposal and to improve energy efficiency, the gas turbines used to power the liquefaction compressors are each fitted with waste heat recovery units. As is the case for the Foundation Project, the waste heat captured from these turbines is used to provide the routine process heating requirements throughout the Gas Treatment Plant, reducing the need to routinely power heaters or boilers.

11.3.1.2 Combined Cycle Electrical Power Generation

A power generation study was conducted to determine the suitability of combined cycle systems for providing electrical power for the Fourth Train Proposal. A focus of this power generation study was to understand the options to move to combined cycle systems, using waste heat recovery from the Gas Turbine Generators installed as part of the Foundation Project to power one or two steam turbine generators.

This study found that all combined cycle power generation options were prohibitively expensive forms of greenhouse gas abatement.

The use of waste heat recovery units required for combined cycle systems on the Foundation Project Gas Turbine Generators would reduce the temperature of the exhaust gas and hence dispersion of these gases, resulting in higher ambient concentrations of atmospheric pollutants and air toxics in the vicinity of Barrow Island.

Combined cycle systems would increase the demand for fresh water on Barrow Island, requiring additional seawater intake and outfall infrastructure to be installed. The additional water to support the combined cycle systems would increase the annual discharge of reject brine from the reverse osmosis facilities by approximately 177 000 tonnes per annum. Wastewater blowdown (estimated at approximately 59 000 tonnes per annum) would also need to be disposed of.

The construction process of the combined cycle systems would require an extended shutdown of each of the Foundation Project Gas Turbine Generators. Although there will be spare capacity within the Foundation Project to enable this operation, such construction is extensive brownfield work; it increases process risk as there will be no spare power capacity during the installation period, and it increases the safety risk due to the proximity of the work to the operational Gas Treatment Plant.

Increased operational complexity was found to result when implementing the combined cycle system, as a new utility system would need to be introduced into the Gas Treatment Plant. This new utility was also predicted to increase the safety risk associated with combined cycle systems.

The prohibitive cost, safety, operability, and environmental impacts have meant that combined cycle systems were not considered appropriate for implementation on the Fourth Train Proposal.

11.3.2 Heating Medium System

Waste heat recovery units fitted to the compressor gas turbine drivers in the liquefaction units will provide all routine process heat requirements during normal operation of the Fourth Train Proposal. This improves the energy efficiency of the gas treatment process. However, during plant start-up or process upset situations, gas-fired heating medium heaters will be required to provide heat when the waste heat recovery units on the LNG compressor gas turbines have not reached operating temperature. The heating medium heaters are required to be maintained on standby mode during routine operations so that the heating medium system can respond to upset situations.

11.3.3 Management of Reservoir Carbon Dioxide

Reservoir CO_2 from the Fourth Train Proposal Gas Fields will be injected into the Dupuy Formation using the approved Foundation Project Carbon Dioxide Injection System infrastructure. The injection of reservoir CO_2 is predicted in the modelling of the Dupuy Formation to be able to occur within existing Foundation Project State Ministerial Conditions, specifically Condition 26 of Statement No. 800.

The Carbon Dioxide Injection System currently under construction as part of the Foundation Project will be the world's largest greenhouse gas storage project when injection operations commence, following commissioning of the second LNG train. This component of the Gorgon Project will reduce greenhouse gas emissions from the Foundation Project by approximately between 3.4 and 4.1 MTPA.

The gas fields developed as part of the Fourth Train Proposal (Geryon, Chandon, Orthrus, and Maenad) contain relatively low concentrations of reservoir CO_2 ranging between approximately 0.3 mol % and 2.1 mol %. By comparison, the Gorgon Gas Field contains on average approximately 14 mol % CO_2 while the Jansz field contains less than 1%. The development of the Fourth Train Proposal is predicted to increase the maximum annual average rate of available reservoir CO_2 by approximately 100 000 tonnes per annum (Table 11-4) or 2% above the approved Foundation Project as documented in the PER for the approved Foundation Project (Chevron Australia 2008).

Table 11-4: Estimated Maximum Annual Rate of Reservoir CO_2 Production Associated with the Fourth Train Proposal Compared to the Approved Foundation Project

	Approved Foundation Project *	Fourth Train Proposal (incremental)	Fourth Train Proposal in addition to the Approved Foundation Project
Estimated maximum annual reservoir CO_2 production	4.2 MTPA	0.1 MTPA	4.3 MTPA

* *Source: PER for the approved Foundation Project (Chevron Australia 2008).*

During the preparation of this PER/Draft EIS, a range of design options for reservoir CO_2 management were investigated, including injection, venting of reservoir CO_2, and regenerative thermal oxidisation of the reservoir CO_2 stream that contains traces of hydrocarbons and hydrogen sulfide. Injection was selected as the preferred method for management of reservoir CO_2. A number of these options were found to not be viable to include in this PER/Draft EIS and so emissions profiles have not been presented. Regenerative thermal oxidisation was cost prohibitive and would result in increased greenhouse gas emissions, so was not further progressed as a design option. Venting is to be used as a contingency to the Carbon Dioxide Injection System and so the emissions resulting from this are included in emissions profiles presented in Table 11-1.

It is predicted that the additional volume of reservoir CO_2 to be extracted during the gas processing operations associated with the Fourth Train Proposal can be accommodated within the scope of the currently approved Foundation Project's Carbon Dioxide Injection System as authorised under Section 13 of the *Barrow Island Act 2003* (WA) (Section 11.3.3.2).

11.3.3.1 Venting of Reservoir Carbon Dioxide

While the Carbon Dioxide Injection System has been designed to accommodate 100% of the volume of the reservoir CO_2 to be removed during routine operations, it is expected that the Fourth Train Proposal will result in less than approximately 5000 tonnes of additional reservoir CO_2 being vented each year above that for the approved Foundation Project. However, as there is potential for a higher level of venting, particularly in the event of unexpected injection well failure or an unexpected reservoir performance, the reference case in this PER/Draft EIS assumes an additional 20 000 tonnes per annum (above the volume approved for the Foundation Project) of reservoir CO_2 available for injection, is vented rather than injected into the Dupuy Formation.

The anticipated volumes of reservoir CO_2 that will be vented and the volumes anticipated to be injected for both the Fourth Train Proposal and approved Foundation Project are listed in Table 11-5. Volumes vented are anticipated to decline over time as the facility operation and CO_2 injection processes are optimised.

For the purposes of the greenhouse gas calculations in this PER/Draft EIS a worst-case operating scenario is assumed where 20% of the reservoir CO_2 is vented to the atmosphere rather than injected. The reference case for venting from the Fourth Train Proposal in addition to the approved Foundation Project is predicted to result in approximately 870 000 tonnes of CO_2-e per annum.

Table 11-5: Predicted Incremental Volumes of Reservoir CO_2 to be Injected and Vented (Fourth Train Proposal compared to the Approved Foundation Project)

		Year 1	Year 2–5	Year 6	Long-term Performance Target
Percentage of Reservoir CO_2 injected into the Dupuy Formation	Fourth Train Proposal	60–90% (0.06–0.09 MTPA)	70–95% (0.07–0.095 MTPA)	80–95% (0.08–0.095 MTPA)	95% (0.095 MTPA)
	Approved Foundation Project	60–90% (2.52–3.78 MTPA)	70–95% (2.94–3.9 MTPA)	80–95% (3.36–3.99 MTPA)	95% (3.99 MTPA)
Percentage vented due to scheduled maintenance and unplanned facilities downtime	Fourth Train Proposal	5–15% (0.005-0.015 MTPA)	5–10% (0.005–0.01 MTPA)	3–5% (0.003–0.005 MTPA)	3% (0.003 MTPA)
	Approved Foundation Project	5–15% (0.21-0.63 MTPA)	5–10% (0.21–0.42 MTPA)	3–5% (0.13–0.21 MTPA)	3% (0.13 MTPA)
Percentage vented due to unforeseen reservoir constraints (including well injectivity failure)	Fourth Train Proposal	0–25% (0–0.025 MTPA)	0–20% (0–0.02 MTPA)	0–15% (0–0.015 MTPA)	2% (0.002 MTPA)
	Approved Foundation Project	0–25% (0–1.05 MTPA)	0–20% (0–0.84 MTPA)	0–15% (0–0.63 MTPA)	2% (0.08 MTPA)

11.3.3.2 Injection of Reservoir Carbon Dioxide

Information about the approved Carbon Dioxide Injection System scope, the site selection process, the geology around the proposed injection site, the behaviour of the reservoir CO_2 in the subsurface, and an overview of the GJVs' proposed integration of monitoring, uncertainty management, and risk mitigation can be found in the approved Foundation Project environmental approval documentation (Chevron Australia 2005, 2008).

Modelling has been undertaken for the Fourth Train Proposal, in line with previous approved Foundation Project studies and government due diligence (Section 11.3.3.2), to determine whether:

- The increase in volume and rate of reservoir CO_2 associated with Fourth Train Proposal can be injected by the approved Foundation Project's Carbon Dioxide Injection System.
- There are any material changes to the behaviour and uncertainties associated with the injection reservoir CO_2 into the Dupuy Formation due to the Fourth Train Proposal.

These studies show the increase in reservoir CO_2, associated with the Fourth Train Proposal, can be injected and accommodated into the Dupuy Formation and that there is no discernible change to the subsurface behaviour and uncertainties associated with the injection of reservoir CO_2 into the Dupuy Formation, as shown in Figure 11-2.

Modelling demonstrates the reservoir CO_2 associated with the Fourth Train Proposal can be injected using the approved Foundation Project's Carbon Dioxide Injection System without any alteration to the approved infrastructure. Therefore, the GJVs are not seeking approval via this PER/Draft EIS to alter the approved Foundation Project's Carbon Dioxide Injection System infrastructure or proposed management. Environmental approval is being sought by this PER/Draft EIS for the use of the approved Foundation Project's Carbon Dioxide Injection System for the Fourth Train Proposal and for the approximately 2% increase in the peak annual rate of injection of reservoir CO_2 from the Fourth Train Proposal Gas Fields into the Dupuy Formation, subject to approvals required by the State Agreement and the *Barrow Island Act 2003* (WA).

Modelling results also demonstrated that the Fourth Train Proposal resulted in no material change to the subsurface behaviour of the injected reservoir CO_2 and did not introduce any different uncertainties associated with CO_2 injection, compared to those assessed and approved for the Foundation Project. Figure 11-2 highlights this with the predicted extent of the CO_2 plume after 1000 years for the approved Foundation Project compared to the Fourth Train Proposal in addition to the approved Foundation Project.

As the uncertainties associated with the Fourth Train Proposal are the same as for the approved Foundation Project the existing management procedures (approved under Section 13 of the *Barrow Island Act 2003* [WA]) and uncertainty management strategies (documented in the approved Foundation Project PER; Chevron Australia 2008) remain appropriate to manage the injection of reservoir CO_2 from the Fourth Train Proposal in addition to the approved Foundation Project. Given the minor increase in reservoir CO_2 injection volume and rate associated with the Fourth Train Proposal it is predicted there will be no material change to the likelihood and consequence of the failure modes and effects analysed as part of approved Foundation Project (Chevron Australia 2008). Therefore, no change is anticipated in the level of potential environmental impact from the underground injection of reservoir CO_2 associated with the Fourth Train Proposal.

The approved Foundation Project is required by Ministerial Conditions to prepare a monitoring program with annual reporting requirements, prior to the commencement of operation of the Reservoir Carbon Dioxide Injection System. The Fourth Train Proposal will use the Reservoir Carbon Dioxide Injection System Monitoring Program.

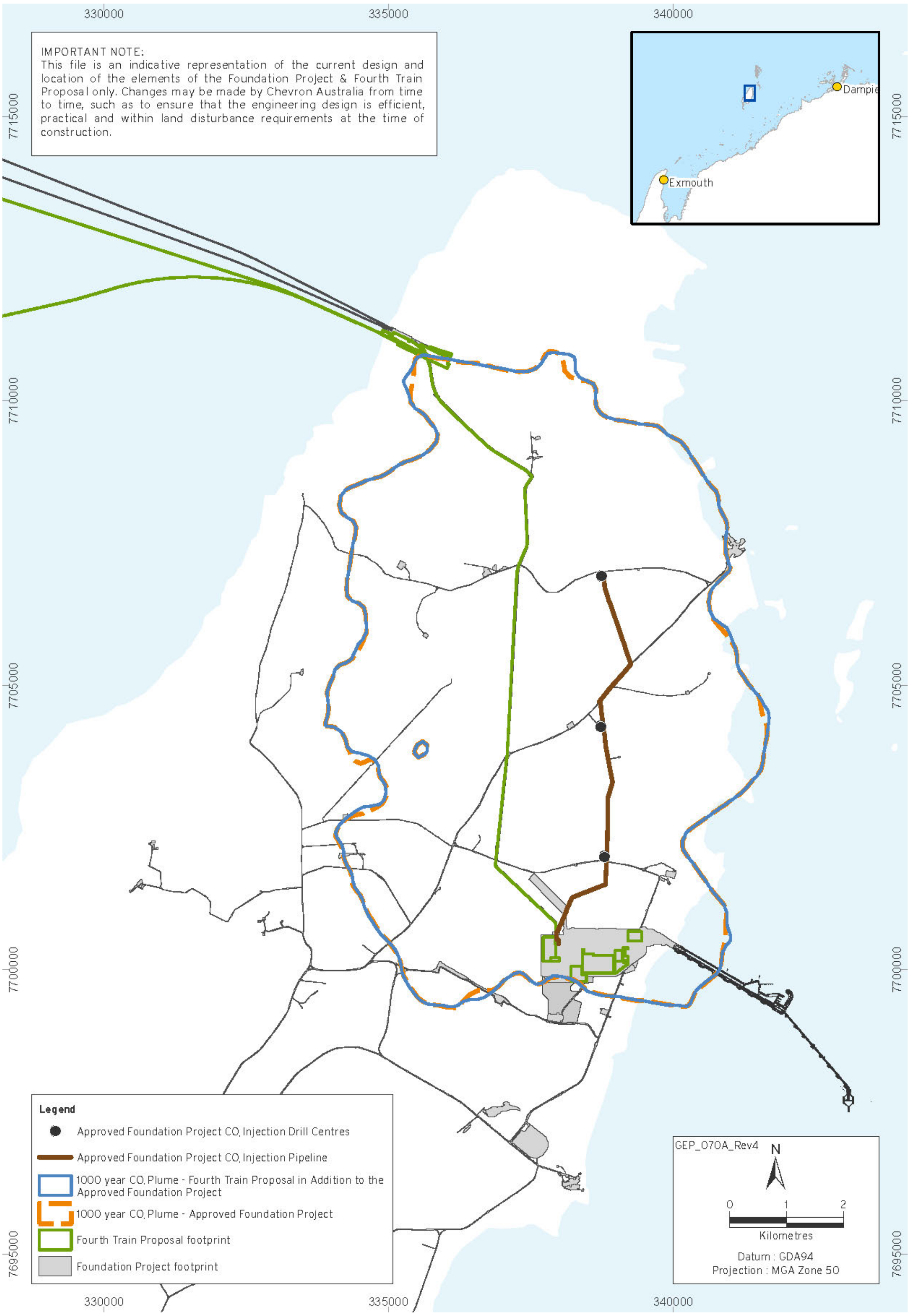

Figure 11-2: Comparison of Reservoir CO_2 Plume Extent (1000 years) between the Approved Foundation Project and the Fourth Train Proposal

11.3.3.3 Regulation of the Carbon Dioxide Injection System

The approved Foundation Project's Carbon Dioxide Injection System is subject to State Ministerial Conditions. Modelling predicts that the Fourth Train Proposal can operate under the existing Foundation Project Ministerial Condition (Statement No. 800 Condition 26) requiring:

- All practicable means are to be implemented to inject: all reservoir CO_2 removed during gas processing operations, and at least 80% (calculated over a five-year rolling average) of the removed reservoir CO_2 during normal gas processing operations.
- The Carbon Dioxide Injection System infrastructure shall be designed and constructed to inject 100% of the reservoir CO_2 that is removed during routine gas processing operations on Barrow Island.
- The Carbon Dioxide Injection System is to be operated according to a monitoring program, which is approved by the Minister for Environment (also relevant to Condition 19 of EPBC Reference: 2003/1294 and 2008/4178).

In accordance with Section 13 of the *Barrow Island Act 2003* (WA), the GJVs are required to obtain approval to inject reservoir CO_2 from the Barrow Island Act Minister (Minister for State Development). Through this approval process, the approved Foundation Project's Carbon Dioxide Injection System has been subject to significant assessment of the work undertaken by the GJVs. Included in this assessment is an extensive due diligence process. The due diligence process, commissioned by Department of State Development (DSD) to provide an independent technical validation, has provided strong support to the technical work that underpins the approved Foundation Project's Carbon Dioxide Injection System. The due diligence process has assessed a range of subsurface, volumetric, and rate uncertainty scenarios associated with the approved Foundation Project. The increase in reservoir CO_2 injection resulting from the implementation of the Fourth Train Proposal is within the ranges of volumetric and rate uncertainty scenarios assessed as part of the approved Foundation Project Section 13 Approval to Dispose of Carbon Dioxide by Injection into Subsurface Formation. Given the minor increase in reservoir CO_2 injection volume and rate associated with the proposal, the Fourth Train Proposal does not increase the risk associated with the approved Foundation Project's Carbon Dioxide Injection System. Concluding comments from the due diligence process can be referenced directly from the DMP website at http://www.dmp.wa.gov.au/7105_8523.aspx and http://www.dmp.wa.gov.au/documents/ExecSumIV.doc.

The operational arrangements of the Carbon Dioxide Injection System are managed in accordance with Section 13 Approval conditions, which regulate the CO_2 injection operations. The volume and rate of reservoir CO_2 to be injected from the Fourth Train Proposal in addition to the approved Foundation Project is within the uncertainty assessed in the Foundation Project Section 13 Approval[12]. Modelling conducted for the Fourth Train Proposal, it is the GJV's view that approvals granted under Section 13 of the *Barrow Island Act 2003* (WA) will be able to accommodate the incremental increase in volumes and rates of CO_2 injection associated with the Fourth Train Proposal given that there is:

- no change to uncertainty management and planning
- no change to land take requirements
- no change to reservoir CO_2 injection well numbers and location
- no change to pressure management, well numbers, and location
- no change to pressure management water injection well numbers and location
- no change to reservoir CO_2 pipeline routes, capacity, and controls

[12] The GJV will discuss with DSD whether the existing *Barrow Island Act 2003* (WA) Section 13 approval will require any amendments.

- no change to the cathodic protection system
- no change to supporting infrastructure (e.g. power supply system).

11.3.4 Flaring

Greenhouse gas emissions from the Fourth Train Proposal will be reduced through the design of the Fourth Train Proposal Gas Treatment Plant, which specifies no routine flaring. Routine flaring is defined as the continuous flaring of process hydrocarbon gas beyond that required for the safe operation of the flare system (i.e. flare pilots and purge gas) and plant (e.g. small flows from equipment purges, which are not practicable to collect) during normal production operations.

Greenhouse gas emissions from the flaring of hydrocarbons is predicted to be a minor contributor (approximately 1%) to the overall greenhouse gas emissions from the Fourth Train Proposal and the Fourth Train Proposal in addition to the approved Foundation Project, as shown in Table 11-1.

Flares are required to ensure the safe operation of the Gas Treatment Plant. A continuous purge may be required, along with flare pilots, to ensure the safe ignition of the flare when required.

Low-pressure hydrocarbon streams in the Gas Treatment Plant (including those from the various regeneration processes) will be redirected either to the fuel gas system or back into the LNG or domestic gas processes. Compressors and other systems in the LNG process will be designed to start-up, operate continuously, and shut down on full recycle to minimise flaring.

The most significant periods of flaring will be during the start-up and shutdown of the LNG Trains. The ability to reduce the volume of gas flared during plant start-up is limited, as the flared gas will not meet the specification for LNG sales and may be outside the specification for use as fuel.

During a plant shutdown, the safety of the Gas Treatment Plant needs to be ensured; this is achieved by depressurising and flaring either the entire inventory of the gas in the facility, or the gas inventory in the section of plant subject to the shutdown. The development of operating procedures for the facility will consider methods for reducing the amount of flared gas during shutdowns to the extent reasonably practicable. Minimising unintended plant outages, e.g. by providing a highly reliable electrical supply, is critical to reducing flaring associated with plant shutdowns.

An additional Boil-off Gas Flare may be installed as part of the Fourth Train Proposal (Section 4.4.4.5). However, the installation of the additional Boil-off Gas Flare is not expected to alter the greenhouse gas emissions from Boil-off Gas flaring, as the greenhouse gas emissions from Boil-off Gas flaring is dependent on the reliability of the Boil-off Gas Compression System and not on the number of Boil-off Gas Flares installed.

11.3.5 Fugitive Emissions and Venting of Hydrocarbons

Greenhouse gas emissions from the fugitive emissions and venting of hydrocarbons is predicted to be a minor contributor (less than 1%) to the overall greenhouse gas emissions from the Fourth Train Proposal, and the Fourth Train Proposal in addition to the approved Foundation Project, as shown in Table 11-1.

As fugitive emissions represent potential safety or environmental hazards, significant engineering work has focused on ensuring such emissions are kept to a very low level. The main sources of fugitive emissions throughout the gas processing facility include:

- flanges and fittings
- valve stem seals.

Measures taken to reduce greenhouse gas emissions from fugitive sources include:

- dry gas seals, or similar, on compressors
- the use of an internal floating roof in the Foundation Project Condensate Tanks
- maximum practicable use of welded piping and the specification of high integrity valves (such as control valves)
- pump seals and joining materials.

Hydrocarbon venting will be minimised as such venting has safety and environmental implications and represents a loss of saleable product. Low-pressure hydrocarbon vapour streams will be redirected back to the Gas Treatment Plant rather than being vented to atmosphere.

11.3.6 Diesel Engines

Greenhouse gas emissions from diesel engines are predicted to be a minor contributor (less than 1%) to the overall greenhouse gas emissions from the Fourth Train Proposal and the Fourth Train Proposal in addition to the approved Foundation Project, as shown in Table 11-1.

While most of the Gas Treatment Plant and associated infrastructure energy requirements will be supplied from natural gas, diesel will also be used to fuel emergency equipment, vehicle operations, and marine support vessels.

The GJVs anticipate that personnel movements between the airport, accommodation, the permanent operations facility and the Gas Treatment Plant will be via a bus service. Along with other vehicles used to transport supplies from the Materials Offloading Facility, WAPET Landing, and for maintenance, the GJVs expect the buses will be fuelled with diesel.

Equipment such as emergency fire pumps and backup power generation systems are required to be operable even in the event of a major incident within the Gas Treatment Plant. These facilities will be fuelled with diesel and although they will not operate routinely, they will be tested regularly to ensure operational integrity.

11.3.7 Emissions Reduction from Proposed Management

Proposed management measures for the Fourth Train Proposal, as outlined in Sections 11.2.3 and 11.3 are predicted to result in a net reduction in greenhouse gas emissions. The use of subsea infrastructure, compared to an offshore gas processing platform, which was part of the 1998 Gorgon Development Concept, is predicted to provide for an approximately 600 000 tonnes/year CO_2-e reduction in greenhouse gas emissions. The injection of reservoir CO_2 from the Fourth Train Proposal is expected to reduce the greenhouse gas emissions by approximately 80 000 tonnes/year of CO_2-e, compared to venting all reservoir CO_2. Waste heat recovery to be installed on the gas turbines is anticipated to reduce greenhouse gas emissions by approximately 270 000 tonnes/year of CO_2-e.

The gross greenhouse gas emissions from the Fourth Train Proposal, if it were to be implemented without this proposed management, is estimated to be approximately 2 569 000 tonnes/year CO_2-e, compared to the net emissions with the proposed management of 1 691 000 tonnes/year CO_2-e.

11.3.8 Greenhouse Gas Emissions Offsets

In 2011 and in anticipation of pricing greenhouse gas emissions, the accreditation of greenhouse gas emissions offsets was formalised with the passage into law of the *Carbon Credits (Carbon Farming Initiative) Act 2011* (Cth; CFI Act). The CFI establishes a robust process for the accreditation of greenhouse offsets through the listing of eligible and ineligible activities, the regulation of approved methodologies, and the accrediting of individual projects and delivered emissions reductions under approved methodologies. Historically, emissions reduction under the CFI Act emissions reductions have been restricted to the land use and agribusiness sectors.

Moves by the Commonwealth Government to introduce its ERF (Section 11.1.2.2) are based on the expansion of the CFI Act as the primary tool for the 'crediting' of emissions reductions from across the Australian economy. To achieve this end, a number of technical working groups have been established to develop methodologies in areas such as transport, the building sector, and industry. It is envisaged that once an emissions reduction has been credited under this process, it would be available for sale to the Commonwealth Government under the ERF, for sale to third parties, or could be surrendered to meet any liability arising from the Safeguard Mechanism component of the ERF.

Given the direction of Commonwealth Government policy, the GJV preference is to focus on managing greenhouse gas emissions from the Fourth Train Proposal, through selection and operation of appropriate technologies and equipment (Section 11.4.2), the investigation of opportunities to bid credited emissions reductions from the Fourth Train Proposal into the ERF, and compliance with any obligations arising from the proposed Safeguarding Mechanism. The GJV does not see a role for either the direct investment in greenhouse gas offset generation projects or in the purchase and voluntary cancellation of carbon credit units issued under the CFI Act.

11.4 Benchmarking

11.4.1 Greenhouse Gas Emissions Intensity Benchmark

The volume of greenhouse gas emissions emitted for each tonne of LNG produced provides a benchmark by which the greenhouse gas emissions intensity of an LNG plant can be compared. However, this metric is not a direct reflection of the efficiency of a particular LNG project as the emissions intensity is heavily influenced by the:

- degree of any pre-processing of the natural gas undertaken as part of the gas production process
- the distance required to transport the gas from its place of production to where it is processed
- composition of the incoming gas stream, particularly the concentration of reservoir CO_2 and nitrogen, as well as the levels of ethane, propane, butanes, and pentanes
- use of air or water for process cooling
- ambient temperature in which the gas plant operates
- capacity for local electricity supply infrastructure to be used for electrical power.

Figure 11-3 shows the greenhouse gas emissions intensity associated with LNG processing for a number of comparable LNG projects currently in production and in construction. Operating LNG projects are shown as dark grey bars while the light grey bars represent the emissions intensity for the LNG projects that are currently under construction. Note: Emissions and energy use data from other LNG projects is not widely published; most publicly available data are restricted to estimates of greenhouse gas emissions published in environmental impact assessment reports.

Where data on the emissions intensity of the associated gas production operations is available, it is presented as an additional white bar. Projects where publicly available data on gas production emissions are not available are indicated with a blue arrow. The Fourth Train Proposal, approved Foundation Project, Snohvit, and Prelude projects use subsea production systems that do not result in any gas production related emissions, but which may result in a slight increase in the emissions intensity for that project compared to a scenario where gas production from that facility would have been undertaken at an offshore platform.

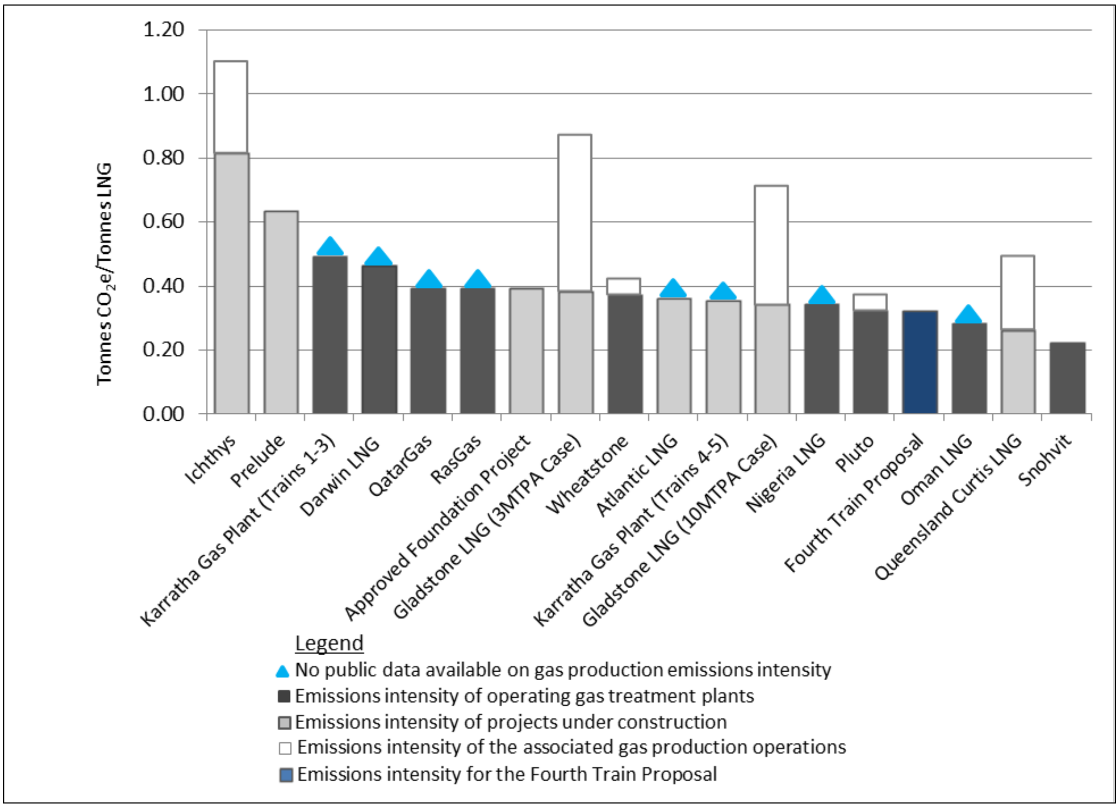

Figure 11-3: Benchmarking Greenhouse Gas Emissions Intensity

Source: Chevron Australia 2010The emissions resulting from domestic gas production and infrastructure electricity consumption are not included in the calculation of the greenhouse gas emissions intensity of the Gas Treatment Plant.

This benchmark data shows a wide disparity between the anticipated LNG processing emissions intensities of the studied projects, which is further compounded when the limited data on overall project emissions intensity are considered. It is reasonable to assume that the projects currently under construction in Australia are all being designed to be energy efficient; highlighting how the project parameters identified above can influence the greenhouse gas emissions intensity of a particular project.

Nevertheless, the LNG processing emissions intensity of the Fourth Train Proposal is amongst the lowest of those projects benchmarked and has the lowest overall project emissions intensity of any LNG project in Australia when gas production related emissions are included in the comparison.

The improvement in emissions intensity between the Fourth Train Proposal and the Foundation Project can be primarily attributed to the lower volumes of reservoir CO_2 anticipated to be processed with the Fourth Train Proposal. Not only does this result in less reservoir CO_2 being vented but less energy is required to process the natural gas and extract the reservoir CO_2.

11.4.2 Technology Selection Comparison

To address the issues with using greenhouse gas emissions intensity to compare LNG projects, a comparison was undertaken benchmarking the technologies selected in Fourth Train Proposal with publicly available information on the technologies being applied by other Australian LNG projects, sourced from environmental impact assessment documents or publicly available management plans. These data are summarised in Table 11-6.

Table 11-6 shows that there are some common technology approaches used across the LNG industry as current applied best practices, including:

- capture of waste heat from gas turbine exhausts to provide process heat
- the use of Boil-off Gas Compressors to recover Boil-off Gas during routine ship loading, but flaring Boil-off Gas from warm ships
- commitment to no routine flaring or venting
- use of a-MDEA for the removal of reservoir CO_2.

It is also apparent from the data in Table 11-6 that many projects have taken quite different approaches to the selection of process technology. For example:

- the use of particular LNG process technology and size of each LNG processing train
- the type and size of gas turbines used to provide mechanical and electrical power
- air or water cooling.

This is likely in response to each project having to be designed to fit within its broader project requirements, including site-specific requirements, commercial requirements, and technology compatibility.

Table 11-6: Technology Comparison of LNG Projects in Australia

Project	Project Phase	Date of Commission	LNG Process Technology	LNG Production	Liquefaction Drivers	Electrical Power Generation	CO_2 Removal Solvent	Process Heat	Flaring and Venting	Use of Turbo Expanders	Nitrogen End Flash Gas	Boil-off Gas Compression	Feed Gas Composition	Additional Greenhouse Mitigation
Wheatstone	Construction	Planned 2016	Conoco Phillips Optimised Cascade - air cooling	Approved for 25 MTPA LNG Foundation Project being constructed for 2 × 4.45 MTPA LNG	Aero-derivative gas turbines Low NOx Inlet air cooling Waste Heat Recovery	Aero-derivative gas turbine generators Low NOx Inlet air cooling Space for future installation of waste heat recovery	a-MDEA Incineration to oxidise H_2S and BTEX in vent gas	Waste heat recovery units installed on LNG compressor gas turbines Gas turbine generators to provide all routine process heat May be installed in the future on gas turbine generators for electrical power generation	No routine flaring from normal operations Venting limited to residual hydrocarbon in Acid Gas Removal Unit and N_2 vent and wastewater treatment	Yes	Vented	Routine compression of Boil-off Gas Flare excess or from warm ships or ships from dry dock	Not disclosed	
Ichthys	Construction	Planned 2016	Propane pre-cooled mixed refrigerant - air cooling	2 × 4.2 MTPA LNG 1.6 MTPA LPG	Unknown	Combined cycle gas turbines	a-MDEA incineration to oxidise CO_2 with H_2S and BTEX in vent gas	Waste heat recovery from gas turbine exhausts to minimise need for gas-fired heating	No routine flaring from normal operations	Yes	Vented	Routine compression of Boil-off Gas Flare excess or from warm ships or ships from dry dock	CO_2= ~8% in Brewster reservoir, ~17% in Plover reservoir	
Prelude	Construction	N/A	Dual mixed refrigerant cold water cooling - steam boilers	1 × 3.5 MTPA	Steam turbines	Steam turbines	a-MDEA vented via Flare Stack to ensure dispersion	Proposal uses an integrated steam system	No venting (principle) of hydrocarbons No continuous flaring of hydrocarbons	No	Vented	Routine compression of Boil-off Gas Flare excess or from warm ships or ships from dry dock	CO_2 = ~9% by volume	Deck space allowed for future compression of reservoir CO_2
Queensland Curtis LNG	Construction	Unknown	Conoco Phillips Optimised Cascade	2 × 3.7 MTPA	Aero-derivative gas turbines (LM2500+G4) Inlet air cooling	Aero-derivative gas turbines (LM2500+G4)	a-MDEA	Waste heat recovery on some gas turbine generators to minimise need for gas-fired	No routine flaring from normal operations	Unknown	Unknown	Unknown	CO_2 = less than 1% (may be as low as 0.2%)	

Project	Project Phase	Date of Commission	LNG Process Technology	LNG Production	Liquefaction Drivers	Electrical Power Generation	CO_2 Removal Solvent	Process Heat	Flaring and Venting	Use of Turbo Expanders	Nitrogen End Flash Gas	Boil-off Gas Compression	Feed Gas Composition	Additional Greenhouse Mitigation
								heating						
Karratha Gas Plant Trains 1 to 3	Operation	Planned 2016	Air Products and Chemicals Inc (APCI) mixed refrigerant	3 × 2.5 MTPA LNG 2 × 600 Tj/day of domestic gas	4 × Frame 5 gas turbines and 1 × Frame 3 gas turbine per LNG train Low NOx Liners Waste heat recovery on two of the Frame 5 gas turbine generators	6 × Frame 5 gas turbine generators	Designed and operated on Sulphinol but operating on a-MDEA	Waste heat recovery on two of the Frame 5 gas turbine generators per LNG train	No routine flaring Venting limited to co-absorbed hydrocarbon in CO_2 stream	No	Used as fuel gas onsite Excess is blended into Domestic Gas Stream	Routine compression of Boil-off Gas Flare excess or from warm ships or ships from dry dock	CO_2 ≈3 mol%	
Karratha Gas Plant Trains 4 and 5	Operation	2004, 2008	Propane pre-cooled mixed refrigerant - air cooling	10 MTPA	2 × Frame 7 gas turbines per LNG train Dry low NOx technology Waste heat recovery on one of the Frame 7 gas turbine	4 × LM6000 gas turbine generators	Designed for Sulphinol but operating on a-MDEA (LNG4) Designed for and operated on a-MDEA (LNG5) Incinerator installed for CO_2 vent gas but now decommissioned (fuel use to combust hydrocarbons was seen as a net negative environmental solution)	Waste heat recovery on one of the Frame 7 gas turbine generators per LNG train	No routine flaring Venting limited to co-absorbed hydrocarbon in CO_2 stream	Yes	Used as fuel gas onsite. Excess is blended into Domestic Gas Stream	Routine compression of Boil-off Gas Flare excess or from warm ships or ships from dry dock	CO_2 ≈3 mol%	
Darwin LNG	Operation	2006	Conoco Phillips Optimised Cascade - air cooling	1 × 3.7 MTPA	Aero-derivative gas turbine (LM2500+) Water injection to reduce NOx	Aero-derivative gas turbine (LM2500+) Water injection to reduce NOx	a-MDEA Incineration to reduce CO_2 with H_2S and BTEX in vent gas	Waste heat recovery installed on four of six LNG compressor gas turbines to provide process heat	Minimise routine flaring volumes Minimise non-routine flaring volumes	Unknown	Nitrogen rejection unit with resultant gas being used as fuel	Routine compression of Boil-off Gas Flare excess or from warm ships or ships from dry dock	CO_2 ≈6 mol%	'The Licensee shall formally commit to a project to offset greenhouse gas emissions from the nameplate 3.7 MTPA LNG Plant' AU$100 000

Project	Project Phase	Date of Commission	LNG Process Technology	LNG Production	Liquefaction Drivers	Electrical Power Generation	CO_2 Removal Solvent	Process Heat	Flaring and Venting	Use of Turbo Expanders	Nitrogen End Flash Gas	Boil-off Gas Compression	Feed Gas Composition	Additional Greenhouse Mitigation
														per year to support improved savannah burning practices
Pluto	Operation	2011–2012	APCI mixed refrigerant	1 × 4.3 MTPA	Gas turbines with waste heat recovery	5 × Frame 6 gas turbine generators	a-MDEA Incineration to reduce CO_2 with H_2S and BTEX in vent gas	Waste heat recovery installed on one or more compressor gas turbine generators	No routine flaring from normal operations	Unknown	Vented	Routine compression of Boil-off Gas Flare excess or from warm ships or ships from dry dock	CO_2 ~2–3%	Investments in offset generation to offset reservoir CO_2 (AU$100 million committed to date)
Approved Foundation Project	Construction	First gas scheduled for 2014	APCI Propane pre-cooled mixed refrigerant	3 × 5 MTPA	6 × 80 MW gas turbines with dry low NOx burners	5 × 116 MW gas turbine generators with dry low NOx burners	a-MDEA Reinjection of vent gas	Waste heat recovery installed on liquefaction gas turbine drivers to provide process heat	No routine flaring Venting limited to co-absorbed hydrocarbon in CO_2 stream	Yes	Used as fuel gas onsite	Routine compression of Boil-off Gas Flare excess or from warm ships or ships from dry dock	CO_2 ≈12–13 mol% (Gorgon) CO_2 ≈ <1% (Jansz)	Greenhouse gas storage of reservoir CO_2 (AU$2 billion capital cost)
Fourth Train Proposal	Seeking Environmental Approval	First gas scheduled for 2018	APCI Propane pre-cooled mixed refrigerant	1 × 5 MTPA	2 × 80 MW gas turbines with dry low NOx burners	1 × 116 MW gas turbine generators with dry low NOx burners	a-MDEA Reinjection of vent gas	Waste heat recovery installed on liquefaction gas turbine drivers to provide process heat	No routine flaring Venting limited to co-absorbed hydrocarbon in CO_2 stream	Yes	Used as fuel gas onsite	Routine compression of Boil-off Gas Flare excess or from warm ships or ships from dry dock	CO_2 ~0.3–1.8 mol%	Greenhouse gas storage of reservoir CO_2

11.5 Conclusion

The Fourth Train Proposal will result in an incremental increase in greenhouse gas emissions compared to the approved Foundation Project. During its operations phase, the Fourth Train Proposal is predicted to result in approximately 1.6 MTPA of CO_2-e. The Fourth Train Proposal in addition to the approved Foundation Project is predicted to produce approximately 7.6 MTPA of CO_2-e. The greenhouse gas emissions intensity from the Fourth Train Proposal is amongst the lowest of those benchmarked.

Greenhouse gas emissions from the Fourth Train Proposal are governed by Commonwealth Government policy, which is designed to provide economic incentives to adopt technologies and practices to reduce emissions. Greenhouse gas emissions from the Fourth Train Proposal will be managed such that they are consistent with the proposed management objective (Section 11.1.1).

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Section 12: Table of Contents

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12. Quarantine Management

Barrow Island is internationally recognised for its conservation values and is an important asset to the conservation estate of Western Australia. Barrow Island supports a diversity of species, some of which have evolved in isolation from the mainland for more than 8000 years and do not occur elsewhere. The conservation values of Barrow Island depend on maintaining the Island's unique biodiversity, a responsibility embraced by the dedicated management of quarantine by the oilfield operations since the 1960s and, more recently, by the Foundation Project.

The Fourth Train Proposal will involve the transfer and movement of materials, personnel, vessels, and aircraft to Barrow Island during construction, commissioning, operations, and future decommissioning. Each transfer and movement may create the potential of introducing Non-indigenous Terrestrial Species and/or Marine Pests to Barrow Island and its surrounding waters. This section assesses the potential quarantine impacts and risks that are reasonably expected from the implementation of the Fourth Train Proposal and the management strategies and measures that will be adopted by the GJVs to manage these risks. This section also outlines the relationship between the Fourth Train Proposal and the approved Foundation Project's Terrestrial and Marine Quarantine Management System (QMS).

12.1 Assessment Framework or Policy

The overarching objective of the quarantine strategy for the Fourth Train Proposal is consistent with that for the Foundation Project, i.e. to 'facilitate the construction and operation of a gas processing facility on Barrow Island and simultaneously protect the conservation values of the Island' (Chevron Australia 2008).

12.2 Foundation Project

12.2.1 Quarantine Management System

In recognition of the potential for the Foundation Project to affect the conservation values of Barrow Island through the introduction of Non-indigenous Terrestrial Species and/or Marine Pests to Barrow Island and its surrounding waters, Chevron Australia on behalf of the GJVs has developed and is implementing the QMS for the approved Foundation Project (Chevron Australia 2013). The QMS governs all materials, personnel, vessels, and aircraft travelling to Barrow Island and its surrounding waters.

The QMS for the approved Foundation Project describes more than 300 documents, including procedures, specifications, guidelines, and checklists, that have been developed to address quarantine risks to Barrow Island and its surrounding waters. The Western Australian EPA stated in Report 1323 for the Gorgon Gas Development Revised and Expanded Proposal, that the QMS 'subject to it [the QMS] being implemented as proposed, is likely to be world's best practice and therefore it is unlikely to be possible to recommend additional practical controls beyond that system' (EPA 2009).

12.2.1.1 Objectives

The objectives of the QMS for the approved Foundation Project, as stated in the Ministerial Conditions, are that the Proponent shall not introduce or proliferate Non-indigenous Terrestrial Species and Marine Pests to or within Barrow Island or the waters surrounding Barrow Island, as a consequence of the Proposal.

The specific objectives of the QMS for the approved Foundation Project are to:

- prevent the introduction of Non-indigenous Terrestrial Species and Marine Pests

- detect Non-indigenous Terrestrial Species (including weed introduction and/or proliferation) and Marine Pests
- control and, unless otherwise determined by the Minister, eradicate detected Non-indigenous Terrestrial Species (including weeds) and Marine Pests
- mitigate adverse impacts of any control and eradication actions on indigenous species taken against detected Non-indigenous Terrestrial Species (including weeds) and Marine Pests.

The Barrow Island Quarantine Policy (Chevron Australia 2008a) emphasises the importance of personnel awareness. Amongst other things, this policy aims to:

- develop and maintain a positive quarantine culture among staff, contractors, and suppliers
- provide the appropriate training to support the implementation and ongoing operation of the quarantine programmes.

12.2.1.2 Background

The QMS for the approved Foundation Project was designed and developed in consultation with a Quarantine Expert Panel (QEP), the Quarantine Advisory Committee (QAC), and community stakeholders. When developing standards for acceptable quarantine risk, the view of the community was that an acceptably low level of risk of introducing Non-indigenous Terrestrial Species and Marine Pests to Barrow Island and its surrounding waters must be achieved, a view accepted by the GJVs and endorsed by the QEP and QAC (Chevron Australia 2008a). An acceptably low risk is judged to be not greater than 'a slight chance of infection' after final quarantine clearance (Chevron Australia 2006).

The QMS defines quarantine management measures, including:

- management measures to prevent introductions of Non-indigenous Terrestrial Species and Marine Pests to Barrow Island (Section 12.2.1.3)
- measures to detect Non-indigenous Species and Marine Pests early enough to consider eradication (Section 12.2.1.4)
- measures to control and eradicate Non-indigenous Terrestrial Species and Marine Pests identified on Barrow Island (Section 12.2.1.5)
- quarantine species action plans (Section 12.2.1.5.1)
- Non-indigenous Species Management Procedure (Section 12.2.1.5.2)
- Weed Hygiene Common User Procedure (Section 12.2.1.5.3)
- quarantine management plans (Section 12.2.1.6)
- zonation (Section 12.2.1.7).

12.2.1.3 Management Measures to Prevent Introductions of Non-indigenous Terrestrial Species and Marine Pests to Barrow Island

A comprehensive and independent expert-based risk assessment process was undertaken between 2003 and 2006 to identify and assess the threats of introduction for all pathways of exposure to Barrow Island (Chevron Australia 2008a). A pathway is a route of exposure that might enable Non-indigenous Terrestrial Species or Marine Pests to be introduced to a native environment outside their natural range. Each pathway is associated with equipment, materials, supplies, personnel, vessels, and aircraft travelling to Barrow Island. The original risk assessments identified 15 pathways for the Foundation Project. However, these were consolidated over time into 13 material pathways:

- food and perishables

- personnel and accompanying luggage
- sand, aggregate, and rock
- marine vessels – topsides and wetsides
- plant and mobile equipment
- containerised goods
- airfreight
- skid, steel, and loose equipment (including pipe)
- direct shipments
- special and sensitive goods and equipment
- crated material, equipment, and goods
- prefabricated modules
- personnel transfers from offshore platforms (vessels, helicopters, and flights).

The independent expert-based risk assessment also demonstrated the management measures that could be adopted to reduce the risk of introduction to an acceptably low level for all pathways. In doing so, a set of systematic and pathway-specific quarantine barriers were analysed in detail for each pathway. This analysis considered the circumstances and quantities of people, material, vessels, and aircraft anticipated to be travelling to Barrow Island. Quarantine barriers are preventive measures applied at a step in the supply chain pathway to prevent Non-indigenous Species or Marine Pests being introduced to Barrow Island and its surrounding waters. These barriers may be physical, chemical, or biological interventions, and/or a quarantine procedure, specification, guideline, or supporting administrative process. Quarantine barriers that could not reduce these risks to an acceptably low level were replaced or augmented with barriers that achieved this requirement (Chevron Australia 2008a).

12.2.1.4 Measures to Detect Non-indigenous Terrestrial Species and Marine Pests Early Enough to Consider Eradication

A detection program has been designed and implemented by the Foundation Project to ensure detection of Non-indigenous Terrestrial Species or Marine Pests occurs 'early enough' to implement eradication programs before significant environmental consequences occur. To meet the objective of 'early enough' detection, a robust methodology has been developed in consultation with numerous quarantine surveillance specialists (including Western Australian DPaW [formerly DEC] Officers). This methodology is designed to detect the presence of an introduction if it is actually present on Barrow Island or in its surrounding waters.

The detection program incorporates three components:

- **Observation**, which provides vigilance for the presence of introduced species and suspect organisms in a person's immediate environment
- **Surveillance**, which is the periodic scientific measurement of ecosystem components using a variety of physical devices and specialist visual/auditory observation methods
- **Monitoring**, which involves the long-term observation of representative samples of the Barrow Island ecosystem to detect changes in its function, structure, and composition.

12.2.1.5 Measures to Control and Eradicate Non-indigenous Terrestrial Species and Marine Pests Identified on Barrow Island

Any Non-indigenous Terrestrial Species (NIS) or a Marine Pest that is detected to have been brought onto Barrow Island or into its surrounding waters by the approved Gorgon Foundation Project after the final quarantine clearance is considered an 'incident' under the

QMS for the approved the Foundation Project. Under the QMS, such incidents trigger the mobilisation of an immediate response to contain and eliminate the Non-indigenous Terrestrial Species and/or Marine Pest and control its spread. Emergency response activities for quarantine incidents include an initial tactical 'first action', as detailed in the Non-indigenous Species First Response Guide (Chevron Australia 2012). If the immediate first response fails to contain, control, and eliminate the NIS or Marine Pest, the Quarantine Incursion Response Plan (Chevron Australia 2010), in conjunction with the Australasian Business Unit (ABU) Emergency Response Plan (Chevron Australia 2011), will be implemented.

12.2.1.5.1 Quarantine Species Action Plans

The Quarantine Species Action Plans are management plans that are available to guide the first response, incursion response, control, and, unless otherwise determined by the Western Australian Minister for Environment, eradication of NIS and Marine Pests. Quarantine Species Action Plans contain mitigating measures to limit the impact caused in the control or eradication of detected NIS on Barrow Island and Marine Pests in the waters surrounding Barrow Island. This ensures that the actions taken in the event of quarantine incidents are based on best-practice methods that have proven effective in similar circumstances.

12.2.1.5.2 Non-indigenous Species Management Procedure

The QMS for the approved Foundation Project includes a Non-indigenous Species Management Procedure (Chevron Australia 2009) for all species that, on the advice of the QEP, the Department of Fisheries, and DPaW, have the potential to impact on the conservation values of Barrow Island and its surrounding waters as the result of Foundation Project-related activities. The Non-indigenous Species Management Procedure will be implemented for any NIS or Marine Pest that survives beyond the immediate first response and the incursion response, and that results in the establishment and/or expansion of the home range of a NIS or Marine Pest on Barrow Island or in its surrounding waters. The output of the procedure is an annual NIS or Marine Pest eradication program, which is supported by risk assessment, risk classification, decision-making model, program scoping exercise, funding and resourcing, assignment of responsibilities, performance monitoring and surveillance, progress reporting, auditing, and review.

12.2.1.5.3 Weed Hygiene Common User Procedure

The Weed Hygiene Common User Procedure (Chevron Australia 2014a) was developed to prevent the proliferation of weeds present on Barrow Island before the Gorgon Gas Development commenced, as well as introduced weeds that survive beyond the immediate first response and incursion response and will impact the conservation values of Barrow Island. This procedure contains the following measures:

- identify Weed Hygiene Zones within which non-indigenous plant species, assessed to be high-risk species, have established weed populations, and/or where an associated seedbank is suspected to occur
- identify the activities on Barrow Island that pose a risk of spreading weeds throughout Barrow Island
- prescribe actions, where practicable, to reduce the risk of spreading weeds throughout Barrow Island.

12.2.1.6 Quarantine Management Plans

The QMS for the approved Foundation Project provides an overarching management framework for the development of specific Quarantine Management Plans. These include Engineering Procurement Construction Management (EPCM) (Downstream and Upstream) Quarantine Management Plans, Contractor Quarantine Management Plans, and Quarantine Management Plans for specialised activities, facilities, and vessels.

12.2.1.7 Zonation

Zonation of Barrow Island and its surrounding waters is a management measure that forms the basis of a number of requirements in the approved Foundation Project QMS, relating to vessel usage, access authority, and incident classification.

Marine quarantine zonation for Barrow Island is used as a management tool to specify fit-for-purpose quarantine requirements for vessels entering the waters surrounding Barrow Island. Marine vessels approaching closer to the Barrow Island shoreline are subject to progressively more stringent quarantine requirements in each defined zone so as to reduce the risk of introducing NIS and Marine Pests to Barrow Island and its surrounding waters to acceptably low levels.

Terrestrial quarantine zonation is a management tool that is used to reduce the likelihood of NIS establishing on Barrow Island and to minimise the potential of current weed populations on Barrow Island from spreading further as a result of Foundation Project activities.

12.2.2 Review of the QMS

The QMS for the approved Foundation Project is reviewed and updated as required by Ministerial Conditions, which require annual review and update during construction of the Foundation Project and every five years during operations, or more often as required (e.g. in response to new information). Reviews address matters such as the overall design and effectiveness of the QMS, progress in environmental performance, changes in environmental risks, changes in business conditions, and any relevant emerging environmental issues.

12.3 Assessment of Quarantine Risk

Large volumes of materials, personnel, vessels, and aircraft will be transferred to Barrow Island to support construction and operations of the Fourth Train Proposal, all of which will contribute to the quarantine risk of the Fourth Train Proposal.

The volumes of materials, personnel, vessels, and aircraft required to be brought to Barrow Island for the Fourth Train Proposal are predicted to be no more than 30% of those required for the Foundation Project. The Fourth Train Proposal will retain the modular construction employed by the Foundation Project (e.g. the onsite assembly of large modular components), thus reducing the number of personnel and the volume of materials to be brought to Barrow Island, compared to a ground-up ‘stick-build’ construction methodology.

The Fourth Train Proposal comprises only limited nearshore construction compared to the Foundation Project. The Foundation Project’s dredging program and construction of the Materials Offloading Facility and LNG Jetty, on the east coast of Barrow Island, required a large number of vessels to operate close to Barrow Island. The Fourth Train Proposal does not include significant east coast marine construction. The main marine construction for the Fourth Train Proposal is the offshore Feed Gas Pipeline System installation and tie-in to the shore crossing.

The increase in volumes of materials, personnel, vessels, and aircraft for the Fourth Train Proposal will create a risk of introducing a NIS or Marine Pest to either Barrow Island or its surrounding waters.

An assessment was conducted of the type of materials, vessels, aircraft, and the number of personnel required by the Fourth Train Proposal. The methods of transfer of materials, personnel, vessels, and aircraft to Barrow Island for the Fourth Train Proposal are expected to be similar to those anticipated for the Foundation Project. No new pathways were identified for the Fourth Train Proposal beyond those already identified, assessed, and managed by the QMS for the Foundation Project. As no new pathways were identified, the existing Foundation Project QMS is expected to be suitable to manage the quarantine risks of the Fourth Train Proposal to an acceptably low level, subject to the annual review process.

Opportunities to reduce the Fourth Train Proposal quarantine risk even further may be identified through the performance monitoring and adaptive management aspects of the QMS implemented by the approved Foundation Project. The results of the quarantine risk assessment, if required, will be built into a future revision of the QMS for the Fourth Train Proposal.

12.3.1 Assessment of Potential Impacts

Introduced NIS or Marine Pests could lead to irreversible and detrimental impacts to the ecological composition and function of Barrow Island and the ecosystem of its surrounding waters. Potential impacts associated with the introduction of NIS or Marine Pests include competition with native fauna and flora (including species listed under the EPBC Act) for resources such as food and habitat; habitat modification; the introduction of diseases and pathogens; and predation.

An assessment was conducted of the Fourth Train Proposal to assess the likelihood and consequence of an environmental impact on Barrow Island or its surrounding waters from the introduction of NIS or Marine Pests. Refer to the spreadsheet in Appendix F2 [Consolidated Risk Assessment Results] for an outline of the potential impacts associated with the introduction of a NIS or Marine Pest due to the implementation of the Fourth Train Proposal. The potential for successful incursion of NIS and Marine Pests is lower for the construction of the Fourth Train Proposal than initially predicted for the construction of the approved Foundation Project due to the implementation of the QMS. The potential for successful incursion in the operations phase of the Fourth Train Proposal is predicted to be the same as for the approved Foundation Project. The risks to the Commonwealth Marine Area are considered trivial due to the quarantine controls imposed by the Commonwealth Department of Agriculture.

It is difficult to predict the effect that any future invasive species may have on the biodiversity of Barrow Island or its surrounding waters due to the uncertainty about the behaviour of species within an ecosystem. For a more detailed account of the predicted impacts from high-risk species, including a risk map outlining areas prone to establishment, refer to the Species Action Plan for that species, as outlined in the approved Foundation Project QMS.

The GJVs consider that the potential impacts from NIS or Marine Pests by the Fourth Train Proposal can be effectively managed under Ministerial Conditions consistent with those already set for the Foundation Project. No measures or controls additional to those required for the approved Foundation Project were assessed as being necessary to manage the potential incremental or additional impacts from the Fourth Train Proposal.

12.4 Implementation and Effectiveness of the Quarantine Management System

The quarantine performance of the Foundation Project can be assessed by the implementation and effectiveness of the QMS. A number of mechanisms can be used to assess the implementation and effectiveness of the QMS for the approved Foundation Project, including:

- Compliance Assessment Reports
- Environmental Performance Reports
- QEP Reports to the Minister for Environment.

These documents fulfil the quarantine compliance reporting and environmental performance reporting obligations for the Foundation Project Ministerial Conditions, and have been submitted to the relevant Ministers for Environment. The Compliance Assessment Reports and the Environmental Performance Reports are publicly available on the Chevron Australia website. A summary of the quarantine-related compliance reports and environmental performance reports from 2013, which were the most recent at the time of submission of this PER/Draft EIS, is listed below to outline the implementation and effectiveness of the QMS.

The most recent Environmental Performance Report for the Ministerial Conditions is for the reporting period 10 August 2012 to 9 August 2013 (Chevron Australia 2013). Aspects of the implementation and the effectiveness of the QMS as described in the Environmental Performance Report 2013 are as follows:

- There were 229 quarantine intercepts prior to final quarantine clearance and 43 quarantine incidents, with corrective actions implemented in response to the incidents, if necessary.
- Two internal audits were conducted to ensure compliance with the QMS—one to determine compliance with the Weed Hygiene Common User Procedure and one to determine compliance with the Non-indigenous Species Management Procedure.
- There were no significant (Level 2, as defined in the QMS) quarantine procedural deviations recorded on Barrow Island (nor have there been since the implementation of the QMS in 2009).
- There is no evidence of NIS or Marine Pests establishing on Barrow Island or in the Controlled Access Zone as a result of the approved Foundation Project. Therefore, no eradication actions or mitigation measures were required for new NIS or Marine Pests.
- There were no proliferations of existing weeds or new weed establishment ('infestation') on Barrow Island as a result of the Gorgon Gas Development. As a result, there was no requirement to develop weed targets for 2013–2014 reporting period.

Annual assessments of the effectiveness of the QMS for the approved Foundation Project are conducted by the QEP, who provide a report of findings to the Western Australian Minister of the Environment and to Chevron Australia (Gorgon QEP 2011, 2012, 2013). Their results are summarised or quoted directly below.

- 'The QEP has reviewed the implementation and effectiveness of the QMS and is satisfied that Chevron Australia has provided evidence that demonstrates the Gorgon Quarantine Management System is meeting, or intends to meet, the requirements of Condition 10 of Statements No. 800 and No. 769.' (Gorgon QEP 2013).
- 'There were 212 Level 1 quarantine intercepts, four Level 2 quarantine intercepts and five Level 3 quarantine intercepts (a quarantine intercept[13] is any case where quarantine inspection prior to final quarantine clearance leads to the detection, containment, and removal of contamination or NIS)' (Gorgon QEP 2013).
- 'There were 47 Level 1 incidents, one Level 2 incident, and no Level 3 incidents (a quarantine incident[14] is the positive identification of an NIS or a Marine Pest detected after final quarantine clearance, or activities that have caused the proliferation of existing weed populations)' (Gorgon QEP 2013).

[13] A Level 1 Quarantine Intercept occurs within the Quarantine Remediation Area, prior to final quarantine clearance by Project Quarantine Inspectors; it is a determination that an intercepted contaminant is likely to be a low biodiversity risk to Barrow Island, irrespective of its mobility. A Level 2 Quarantine Intercept occurs the Quarantine Remediation Area, prior to final quarantine clearance by Project Quarantine Inspectors; it is a determination that an intercepted contaminant is likely to be of high biodiversity risk but low mobility. A Level 3 Quarantine Intercept occurs within the Quarantine Remediation Area, prior to final quarantine clearance by Project Quarantine Inspectors; it is a determination that an intercepted contaminant is likely to be of high biodiversity risk and is highly mobile (Chevron Australia 2013).

[14] A Level 1 Quarantine Incident is the detection of a confirmed NIS on freight, people, vessels, or aircraft, after final quarantine clearance, within the Quarantine Terrestrial Controlled Access Zone; or the detection of species in the Limited Access Zone where the invasive risk of such species is assessed as low. A Level 2 Quarantine Incident is the detection of a confirmed NIS in the Quarantine Terrestrial Limited Access Zone on Barrow Island except where the species is assessed to be low risk (see Level 1). A Level 3 Quarantine Incident is the detection of a confirmed NIS in the Quarantine Terrestrial Restricted Access Zone on Barrow Island, except where the species is assessed to be low risk (see to Level 1); or the detection of NIS in any Access Zone on Barrow Island where the invasive risk of such species is assessed to be high (Chevron Australia 2014).

- 'There is no evidence that any introduced NIS or marine pests were established during the reporting period as a result of the Gorgon Gas Development' (Gorgon QEP 2013).
- 'The QEP concluded that the response to detections has been well managed by the [Western Australian] Department of Fisheries (DoF) and Chevron Australia' (Gorgon QEP 2013).
- 'The QEP noted that the Barrow Island non-indigenous invertebrate species surveillance program has been highly successful, resulting in one of the best-described invertebrate communities in Australia, if not the world' (Gorgon QEP 2013).
- 'The QEP also notes that Chevron Australia's and its contractors' responses to Corrective Actions Requests and Opportunities for Improvement identified during audits and inspections were reviewed and closed out in a timely manner during 2013' (Gorgon QEP 2013).
- 'The Quarantine Expert Panel was also pleased to see that Chevron Australia has been recognised for its commitment to protecting Barrow Island by the United Nations (UN) Association of Australia at its 2012 World Environment Awards. The Gorgon Quarantine Management System received the Business Award for Best Practice Program which demonstrates excellence in environmental management and sustainable development, consistent with global UN standards' (Gorgon QEP 2012).
- The Foundation Project 'has maintained the exceptionally high standards set and has gone beyond the original barriers proposed and assessed in the [Quarantine Hazard Analysis] QHAZ of the pathways' (Gorgon QEP 2011).
- Detection programs have been developed for non-indigenous plants, invertebrates, vertebrates, and marine pests. These programs have been implemented on Barrow Island by reputable expert consultants recognised for their expertise in their respective fields. All the terrestrial programs have been implemented in the manner required to demonstrate that, over time, a statistical power of 0.8 is being achieved (Gorgon QEP 2011).
- 'The QEP is of the view that the principles on which the Gorgon QMS has been developed continue to be well-founded and the barriers established appear effective in achieving a low risk of introduction or proliferation of non-indigenous terrestrial species and marine pests to or within Barrow Island or the waters surrounding Barrow Island' (Gorgon QEP 2012, 2013).

12.5 Predicted Environmental Outcome

No additional pathways for the introduction of NIS or Marine Pests to Barrow Island or its surrounding waters have been identified for the Fourth Train Proposal. Therefore, the transfer and movement of materials, personnel, vessels, and aircraft to Barrow Island for the Fourth Train Proposal can be managed by the existing management measures and barriers included in the QMS for the approved Foundation Project.

The QMS specifies a risk assessment process that ensures the risk of introduction is acceptably low. The proposed measures to prevent, eradicate, and detect the introduction of NIS or Marine Pests from the implementation of the Fourth Train Proposal are such that the risk of the introduction of NIS or Marine Pests is environmentally acceptable.

The QMS implementation by the Foundation Project has been found to be effective at managing the quarantine risks associated with the Foundation Project. Therefore, the GJVs consider that the approved Foundation Project QMS, as amended from time to time, is suitable to effectively manage the quarantine risks from the Fourth Train Proposal such that risks are environmentally acceptable and the environmental objective (Section 12.1) is met.

12.6 References Cited in Section 12

Chevron Australia. 2006. *Final Environmental Impact Statement/Environmental Review and Management Programme for the Gorgon Gas Development*. Chevron Australia, Perth, Western Australia.

Chevron Australia. 2008. *Gorgon Gas Development Revised and Expanded Proposal Public Environmental Review*. Chevron Australia, Perth, Western Australia.

Chevron Australia. 2008a. *Barrow Island Quarantine Policy*. Chevron Australia, Perth, Western Australia.

Chevron Australia. 2009. *Non-indigenous Species Management Procedure*. Chevron Australia, Perth, Western Australia.

Chevron Australia. 2010. *Quarantine Incursion Response Plan*. Chevron Australia, Perth, Western Australia.

Chevron Australia. 2011. *ABU Emergency Response Plan*. Chevron Australia, Perth, Western Australia.

Chevron Australia. 2012. *Non-Indigenous Species First Response Guide*. Chevron Australia, Perth, Western Australia.

Chevron Australia. 2013. *Gorgon Gas Development and Jansz Feed Gas Pipeline: Ministerial Implementation Statement No. 800, Ministerial Implementation Statement No. 769, EPBC Reference: 2003/1294 (as amended) and EPBC Reference: 2008/4178 Environmental Performance Report 2013*. Available from: http://www.chevronaustralia.com/ourbusinesses/gorgon/environmentalresponsibility/environmentalapprovals.aspx [Accessed 02 March 2013]

Chevron Australia. 2014. *Barrow Island Quarantine: Terrestrial and Marine Quarantine Management System*. Chevron Australia, Perth, Western Australia.

Chevron Australia. 2014a. *Weed Hygiene Common User Procedure*. Chevron Australia, Perth, Western Australia.

Environmental Protection Authority. 2009. *Gorgon Gas Development Revised and Expanded Proposal: Barrow Island Nature Reserve*. Available from: http://epa.wa.gov.au/epadoclib/2937_rep1323gorgonrevper30409.pdf [Accessed 02 March 2013]

Gorgon Quarantine Expert Panel. 2011. *Report provided to the Minister for Environment and Chevron Australia Pty Ltd on the Effectiveness of the Gorgon Quarantine Management System for the period 1 October 2010 to 30 September 2011*. Gorgon Quarantine Expert Panel, Perth, Western Australia.

Gorgon Quarantine Expert Panel. 2012. *Report provided to the Minister for Environment and Chevron Australia Pty Ltd on the Effectiveness of the Gorgon Quarantine Management System for the period 1 October 2011 to 30 September 2012*. Gorgon Quarantine Expert Panel, Perth, Western Australia.

Gorgon Quarantine Expert Panel. 2013. *Advice provided to the Minister for Environment and General Manager Greater Gorgon Area, Chevron Australia Pty Ltd on the Effectiveness of the Gorgon Quarantine Management System*. Gorgon Quarantine Expert Panel, Perth, Western Australia.

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13. Matters of National Environmental Significance – Impacts and Management

13.1 Introduction

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) provides a legal framework to protect and manage internationally and nationally important flora, fauna, ecological communities, and heritage places—defined in the EPBC Act as matters of national environmental significance (matters of NES). Matters of NES relevant to the Fourth Train Proposal (termed controlling provisions) were determined by the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities (SEWPaC; now DotE) (EPBC Reference: 2011/5942) following referral of the Fourth Train Proposal (Chevron Australia 2011), as:

- National Heritage Places (Sections 15B and 15C of the EPBC Act)
- Listed threatened[15] species and communities (Sections 18 and 18A of the EPBC Act)
- Listed migratory species (Sections 20 and 20A of the EPBC Act)
- Commonwealth Marine Environment (Sections 23 and 24A of the EPBC Act).

These controlling provisions are identified within a set of guidelines, referred to as the Tailored Guidelines, which were issued to Chevron Australia (SEWPaC 2011), to inform the preparation of this Draft Environmental Impact Statement for the Fourth Train Proposal. These Tailored Guidelines establish the scope of the assessment required for the controlling provisions. This Section presents and discusses the results of this assessment.

Table 13-1 summarises the controlling provisions for the Fourth Train Proposal. The existing status of each controlling provision is described in Section 6.

Table 13-1: Summary of Controlling Provisions for the Fourth Train Proposal

Controlling Provision	Relevant Matter of National Environmental Significance
National Heritage Places	The Ningaloo Coast is the only National Heritage Place identified as having the potential to be impacted by the Fourth Train Proposal. The Ningaloo Coast, including both Commonwealth and State marine and terrestrial components, is a listed National Heritage Place. The Ningaloo Coast is located approximately 130 km south-west of Barrow Island. Sections 6.7.2 and 6.7.3 describe the environmental baseline.
Listed threatened species and communities	Thirty listed threatened species, including nine terrestrial species on Barrow Island and 21 marine species, may be present within the Fourth Train Proposal Area. These species include terrestrial and marine mammals, marine reptiles, fish, subterranean vertebrates, land birds, and seabirds. Sections 6.5.2 and 6.5.3 describe the environmental baseline for terrestrial listed species and their habitats, while Sections 6.6.1 and 6.6.2 describe the environmental baseline for marine listed species and their habitats. Only a proportion of these species have been identified as being potentially impacted by the Fourth Train Proposal activities based on their likely presence within the vicinity of the Fourth Train Proposal activities (Sections 13.3, 13.4 and Appendix E2 [Conservation-significant Species Considered for Assessment in this PER/Draft EIS]).

[15] Note: 'Threatened Species' may encompass all current categories for species listings under the EPBC Act list of threatened Fauna that are relevant to the Fourth Train Proposal Area. These include 'Critically Endangered', 'Endangered', 'Vulnerable', and 'Conservation Dependent' species.

Controlling Provision	Relevant Matter of National Environmental Significance
Listed migratory species	Eighty-two EPBC Act-listed migratory species (of which 15 are also listed as threatened) may be present within the Fourth Train Proposal Area. These include fish, marine mammals, marine reptiles, shorebirds, seabirds, and raptors. Only a proportion of these species have been identified as being potentially impacted by the Fourth Train Proposal activities based on their likely presence within the vicinity of the Fourth Train Proposal activities (Sections 13.3, 13.4 and Appendix E2 [Conservation-significant Species Considered for Assessment in this PER/Draft EIS]).
Commonwealth Marine Environment	The Commonwealth Marine Area includes the waters, the seabed, and the airspace. The Fourth Train Proposal overlaps the Commonwealth Marine Area associated with the North-west Marine Region, including part of the Montebello Commonwealth Marine Reserve and Key Ecological Features (Figure 13-1). The environmental baseline for the regional and local (Fourth Train Proposal Area) Commonwealth Marine Area is provided in: • Section 6.4.1 for the airspace • Sections 6.4.2, 6.4.4.3, and 6.6.1 for the seabed and its benthic habitats • Sections 6.4.3, 6.4.4, and 6.6.2 for the water column and its marine fauna • Sections 6.8.3.2 and 6.8.4.2 for maritime cultural heritage and other sea users

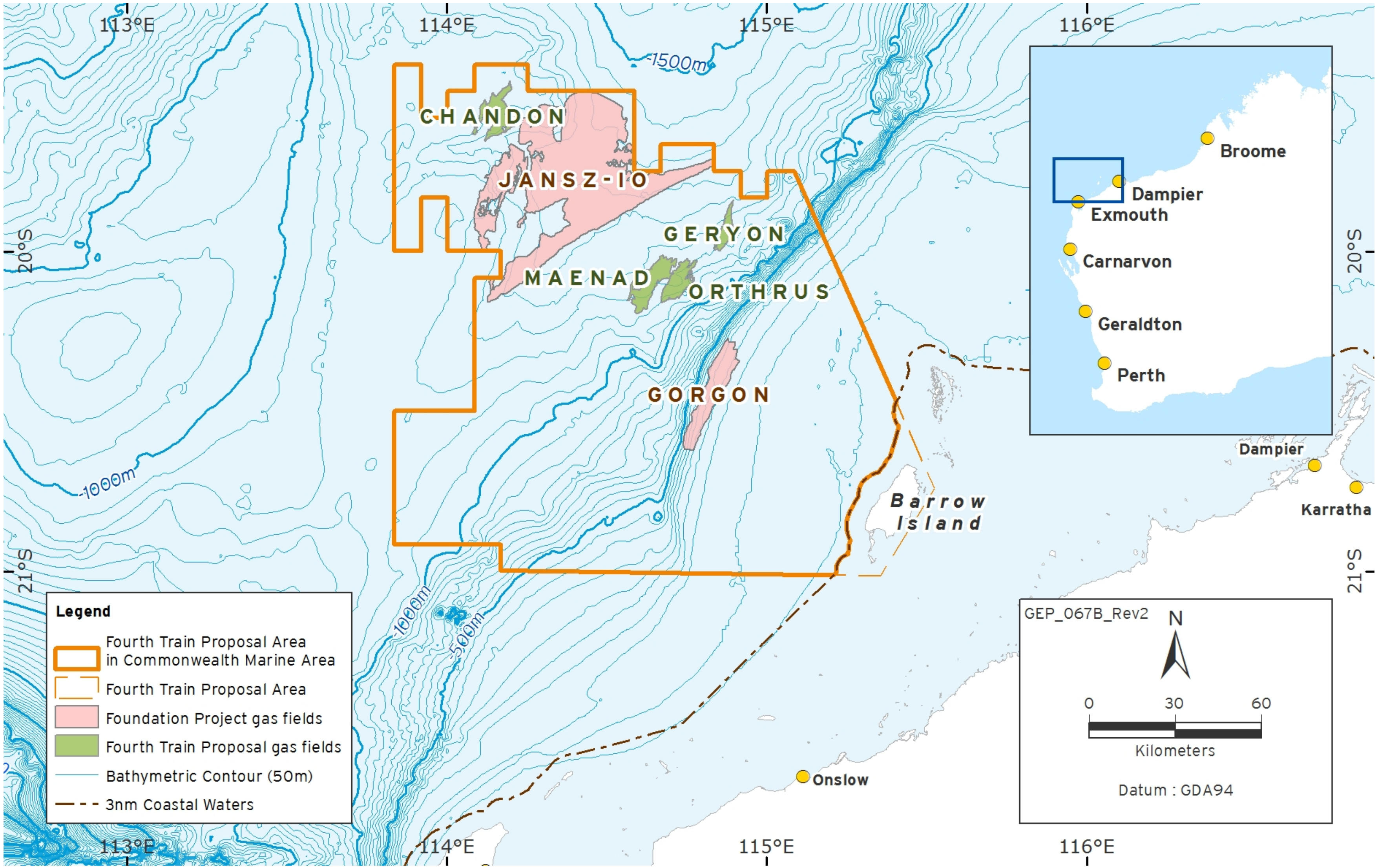

Figure 13-1: The Commonwealth Marine Area in Relation to the Fourth Train Proposal

13.1.1 Approach

The approach used to identify and assess potential impacts of the Fourth Train Proposal on the controlling provisions is described in Section 8. Both the potential incremental (including different) impacts introduced by the Fourth Train Proposal alone, and additional impacts of the Fourth Train Proposal when added to the impacts assessed and approved for the Foundation Project have been identified, predicted, and evaluated for their acceptability. Cumulative impacts upon the controlling provisions are assessed in Section 15.

Those stressors where the potential impact on the environmental factor was considered 'Trivial' were screened out from further assessment and are not discussed within this Section, except in the case of stakeholder interest; refer to Section 8.2.2 for further details. The acceptability of impacts was assessed in regard to the assessment framework, which is determined for each controlling provision. In determining acceptability, the sensitivity, value, and quality of the receiving environment and the intensity, duration, magnitude, and geographic extent of the identified impacts were also considered. As part of the assessment framework, objectives were established using previous Foundation Project assessments, reflecting the close synergies and relationships between the Foundation Project and the Fourth Train Proposal. The objectives are consistent with the objects and principles of the EPBC Act, including that of ecologically sustainable development (Table 1-1), and the aims and objectives of the various plans and policies referenced within the assessment framework of Sections 13.2 to 13.5.

This PER/Draft EIS also draws on experience to date from the Foundation Project, where relevant to the Fourth Train Proposal (Section 16.2.1). Environmental monitoring studies (Sections 3.5.1 and 3.5.2) and records of environmental incidents associated with the Foundation Project (Appendix G [Foundation Project Incidents Relevant to the Assessment of the Fourth Train Proposal]) were also considered within the assessment of the Fourth Train Proposal. Experience gained from the Foundation Project was used to better understand the potential impacts associated with the Fourth Train Proposal, and help validate the efficacy of the existing management systems in place. Where scientific uncertainty surrounding the seriousness or irreversibility of an impact exists, a conservative approach was used for the assessment of impacts and a precautionary adaptive management approach was adopted.

13.1.2 Scope of the Assessment

A description of the Fourth Train Proposal, including the activities surrounding its implementation is given in Section 4; this description also provides the scope of activities upon which the assessment undertaken in this Section is based.

Of particular note to the assessment of potential impacts on the controlling provisions:

- Some uncertainty exists regarding options for the implementation of the Fourth Train Proposal. Where options could have differing potential impacts, or may require additional mitigation and management measures, these are discussed. The predicted environmental outcome considered the option that would likely result in the worst-case potential impacts.
- While the assessment focused on potential impacts during the construction and operations phases of the Fourth Train Proposal, the potential impacts on the controlling provisions during the decommissioning phase are anticipated to be similar to those during construction. As with construction activities, decommissioning activities are expected to be short term, and the type, level, and location of activities are likely to be similar to those undertaken during construction (Section 4.8). As advances in decommissioning technology and information are likely, as well as potential changes to decommissioning procedures and regulatory requirements prior to decommissioning starting, potential impacts associated with decommissioning should be considered in light of those assessed for construction unless otherwise stated. This assessment considers all activities, whether

undertaken within Commonwealth and/or State jurisdiction that may result in potential impacts to any one of the controlling provisions under the EPBC Act (Table 13-1).

- This Section draws on the assessments undertaken in Sections 5, 9 to 12, and 14 where there is opportunity to further substantiate the assessment of impacts on the controlling provisions.
- Consideration of the potential for the introduction and/or spread of marine pests and non-indigenous terrestrial species is not assessed within this Section, but is discussed in Section 12.

13.1.3 Assessment Structure

For each controlling provision, the following information is provided:

- an environmental objective against which the assessment will be made
- the stressors identified as having the potential to impact the controlling provision, and the types of potential impact on the controlling provision
- the assessment of potential incremental, additional, and additive impacts of the Fourth Train Proposal on the controlling provision
- the relevant Environmental Management and Monitoring Plans, Programs, Systems, Procedures and Reports (collectively referred to as EMPs), Subsidiary Documents (requiring regulator approval) and, where relevant, Ministerial Conditions, that will be adopted to manage the potential impacts of the Fourth Train Proposal, and illustrative mitigation and management measures from these
- the predicted environmental outcome.

Section 13.6 summarises the environmental management framework relevant to the management of potential impacts on the controlling provisions. Section 13.7 concludes with an overall discussion as to the predicted environmental outcome, and the acceptability of the Fourth Train Proposal on the controlling provisions in relation to the environmental objectives.

Note: This Section has been prepared as an integral part of the PER/Draft EIS and does not cover all items required in the Tailored Guidelines. Detailed assessments relevant to a controlling provision are referenced accordingly. Table 1-3 summarises where each of the Tailored Guideline requirements are met in this PER/Draft EIS, with more detail provided in Appendix B3 [Commonwealth (Tailored Guideline) Requirements for the Contents of this Draft EIS].

13.2 National Heritage Places

13.2.1 Assessment Framework

13.2.1.1 Assessment Objective

The objective established in this PER/Draft EIS for conservation areas, including National Heritage Places, is:

> *To protect the environmental and social values of areas identified as having significant environmental and/or national heritage attributes.*

Table 13-2 summarises the national environmental and heritage values of the Ningaloo Coast, as described by DotE.

Table 13-2: Summary of Environmental and Heritage Values of the Ningaloo Coast

Value	Summary Description
Environmental	• One of the best-developed nearshore reefs in the world and the largest fringing coral reef in Australian waters • Annual aggregation of Whale Sharks coinciding with main coral spawning across Ningaloo Reef. The reef provides habitat and food resources for a range of other EPBC Act-listed marine fauna (e.g. marine turtles) • Limestone parapets and wavecut terraces provide information on the processes affecting, and changes within, the marine environment in the region over millions of years • A network of caves, groundwater streams, pools, karsts, and aquifers housing an abundance of subterranean fauna, some of which are endemic to the Cape Range • Diversity of reptiles and vascular plants in the drylands.
Heritage	• Archaeological deposits in rock shelters dated between 35 000 and 17 000 years ago • Shell beads discovered and dated to more than 32 000 years old • The Ningaloo Coast has potential to reveal further significant cultural heritage.

Adapted from DotE (n.d.)

13.2.1.2 Relevant Policy, Plan, and Guideline Documents

Table 13-3 lists relevant policy, plan, and guideline documents relating to the assessment of impacts on the Ningaloo Coast.

Table 13-3: Policies, Plans, and Guidelines Relevant to Impacts on the Ningaloo Coast

Policy, Plan, Guideline	Intent
Ningaloo Marine Park (Commonwealth Waters) Management Plan (Commonwealth of Australia 2002)	Provides a management strategy for the Ningaloo Marine Park (Commonwealth Marine Area) to be managed as a Category II Reserve (National Park) according to the International Union for Conservation of Nature (IUCN) protected area classification system. The management plan expired in 2009 and interim management arrangements are in place until the conclusion of marine bioregional planning process for the North-west Marine Region.
Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005–2015 (Department of Conservation and Land Management [CALM] 2005)	The overall vision of the plan is to ensure that marine ecosystem health is maintained or improved, and that cultural and Aboriginal heritage values are fully protected from adverse human impacts.
Cape Range National Park Management Plan No 65 2010 (DEC and Conservation Commission of Western Australia 2010)	Provides for the protection of the park's significant values, which include conservation and cultural values; subterranean fauna; diverse habitats; and the presence of species occurring at the limits of their geographic range or as geographically isolated populations.

13.2.2 Assessment and Mitigation of Potential Impacts

The closest boundary of the Ningaloo Marine Park is approximately 130 km south-west of Barrow Island (Section 6.7.2). The stressor identified as having the potential to impact the National Heritage values of the Ningaloo Coast (Table 13-4) is spills and leaks. Atmospheric emissions (except dust) were identified as a 'Trivial' stressor, but have been included due to stakeholder interest.

13.2.2.1 Atmospheric Emissions (except dust)

Atmospheric emissions (except dust) can result in effects on vegetation and ecosystems, either by directly affecting plant physiology, growth, and vitality, by adding nutrients to the soil, or by acidifying the soil or marine waters through wet or dry deposition of emissions. Atmospheric emissions also have the potential to impact terrestrial and marine fauna through inhalation, bioaccumulation of contaminants, and through alterations to their environment (e.g. through soil or ocean acidification).

Atmospheric emissions predicted to result from the Fourth Train Proposal are detailed in Section 5.2. Atmospheric dispersion modelling conducted for the Fourth Train Proposal considered the potential cumulative impacts on ambient air quality in the Pilbara Region, including the Ningaloo Coast. Further information regarding the sources considered as part of the assessment is provided in Section 15.3.1. The key atmospheric pollutants of concern in relation to the controlling provisions include oxides of nitrogen and sulfur and ground-level ozone produced during the operation of the Gas Treatment Plant. In the absence of Australian ecosystem-specific criteria, potential impacts of atmospheric pollutants and air toxics within marine and terrestrial ecosystems were assessed with reference to human exposure limits established in the National Environment Protection (Ambient Air Quality) Measure (NEPM), the National Exposure Standards [NOHSC: 1003–1995] (as amended – Safe Work Australia [SWA] 1995), and World Health Organization (WHO) Air Quality Guidelines for Europe (WHO 2000). The suitability of criteria for Barrow Island and its surrounding waters was assessed in support of the Foundation Project's Air Quality Management Plan (URS 2011, 2011a). Those assessments concluded that the criteria selected for the Foundation Project provide the most conservative benchmark to assess potential impacts of air quality on terrestrial and marine ecosystems and their fauna.

The air quality assessment concluded that nitrogen dioxide (NO_2) and ozone (O_3) levels as a result of the operation of the Fourth Train Proposal are predicted to be highest over Barrow Island, reducing rapidly away from Barrow Island. Cumulative concentrations of NO_2 from the Fourth Train Proposal, and emissions from the Foundation Project and other considered actions in the Pilbara Region were predicted to be within the established criteria. Cumulative concentrations of O_3 during routine and black start operations were also predicted to be within the established criteria, with natural causes (e.g. from bushfires) being the major (70%) contributor to regional O_3 levels.

Sulfur and nitrogen deposition rates for the Ningaloo Coast (taken as Coral Bay) were predicted to be 0.29 kg/ha/year and 0.93 kg/ha/year respectively, which are well below the critical loads established for ecosystems relevant to this assessment of between 4 to 8 kg/ha/year for sulfur and 15 to 20 kg/ha/year for nitrogen.

Proposed measures that will be implemented to mitigate and manage the potential impacts associated with atmospheric emissions sources are described in Section 5.2.4.

Given the results of the air quality assessment, the likelihood for one or more of the National Heritage values to be lost, degraded, damaged, altered, modified, obscured, or diminished to an unacceptable level as a result of atmospheric emissions from the Fourth Train Proposal is considered remote. It is acknowledged that the modelling assessment is a prediction, and may therefore carry some uncertainty. However, conservative emission production rates and equipment specifications were used where there was uncertainty in the planning and set-up of the modelling assessments. This produced reliable and conservative results, which are predicted to be the worst-case scenarios within the range of development concepts being proposed for the Fourth Train Proposal. Therefore, the atmospheric emissions associated with the Fourth Train Proposal are not predicted to result in any unacceptable potential incremental or additional impacts on the Ningaloo Coast.

13.2.2.2 Spills and Leaks

A spill or leak of hydrocarbons or hazardous materials has the potential to adversely impact the ecological and heritage values of the Ningaloo Coast through reduced water and sediment quality, which may then have secondary impacts upon the amenity of the area and upon marine biodiversity. The level of impact from spills and leaks depends on factors including the magnitude and type of spill or leak (e.g. condensate or diesel), oceanographic conditions, and the sensitivity of the receiving environment. Hydrocarbons may impact water quality in the form of surface sheens (slicks), entrained oil in the water column, or dissolved aromatic hydrocarbons. Chemicals that could be used to treat spills (e.g. surfactants) also have the potential to impact water quality in terms of changes to chemical and physical characteristics of the receiving water body.

Hydrocarbon spill trajectory modelling was undertaken for multiple scenarios relevant to the construction and operation of the Fourth Train Proposal, including a worst-case 11-week subsea well blowout occurring within the Chandon Gas Field, an Offshore Feed Gas Pipeline System rupture, and several marine vessel spill scenarios. Considerations for the selection of the Chandon Gas Field as representing the worst-case subsea well blowout scenario for the Fourth Train Proposal included its condensate-to-gas ratio, which is high relative to other Fourth Train Proposal gas fields. Hydrocarbon spill trajectory modelling was undertaken using established models recognised within the industry and by regulators. Additional discussion on the scenarios modelled, modelling assumptions, results, and proposed management is provided in Section 5.7. The locations of spill and leak scenarios used for the modelling are illustrated in Figure 13-2.

An ecological risk assessment was also undertaken using the results of the hydrocarbon spill trajectory modelling to assess the likely ecological consequences on the Ningaloo Coast and to evaluate the overall potential impact associated with each spill scenario (Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill]); this risk assessment included details of the modelling methods, assumptions, and limitations.

Comparison of modelled scenarios indicated that an extended (11-week) unmitigated (i.e. no intervention or response) subsea well blowout simulated from the Chandon Gas Field has the greatest potential to impact to the Ningaloo Coast. Modelling indicated that surface, entrained, and dissolved hydrocarbons have the potential to encroach on the Ningaloo Coast, and eventually make contact with the shoreline. Entrained hydrocarbons were predicted to reach the Ningaloo Coast at concentrations >500 ppb, with much lower concentrations of surface and dissolved hydrocarbons anticipated to reach the Ningaloo Coast. The annualised probability of a well blowout occurring at the Chandon Gas Field, and the hydrocarbons impacting the Ningaloo Coast is very low; the worst-case seasonal (summer) probability was calculated as 9.63×10^{6} (i.e. 1 in 104 000 chance per year).

Assessment of modelled pipeline rupture scenarios concluded that toxicity or physical oiling impacts to flora and/or fauna at the Ningaloo Coast would be extremely unlikely, or not expected given the low probability (1%) of surface or entrained hydrocarbons above threshold concentrations reaching the coast and the expected weathering of the hydrocarbons during their travel (12 to 13 days). Modelling predicted that a large diesel spill (80 m^3) from a marine vessel (e.g. due to a ruptured fuel tank) could result in entrained hydrocarbons reaching the Ningaloo Coast. However, there is a very low probability (less than 1% chance) that the 10 ppb threshold would be breached if this spill scenario occurred.

Table 13-4 provides additional information on oil spill characteristics and potential impacts to the key ecological sensitivities within the Ningaloo Coast in relation to the well blowout scenario, including the nature of the released hydrocarbons and the timing of their contact.

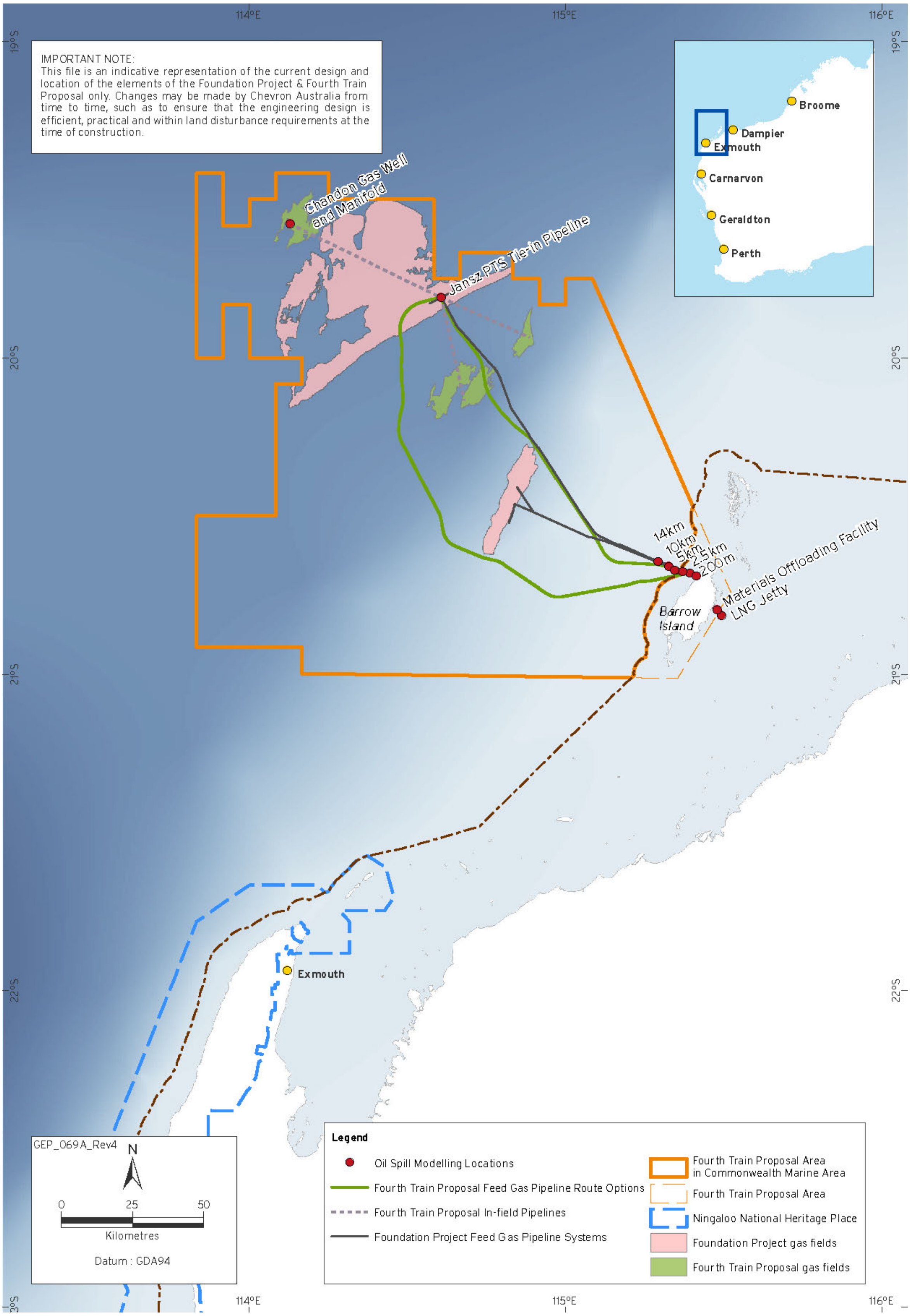

Figure 13-2: Oil Spill Modelling Location

Table 13-4: Potential Impacts to the Ningaloo Coast Following an 11-week Subsea Well Blowout in the Chandon Gas Field

Spill Component	Summary of Spill Characteristics	Potential Impacts within the Ningaloo Coast
Surface oil	If a well blowout were to occur, there was a low (3%) predicted probability that a hydrocarbon sheen (between 1 and 10 g/m^2) would reach inshore areas of the Ningaloo Coast during winter, following 29 days at sea. The mean expected maximum shoreline concentration was predicted to be 1 g/m^2 during this period. Surface slicks in the form of a sheen were not predicted to reach the coastline at any other time of year; however, maximum shoreline concentrations of surface hydrocarbons were predicted to reach the Muiron Islands towards the northern extent of the Ningaloo Coast during summer (60 g/m^2) as a result of gradual accumulation of residues following contact by trace (below threshold) films of condensate.	The very low volumes of hydrocarbons predicted to reach the Ningaloo Coast as a surface slick and the weathering that would have occurred over the 29 days of travel, suggest that the hydrocarbon residues remaining at the Ningaloo Coast would have very limited potential for acute toxicity or oiling effects on coastline habitats or surface-dwelling fauna. Potential impacts associated with inhalation on air-breathing fauna, such as marine mammals and marine turtles, are considered very unlikely. Natural and cultural heritage values within the terrestrial components of the Ningaloo Coast, for which the area was inscribed, including unique karst environments and cultural heritage sites, are located away from the immediate shoreline and beyond the potential reach of hydrocarbon residues, which may be transferred by spray associated with breaking surf or transported inland by infrequent storm surge events, abnormally high tides, and potential changes in sea level during the predicted life of the Fourth Train Proposal. In addition, the probability of surface slicks reaching the Ningaloo Coast at any time of the year is either very low or no contact.
Entrained oil	If a well blowout were to occur, the probability of entrained hydrocarbons between 10 ppb and 100 ppb reaching the Ningaloo Coast was predicted to be 50% in spring and 70% in autumn, following 10 days and 11 days at sea (respectively). The highest probability of entrained hydrocarbon concentrations exceeding 500 ppb reaching the Ningaloo Coast was 23% in spring. The maximum predicted entrained hydrocarbon concentration reaching the Ningaloo Coast was 2900 ppb in spring. Mean concentrations are predicted to be far lower, reaching a maximum 315 ppb in spring at the Ningaloo Coast (Muiron Islands).	Potential contamination of karst environments with marine incursions could occur where entrained and/or dissolved (aromatic) hydrocarbons are transported (i.e. through mixing of different water bodies) into karst environments at depth. Although the levels of dissolved (aromatic) hydrocarbons are not expected to reach concentrations that may result in acute toxic effects on fauna, predictions indicated that the levels of entrained hydrocarbons could reach levels at which toxic effects and physical smothering may occur. In the unlikely event of entrained condensate reaching the Ningaloo Coast, physical oiling of corals and other benthic habitat has the potential to occur. Worst-case maximum concentrations of between 400 and 2940 ppb are predicted for entrained hydrocarbons; however, mean maximum levels of entrained condensate were predicted to be considerably lower (50 to 315 ppb). The potential levels of entrained hydrocarbons may also cause toxic effects to nearshore and pelagic species of marine fauna, including smothering of EPBC Act-listed fauna, or of habitats that may play a functional role for those species: • Annual coral spawning and Whale Shark aggregations, which occur during autumn, would be vulnerable to entrained hydrocarbons reaching the Ningaloo Coast. The maximum potential concentration of entrained condensate predicted to reach the Ningaloo Coast was 560 ppb; this
Dissolved (aromatic)	In the unlikely event of a blowout occurring, the probability of dissolved aromatic hydrocarbons	

Spill Component	Summary of Spill Characteristics	Potential Impacts within the Ningaloo Coast
hydrocarbons	between 5 ppb and 50 ppb reaching the Ningaloo Coast is predicted to be 23% during spring and ≤6% for all other times of the year. The maximum concentration of dissolved aromatic hydrocarbons predicted to reach the Ningaloo Coast are low (30 ppb), with mean concentrations predicted to be ≤5 ppb for all seasons.	was predicted to occur during spring, outside the major coral spawning event at Ningaloo. Hydrocarbons that reach the Ningaloo Coast during spring will have undergone weathering over a minimum 11 days (prior to contact with the Ningaloo Coast), and it is possible the efficacy of the entrained condensate would be reduced during this time. • Exposure of marine turtles to worst-case concentrations of entrained condensate that may occur in spring or summer could induce injury or irritation in their soft tissues, and could foul nesting, internesting, and foraging habitat. However, marine turtles exhibit cyclical nesting patterns, and the Ningaloo Coast is just one of a number of locations providing nesting, internesting, and foraging habitat for marine turtles across the North-west Marine Region. Therefore, it is considered unlikely that a substantial reduction in survival for any marine turtle species at a species level would occur (Section 13.4.2.3.1). • Dugongs may also be vulnerable where areas of habitat, particularly seagrass, could be smothered and degraded. However, long-term effects to Dugongs are not expected as Dugongs are migratory and move to alternative feeding areas due to the ephemeral nature of their seagrass food source (Section 13.4.2.2.1).

The annualised probability of a spill or leak of hydrocarbons encroaching on the Ningaloo Coast is very low. In addition, modelling assumes that there would be no response to mitigate or manage the spill; therefore, modelling outcomes are considered to be conservative. The potential consequence of spills and leaks that could result from the Fourth Train Proposal activities are unlikely to result in any direct or indirect incremental or additional impact on the values of the Ningaloo Coast that would be considered unacceptable in the context of the values for which the Ningaloo Coast is protected. The potential impacts to the environmental values of the Ningaloo Coast were determined to be 'Low'.

13.2.3 Proposed Management

While National Heritage Places was not a controlling provision for the Foundation Project, the GJVs consider that the management framework being used by the Foundation Project, when extended to apply to the Fourth Train Proposal, provides adequate mechanisms to effectively prevent and manage the potential impacts of the Fourth Train Proposal on the Ningaloo Coast. This includes relevant Commonwealth and State Ministerial Conditions, relevant EMPs, and Subsidiary Documents (Section 16.2).

It is anticipated that new EMPs will be developed, as required under EPBC Ministerial Conditions (Conditions 16, 16A, and 16B of EPBC Reference: 2003/1294, and Conditions 1 and 2 of EPBC Reference: 2005/2184) for the drilling and completion of Fourth Train Proposal production wells and for activities associated with the installation of the Fourth Train Proposal Offshore Feed Gas Pipeline System[16], or equivalent Environment Plan. The GJVs anticipate that the mitigation and management measures included in the existing Foundation Project EMPs and Subsidiary Documents for offshore drilling and completion and pipeline installation will also apply to, and will prevent and manage any potential impact to marine fauna as a result of, the Fourth Train Proposal.

Where relevant, the GJVs propose to make minor changes to a number of Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal. These changes are described in Section 16.2.3.3. The existing EMPs that are relevant to addressing potential impacts to the Ningaloo Coast for the Fourth Train Proposal include:

- Best Practice Pollution Control Design
- Air Quality Management Plan
- Decommissioning and Closure Plan.

Section 5.7.3 describes the proposed measures to manage and mitigate the occurrence and impact of potential spills and leaks. These measures include a range of engineering controls and systems aimed at preventing a spill or leak occurring, and the implementation of response measures in the unlikely event of a spill or leak. The measures are considered to be sufficient to manage the potential risks of spills and leaks occurring, and also the potential impacts that may arise under the remote circumstances that a hydrocarbon spill encroaches upon the Ningaloo Coast.

13.2.4 Predicted Environmental Outcome

The Ningaloo Coast is a unique area noted in its National Heritage listing for its diversity of marine species, its unique geomorphic features, and its contribution to understanding Australia's natural and cultural history.

The Fourth Train Proposal was assessed for its potential to impact these National Heritage values as a result of its operational atmospheric emissions and in the event of a major hydrocarbon spill or leak. However, when the same management framework for the

[16] Given the establishment of the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) on 1 January 2012, it is acknowledged that these conditions may be changed for the Fourth Train Proposal and the requirement with respect to petroleum activities covered under a Subsidiary Document requiring NOPSEMA approval.

approved Foundation Project was applied to the Fourth Train Proposal, the assessment of potential impacts concluded that:

- No incremental, additional or cumulative impacts on the flora, fauna, and landforms, or the marine ecosystem of the Ningaloo Coast are predicted to occur as a result of the Fourth Train Proposal.
- The Ningaloo Coast may be exposed to hydrocarbons in the event of a subsea well blowout in the Chandon Gas Field. Widespread impacts to the area's environmental values are considered unlikely. The predicted travel time for the hydrocarbons to reach the Ningaloo Coast (worst-case of ten days) will also allow for response measures to be implemented to limit any shoreline contact.

Low impact ratings were assessed for both spills and leaks and atmospheric emissions from the Fourth Train Proposal; these stressors are not expected to act synergistically to result in additive impacts to the Ningaloo Coast that may be greater than those assessed for the individual stressors.

When considered on its own, or in conjunction with the approved Foundation Project and other considered actions (Section 15.3), the Fourth Train Proposal is not expected to result in any unacceptable adverse effects to the National Heritage values of the Ningaloo Coast in the context of the relevant objects and principles of the EPBC Act, or relevant management or policy documents (Table 13-3). Therefore, the environmental objective established for this assessment (Section 13.2.1) is predicted to be met and the potential impacts of the Fourth Train Proposal in respect of this controlling provision are evaluated to be acceptable.

13.3 Listed Threatened and Migratory Species and Communities – Terrestrial Environment

13.3.1 Assessment Framework

13.3.1.1 Environmental Objective

The objective established in this PER/Draft EIS for EPBC Act-listed threatened and migratory species is:

> *To maintain the abundance, diversity, geographic distribution and productivity of EPBC Act-listed threatened and/or migratory species at species and ecosystems levels through the avoidance or management of adverse impacts and improvement in knowledge.*

13.3.1.2 Relevant Policy, Plan, and Guideline Documents

Table 13-5 lists policy, plans, and guideline documents relating to the assessment of impacts on listed terrestrial species of relevance to the Fourth Train Proposal.

Table 13-5: Policies, Plans, and Guidelines Relevant to Impacts on Listed Terrestrial Species

Policy, Plan, Guideline	Intent
Australia's Biodiversity Conservation Strategy 2010–2020 – consultation draft (National Biodiversity Strategy Review Task Group 2009)	Sets a national direction for biodiversity conservation over the next decade, including a vision that 'Australia's biodiversity is healthy, resilient to climate change, and valued for its essential contribution to our existence'.

Policy, Plan, Guideline	Intent
Terrestrial Avifauna and their Habitats	
The Action Plan for Australian Birds 2000, including the supplement Recovery Outline for the White-winged Fairy-wren (Barrow Island) (Environment Australia 2000)	The Recovery Outline for the White-winged Fairy-wren (Barrow Island) specifies as its key objective to 'maintain [the] population'.
Commonwealth Conservation Advice on *Malurus leucopterus edouardi* (White-winged Fairy-wren [Barrow Island]) (Threatened Species Scientific Committee 2008)	Provides advice as to the priority actions for recovery and conservation of this species in the wild. The overall objective is to aid the recovery of the species population and threat abatement.
Terrestrial Mammals and their Habitats	
Action Plan for Australian Marsupials and Monotremes (Wildlife Australia 1996)	Provides taxon summaries and recovery outlines for Australian marsupials and monotremes, and determines priorities for the conservation research and management needed to prevent further extinctions of Australia's unique species.
Western Barred Bandicoot *Perameles bougainville*, Burrowing Bettong *Bettongia lesueur*, and Banded Hare-Wallaby *Lagostrophus fasciatus* National Recovery Plan (Richards 2012)	The long-term objective of this Recovery Plan is to 'undertake conservation actions which: • ensure the survival and maintain or improve the status of the Western Barred Bandicoot and Shark Bay Islands subspecies of the Burrowing Bettong and Banded Hare-wallaby and Barrow Island subspecies of the Burrowing Bettong based on the IUCN criteria 2001 extent of occurrence.' Note that the Western Barred Bandicoot does not occur on Barrow Island and is not relevant to the Fourth Train Proposal.
Recovery Plan for the Golden Bandicoot *Isoodon auratus* and Golden-backed Tree-rat *Mesembriomys macrurus* 2004–2009 (Palmer *et. al.* 2003)	The overall objectives of this Recovery Plan include: • to 'maintain or improve the conservation status of the Golden Bandicoot (Barrow Island) *Isoodon auratus barrowensis*'.
Commonwealth Conservation Advice on *Lagorchestes conspicillatus conspicillatus* (Spectacled Hare-wallaby [Barrow Island]) (Threatened Species Scientific Committee 2008a)	Provides advice as to the priority actions for recovery and conservation of this species in the wild. The overall objective is to aid the recovery of the species population and threat abatement.
Commonwealth Conservation Advice on *Macropus robustus isabellinus* (Barrow Island Euro) (Threatened Species Scientific Committee 2008b)	Provides advice as to the priority actions for recovery and conservation of this species in the wild. The overall objective is to aid the recovery of the species population and threat abatement.
Subterranean Fauna and their Habitats	
The Action Plan for Australian freshwater fishes, including the supplement Recovery Outline for the Blind Cave Eel (*Synbranchidae Ophisternon candidum)* (Environment Australia 1993)	This Action Plan provides taxon summaries and recovery outlines for Australian freshwater fishes, and determines priorities for the conservation research and management required for the conservation of Australia's unique species.
Commonwealth Conservation Advice on *Milyeringa veritas* (Blind Gudgeon) (Threatened Species Scientific Committee 2008c)	This document provides advice as to the priority actions for recovery and conservation of this species in the wild. The overall objective is to aid the recovery of the species population and threat abatement.

Policy, Plan, Guideline	Intent
Commonwealth Conservation Advice on *Ophisternon candidum* (Blind Cave Eel) (Threatened Species Scientific Committee 2008d)	This document provides advice as to the priority actions for recovery and conservation of this species in the wild. The overall objective is to aid the recovery of the species population and threat abatement.

13.3.1.3 Identification of Species and their Habitats

Barrow Island is an important refuge for many rare and threatened species, some of which are not found elsewhere. The species included for assessment within this Section are those detailed within the Tailored Guidelines, or those EPBC Act-listed species or their habitats identified as being potentially exposed to Fourth Train Proposal activities. The identification process and the full list of species that were considered are presented in Appendix E2 [Conservation-significant Species Considered for Assessment in this PER/Draft EIS].

The EPBC Act-listed threatened terrestrial fauna assessed include five mammal species, one bird species, and two subterranean fauna species, which are all listed as Vulnerable under the EPBC Act (Table 13-6). Further environmental baseline information on these species can be found in Section 6.5.3.

Table 13-6: EPBC Act-listed Threatened Species on Barrow Island Potentially Affected by the Fourth Train Proposal

Species Grouping	Common Name	Scientific Name	Protected Status	Occurrence in the Vicinity of the Fourth Train Proposal
Land Birds	White-winged Fairy-wren (Barrow Island)	*Malurus leucopterus*	Vulnerable	Likely
Mammals	Boodie	*Bettongia lesueur*	Vulnerable	Likely
	Golden Bandicoot	*Isoodon auratus barrowensis*	Vulnerable	Likely
	Spectacled Hare-wallaby	*Lagorchestes conspicillatus conspicillatus*	Vulnerable	Likely
	Barrow Island Euro	*Macropus robustus isabellinus*	Vulnerable	Likely
	Black-flanked Rock-wallaby[1]	*Petrogale lateralis lateralis*	Vulnerable	Unlikely
Subterranean Fauna	Blind Gudgeon	*Milyeringa veritas*	Vulnerable	Likely
	Blind eel[2]	*Ophisternon* sp.	Vulnerable	Possible

1 *The Black-Flanked Rock-wallaby is not considered to be impacted by the Fourth Train Proposal but has been assessed as required by the Tailored Guidelines.*

2 *The record of the blind eel (Ophisternon sp.) from Barrow Island was not identified to species level. Given the wide range of the Blind Cave Eel (Ophisternon candidum) in stygal ecosystems in the Pilbara, the blind eel is taken to be the Ophisternon candidum for assessment purposes and is assigned the relevant conservation status.*

Barrow Island does not host any ecological communities listed under the EPBC Act. However, habitats identified as important for EPBC Act-listed terrestrial species on Barrow Island are (Chevron Australia 2008):

- warrens that are habitat for Boodies (*Bettongia lesueur*)
- termite mounds that support high species-richness

- nests of raptors (birds of prey), which are not represented on Barrow Island in high numbers, and which provide habitat for fauna of high conservation significance
- freshwater aquifers (for subterranean fauna).

Further information on the characteristics and presence of these habitats on Barrow Island is presented in Section 6.5.2.

13.3.2 Assessment and Mitigation of Potential Impacts

A number of potential stressors related to the Fourth Train Proposal activities occurring on Barrow Island were identified as having the potential to impact upon EPBC Act-listed threatened and/or migratory terrestrial species or their habitat (Table 13-7). Physical interaction and noise and vibration were assessed as 'Medium' in terms of potential impact rating to terrestrial fauna. Clearing and earthworks, spills and leaks, and physical presence were also assessed as 'Medium' to subterranean fauna. All other stressors identified were considered to have either 'Low' or 'Trivial' potential impacts on one or more EPBC Act-listed species or their habitats.

The potential impact ratings are representative of the potential impacts to the most sensitive species or habitat to each stressor. Therefore, these potential impact ratings do not apply equally to all EPBC Act-listed terrestrial species. For example, the 'Medium' impact rating for noise reflects the potential impacts of noise emissions on the White-winged Fairy-wren (Barrow Island), which is identified as the most sensitive of the EPBC Act-listed species to noise. The potential impact ratings are detailed in Table 13-7.

The impact assessment for EPBC Act-listed threatened and/or migratory terrestrial species or their habitat is detailed in the sections below, along with a description of the management framework for potential impacts due to the Fourth Train Proposal. Additional detail used to inform the assessment outcomes, as well as specific illustrative mitigation and management measures is provided in Section 9, and cross-references to further information are provided where appropriate.

Table 13-7: Stressors to Listed Terrestrial Species from the Implementation of the Fourth Train Proposal

EPBC Act-Listed Fauna	Stressor	Illustrative Mitigation and Management	Potential Impact Rating	
			Incremental	Additional
Land Birds • White-winged Fairy-wren (Barrow Island)	Clearing and earthworks	Table 9-4	Low	Low
	Noise and vibration	Section 5.4.4	Medium	Medium
Mammals[1] • Boodie • Golden Bandicoot • Spectacled Hare-wallaby • Barrow Island Euro	Clearing and earthworks	Table 9-4	Low	Low
	Fire	Table 9-11	Low	Low
	Physical interaction	Table 9-15	Medium	Medium
Habitats • Boodie warrens • Termite mounds • Raptor nests	Clearing and earthworks	Table 9-4	Low	Low

EPBC Act-Listed Fauna	Stressor	Illustrative Mitigation and Management	Potential Impact Rating	
			Incremental	Additional
Subterranean vertebrates • Blind Gudgeon • Blind eel[2] **Habitats** • Freshwater aquifer	Spills and leaks	Table 9-5	Medium	Medium
	Unplanned carbon dioxide migration	Section 11.3.3	Trivial	Trivial

1 *The Black-Flanked Rock-wallaby is not considered to be affected by stressors relating to the Fourth Train Proposal, but has been assessed as required by the Tailored Guidelines.*

2 *The record of the blind eel (Ophisternon sp.) from Barrow Island was not identified to species level. Given the wide range of the Blind Cave Eel (*Ophisternon candidum*) in stygal ecosystems in the Pilbara, the blind eel is taken to be Ophisternon candidum for assessment purposes and is assigned the relevant conservation status.*

13.3.2.1 Avifauna

13.3.2.1.1 White-winged Fairy-wren (Barrow Island)

The White-winged Fairy-wren (Barrow Island) is abundant in most habitats on Barrow Island, especially those with complex vegetation structure. Studies have suggested that White-winged Fairy-wrens (Barrow Island) are generalists on Barrow Island, e.g. they are not restricted to a particular vegetation association (Chevron Australia 2012; Bamford and Moro 2011). The stressors identified from the Fourth Train Proposal (Table 13-7) that are considered relevant to the White-winged Fairy-wren (Barrow Island) include vegetation clearing and earthworks, and operational noise.

During construction, clearing for the Fourth Train Proposal horizontal directional drilling site will lead to the loss of a limited area (up to approximately 10 ha) that may be used by the White-winged Fairy-wren (Barrow Island). The Fourth Train Proposal will also result in a delay to Foundation Project reinstatement activities, and may require re-clearing of Foundation Project land that has been reinstated, which will prevent these areas from being used as habitat by the White-winged Fairy-wren (Barrow Island) until they are finally rehabilitated.

The White-winged Fairy-wren (Barrow Island) is known to forage and nest widely over a range of habitats on Barrow Island (Chevron Australia 2012; Bamford and Moro 2011). The Fourth Train Proposal horizontal directional drilling site does not contain *Melaleuca cardiophylla*—identified as a species that may be favoured, but not relied upon, by the White-winged Fairy-wren (Barrow Island) (Bamford and Moro 2011). Therefore, areas subject to vegetation clearing represent a very small part of the habitat used by the White-winged Fairy-wren (Barrow Island) on Barrow Island, and individuals that may use this area are also expected to use neighbouring habitat (Sections 9.6.2.1 and 9.6.2.8.3).

The White-winged Fairy-wren (Barrow Island) is a passerine bird (songbird), which is thought to be the most noise-sensitive animal type on Barrow Island. Noise can potentially interfere with the communications of passerine birds, which rely on calling to establish and maintain territories and to attract mates. During operations, noise from the Gas Treatment Plant has the potential to mask White-winged Fairy-wren (Barrow Island) communication within the 60 dB(A) contour (Sections 9.6.2.6and 9.6.2.8.3). The predicted 60 dB(A) contour for the Fourth Train Proposal additional to the Foundation Project ranges from approximately 0 m to 800 m from the boundary of the Gas Treatment Plant site. This represents no increase to the area of potential impacts assessed and approved for the Foundation Project.

The assessment concluded that the potential impacts, including additive impacts, will be localised, and are not expected to result in adverse effects to the White-winged Fairy-wren (Barrow Island) population.

13.3.2.1.2 Raptor Nests

Ospreys and White-bellied Sea-eagles occur and nest in a variety of locations around Barrow Island. No nests are currently present in areas to be cleared as part of the Fourth Train Proposal Footprint, or were cleared as part of the Foundation Project (Chevron Australia 2008). Therefore, potential impacts to raptor nests are not predicted.

13.3.2.2 Mammals

13.3.2.2.1 Black-flanked Rock-wallaby, Boodie, Golden Bandicoot, Spectacled Hare-wallaby, and Barrow Island Euro

The Black-flanked Rock-wallaby (*Petrogale lateralis lateralis*) is restricted to the deeply incised valleys on the west coast of Barrow Island, away from the vicinity of the Fourth Train Proposal and the Foundation Project. Due to the spatial separation between the Fourth Train Proposal and Black-flanked Rock-wallaby habitat, potential impacts to the Black-flanked Rock-wallaby are not predicted. Therefore, the Black-flanked Rock-wallaby is excluded from further assessment.

The Boodie, Golden Bandicoot (*Isoodon auratus barrowensis*), Spectacled Hare-wallaby (*Lagorchestes conspicillatus conspicillatus*), and Barrow Island Euro (*Macropus robustus isabellinus*) species are dispersed widely across most of Barrow Island (Chevron Australia 2014) and are not restricted to the Fourth Train Proposal Footprint or its vicinity. Given the similarities in distribution and threats identified for these mammal species, the following assessment considers these species together. The stressors identified from the Fourth Train Proposal (Table 13-7) that are considered relevant to the Boodie, Golden Bandicoot, Spectacled Hare-wallaby, and Barrow Island Euro include physical interaction, vegetation clearing, and unplanned fire.

Physical Interaction

Individuals of these EPBC Act-listed mammal species have the potential to be impacted by physical interaction, including during clearing activities, through entrapment and by vehicles. The potential for physical interaction is highest from vehicles travelling at night, when mammals are most active on Barrow Island. Physical interactions are also more likely to occur on roads that are subject to frequent vehicle movements, such as from Butler Park (Construction Village) to the Gas Treatment Plant site. Peak vehicle numbers are not predicted to rise from those for the Foundation Project. The area within which vehicles will operate will remain largely the same as those for the Foundation Project; therefore, physical interactions will not extend to fauna with home ranges outside this area. Construction machinery is expected to have less potential to impact fauna than vehicles travelling on roads, as these mammals will be able to relocate and therefore avoid direct impacts. Other activities, e.g. grading and trenching, are expected to pose less risk as most fauna will have left the area following clearing. Individuals of these mammal species are also at risk of entrapment in open excavations during construction; these excavations are necessary for the installation of the Feed Gas Pipeline System, drainage, sumps etc. Excavations will mostly take place at the Fourth Train Proposal horizontal directional drilling site, Fourth Train Proposal Feed Gas Pipeline System (within the Foundation Project Feed Gas Pipeline Systems Footprint), and within 50 ha at the Gas Treatment Plant site. During the operations phase, the potential for impacts from physical interaction is decreased—fewer vehicles will be travelling on the roads, clearing activities will not be taking place, and fewer excavations, e.g. the Feed Gas Pipeline System trench, will be open.

Vegetation Clearing and Unplanned Fire

Removal of habitat, including termite mounds, either by vegetation clearing (Section 9.6.2.1) or as the result of an unplanned fire occurring outside the Combined Gorgon Gas Development Footprint, has the potential to impact mammal species in adjacent areas as a result of increased competition or predation from animals entering the area due to loss of habitat.

Clearing of vegetation will occur over up to 10 ha at the Fourth Train Proposal horizontal directional drilling site, and may occur over up to 25 ha of reinstated Foundation Project land. Displacement of fauna may lead to the local loss of individuals through competition, which may include individuals of conservation-significant species. However, clearing is expected to affect only a small number of terrestrial animals because of the small size of the area to be cleared, which is approximately 0.1% of Barrow Island.

Areas no longer required for future construction or operation, including at the horizontal directional drilling sites and Foundation Project Feed Gas Pipeline Systems Footprint, will be rehabilitated, thus making these areas available for terrestrial fauna to use as habitat. Examples of areas that will not be reinstated include maintenance areas and access routes.

Potential unplanned fire is expected to be small and restricted to the vicinity of the Combined Gorgon Gas Development Footprint due to the mitigation and management measures in place (Section 9.6.2.4). The removal of habitat as a result of fire is expected to affect a small number of these mammal species, which will relocate to adjacent areas of suitable habitat. Areas potentially impacted by fire will be available for grazing or foraging when the vegetation recovers.

Potential impacts to mammals as a result of vegetation clearing or unplanned fire are predicted to be largely short term (small areas may not be rehabilitated e.g. to facilitate maintenance or inspection) and localised. The mobile nature and large home ranges of these mammals (Section 6.5.3.2), and the suitability of neighbouring habitats for grazing, foraging, and refuge are expected to limit any potential impacts resulting from vegetation clearing or unplanned fire to a small number of individuals .

Summary

Potential impacts to individuals are predicted to be at a higher rate during construction when more vehicle journeys are made and more machinery is used, than the operations phase. Monitoring to date of the mammal populations in both ‘At Risk’ and ‘Reference’ zones indicates the construction of the Foundation Project to date is not affecting the population viability of the target species (i.e. Barrow Island Euro, Spectacled Hare-wallaby, Golden Bandicoot, and Boodie [Section 9.6.2.8.1]). The Fourth Train Proposal additional to the approved Foundation Project will increase the duration of the construction period, with a small increase to the cleared area on Barrow Island. Therefore, potential impacts, including additive impacts, to the target mammal species as a result of the Fourth Train Proposal are predicted to affect individuals, without affecting population viability.

13.3.2.2.2 Mammal Habitats

Habitats identified as important for EPBC Act-listed mammal species on Barrow Island are (Chevron Australia 2008):

- warrens that are habitat for Boodies
- termite mounds that support high species-richness.

No Boodie warrens are currently present in areas to be cleared as part of the Fourth Train Proposal. The Fourth Train Proposal horizontal directional drilling site has been located south of the Foundation Project horizontal directional drilling site, away from the Boodie warren to the north. The Foundation Project impacted one active Boodie warren through vegetation clearing and earthworks activities during construction of the Gas Treatment Plant site (Chevron Australia 2008).

Termite mounds are found in large numbers across Barrow Island, averaging approximately 1.8 mounds per hectare; the distribution of approximately 10 000 termite mounds has been mapped over an area of approximately 5770 ha (Figure 6-11). Approximately 70 termite mounds are anticipated to be removed as part of the Fourth Train Proposal. The Fourth Train Proposal additional to the approved Foundation Project will increase the number of termite mounds cleared to approximately 710. Termite mounds provide shelter for species including the Golden Bandicoot. However, due to the large number of termite mounds remaining unaffected by the Combined Gorgon Gas Development, a reduction in the overall carrying capacity for fauna on Barrow Island is not predicted.

13.3.2.3 Listed Subterranean Fauna

13.3.2.3.1 Blind Gudgeon, Blind Eel, and Subterranean Fauna Habitat

The Blind Gudgeon (*Milyeringa veritas*) is assumed to be widespread on Barrow Island due to the extensive unconfined freshwater aquifer that provides habitat. Sampling to date has not located the Blind Gudgeon in the vicinity of the Gas Treatment Plant site, although one individual was collected from a sampling bore on the Administration and Operations Complex site close to the Additional Support Area and eight individuals were collected from a borehole in the centre of Barrow Island, located approximately 64 km west of from Butler Park (Construction Village). There is one unconfirmed report of the blind eel on Barrow Island, with a single individual recovered from a seismic drill hole on approximately 2 km east of the Fourth Train Proposal horizontal directional drilling site. This species occurs sympatrically with the Blind Gudgeon at Cape Range (on the mainland) and may similarly be widely distributed at Barrow Island.

The blind eel (*Ophisternon* sp.) has not been identified to species level but is treated as the Blind Cave Eel (*Ophisternon candidum*) for assessment purposes. *Ophisternon candidum* is listed as Vulnerable under the EPBC Act and as a Schedule 1 species under the Wildlife Conservation Act. The following assessment considers the Blind Gudgeon and the blind eel together.

The stressors identified from the Fourth Train Proposal (Table 13-7) that are considered relevant to subterranean fauna have the potential to impact these species directly (spills and leaks) or indirectly (e.g. through vegetation clearing and earthworks).

Spills and Leaks

There is potential for hazardous materials (e.g. hydrocarbons or contaminated wastewater) to impact subterranean fauna habitats, including groundwater, from accidental spills or leaks. In the event of an uncontained spill, contaminants would have only a small impact area within troglofauna habitat, as liquids will pass through the soil profile and enter the watertable before spreading (Chevron Australia 2012). The Fourth Train Proposal additional to the approved Foundation Project will result in increased quantities of hazardous materials that have the potential to result in spills or leaks. However, no different sources will be introduced. Although spills and leaks could occur during construction and operation of the Fourth Train Proposal, these are expected to be contained through design controls (e.g. bunding) and/or timely spill response and clean-up actions. The Foundation Project has reported one detection of levels of analytes above reporting limits (Section 3.5.1.6). However, based on the groundwater monitoring results to date, Foundation Project construction activities have not adversely impacted groundwater as a habitat for stygofauna (Section 3.5.1.6).

The Fourth Train Proposal additional to the approved Foundation Project may result in potential impacts within the Combined Gorgon Gas Development Footprint or its immediate vicinity without compromising the population viability of subterranean fauna species identified on Barrow Island.

Unplanned Carbon Dioxide Migration

Carbon dioxide (CO_2) has the potential to impact stygofauna by acidifying the groundwater, or by reducing the concentration of oxygen available for troglofauna.

The Fourth Train Proposal will dispose of reservoir CO_2 via injection using Foundation Project infrastructure (Section 11.3.3). No additional CO_2 injection wells or CO_2 pipeline will be required for the Fourth Train Proposal.

The development of the Fourth Train Proposal is predicted to increase the maximum annual average rate of available reservoir CO_2 by approximately 2% above the approved Foundation Project rate as documented in the PER for the approved Foundation Project (Chevron Australia 2008), and can be accommodated within the scope of the currently approved Foundation Project's Carbon Dioxide Injection System as authorised under Section 13 of the *Barrow Island Act 2003* (WA) (Section 11.3.3.3). The Fourth Train Proposal is not expected to introduce any different subsurface, volumetric, and rate uncertainties associated with CO_2 injection, compared to those assessed and approved for the Foundation Project (Section 11.3.3.2).

Foundation Project design includes the selection of the Dupuy Formation for the injection of reservoir CO_2; the Dupuy Formation has multiple baffles and barriers to contain the injected CO_2 and prevent CO_2 migration or slow its rate In addition, the Foundation Project has committed to ensuring that decommissioned wells completed in the Dupuy Formation will be worked over to ensure suitability for CO_2 service. Given the current measures to mitigate risks associated with unplanned CO_2 migration, it is considered highly unlikely that such a situation would eventuate over the life of the Combined Gorgon Gas Development.

Potential impacts are predicted to be restricted to subterranean fauna habitat in the vicinity of the Fourth Train Proposal and Foundation Project. As listed subterranean species are expected to be well represented outside this area, no impacts to population viability are anticipated.

13.3.3 Proposed Management

The assessment of potential impacts of the Fourth Train Proposal on EPBC Act-listed terrestrial threatened species, their communities, and habitat has not identified any different impacts compared to those assessed and approved for the Foundation Project. The Fourth Train Proposal is not expected to change the level of impact assessed and approved for the Foundation Project. Therefore, the GJVs intend to manage potential impacts associated with the implementation of the Fourth Train Proposal in a manner consistent with the environmental management framework established and currently being implemented for the Foundation Project (Section 16.2). This framework provides the basis to manage impacts on all terrestrial and subterranean fauna through a series of EMPs; relevant EMPs include:

- Terrestrial and Subterranean Environment Protection Plan and associated Procedures
- Terrestrial and Subterranean Environment Monitoring Program
- Short Range Endemics and Subterranean Fauna Monitoring Plan
- Fire Management Plan
- Horizontal Directional Drilling Management and Monitoring Plan
- Air Quality Management Plan
- Long-term Marine Turtle Monitoring Plan (for the management of light spill)
- Solid and Liquid Waste Management Plan
- Post-Construction Rehabilitation Plan and associated sub-Plan
- Carbon Dioxide System Monitoring Program
- Terrestrial and Marine Quarantine Management System
- Project Site Rehabilitation Plan
- Decommissioning and Closure Plan.

The GJVs propose to make minor changes to these existing Foundation Project EMPs to ensure that they also apply to the specific construction and operations activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal horizontal directional drilling activities, locations, and potential impacts will need to be prepared and approved (Section 16.2.3.3). However, the GJVs anticipate that the mitigation and management measures included in the existing Foundation Project Horizontal Directional Drilling Management and Monitoring Plan will also apply to, and will prevent and manage any potential impact to, listed terrestrial species as a result of the Fourth Train Proposal.

13.3.4 Predicted Environmental Outcome

No EPBC Act-listed threatened and/or migratory terrestrial species, or their habitats, are limited to areas potentially impacted by the Fourth Train Proposal on Barrow Island. No threatened ecological communities were identified within the Fourth Train Proposal Area.

Potential incremental impacts during construction and operations are predicted to be localised. No different impacts were identified.

The Fourth Train Proposal will extend the duration of construction activities on Barrow Island, during which time potential additional impacts to listed terrestrial species may occur. The Fourth Train Proposal will also increase the area over which potential impacts may occur during construction. During operations, potential additional impacts are expected to be largely similar to those of the Foundation Project alone and are expected to be localised.

This assessment of the Fourth Train Proposal has not identified any unacceptable direct, indirect, facilitated, unknown, unpredictable, or irreversible impacts on any listed terrestrial species, or on the availability of suitable habitat for a species.

With the proposed management framework in place, the Fourth Train Proposal is not anticipated to affect the abundance, diversity, or geographic distribution of terrestrial and subterranean fauna. The Fourth Train Proposal, together with the Foundation Project and other considered actions, is also not anticipated to result in any substantial cumulative impacts to EPBC Act-listed terrestrial species and their habitat (Section 15.5.1.2).

The mitigation and management measures that the GJVs intend to adopt for the Fourth Train Proposal reflect a conservative approach. Monitoring programs, which include a number of EPBC Act-listed species, are adaptive in nature, and will allow for the identification and management of potential impacts as the Fourth Train Proposal is implemented. Monitoring programs will be updated to reflect the Fourth Train Proposal, as necessary.

With the implementation of the proposed management measures (Section 13.3.3), the GJVs consider that the potential impacts identified for listed terrestrial species or their habitat will be adequately managed such that the impacts are environmentally acceptable and the environmental objective for this controlling provision (Section 13.2.1.1) is met. Implementation of the Fourth Train Proposal in conjunction with the Foundation Project is also not predicted to conflict with, or be inconsistent with, the objects and principles of the EPBC Act, or the objectives, strategies, and plans listed for the protection and recovery of relevant EPBC Act-listed threatened terrestrial species and their communities.

13.4 Listed Threatened and Migratory Species and Communities – Marine Species, and Their Habitats

13.4.1 Assessment Framework

13.4.1.1 Environmental Objective

The objective established in this PER/Draft EIS for the assessment of potential impacts on EPBC Act-listed threatened and migratory species and their communities is:

To maintain the abundance, diversity, geographic distribution, and productivity of EPBC Act-listed threatened or migratory species at species and ecosystems levels through the avoidance or management of adverse impacts and improvement in knowledge.

13.4.1.2 Relevant Policy, Plan, and Guideline Documents

Commonwealth, State, and local policy and framework documents relating to EPBC Act-listed marine threatened and/or migratory species and their communities with the potential to be impacted by the Fourth Train Proposal are listed in Table 13-8. Distribution patterns for marine fauna are not delineated by the 3 nm jurisdictional coastal water boundary; therefore, relevant Commonwealth and State documents have been listed.

Table 13-8: Policies, Plans, and Guidelines Relevant to EPBC Act-Listed Marine Species Potentially Impacted by the Fourth Train Proposal

Policy, Plan, Guideline	Intent
Marine Fauna and their habitats	
Australia's Biodiversity Conservation Strategy 2010–2020 – consultation draft (National Biodiversity Strategy Review Task Group 2009)	Sets a national direction for biodiversity conservation over the next decade, including a vision that 'Australia's biodiversity is healthy, resilient to climate change, and valued for its essential contribution to our existence'.
Marine Bioregional Plan for the North-west Marine Region (SEWPaC 2012) and associated Conservation Value Report Cards	Sets out broad objectives for the region's biodiversity, identifies regional priorities, and outlines strategies and actions to achieve these. As part of the overall Plan, Conservation Value Report Cards present environmental baseline information and conservation values for the Commonwealth Marine Environment and EPBC Act-listed threatened and migratory species.
Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007–2017 (DEC 2007)	Directs management of the three reserves (Montebello Marine Park, Barrow Island Marine Park, and Barrow Island Marine Management Area) with the intent to conserve the marine environment and support commercial and recreational activities that are compatible with the maintenance of environmental quality.
Fish and their habitats	
Whale Shark Recovery Plan 2005–2010 (DEH 2005)	The objective of this Recovery Plan is to 'maintain existing levels of protection for the Whale Shark in Australia while working to increase the level of protection within the Indian Ocean and Southeast Asian region to enable population growth, so that the species can be removed from the threatened species list of the EPBC Act.'
Memorandum of Understanding (MoU) on the Conservation of Migratory Sharks (Convention on Migratory Species [CMS] 2007)	Australia is a signatory to this MoU, which aims to achieve and maintain a favourable conservation status for seven shark species, including ensuring healthy and viable populations of these species remain in their existing habitats.
Approved Conservation Advice for *Pristis clavata* (Dwarf Sawfish) (Department of Environment, Water, Heritage and Arts [DEWHA] 2009)	Provides advice as to the priority actions for recovery and conservation of this species in the wild. The overall objective is to aid the recovery of the species and abatement of threats (e.g. habitat degradation).

Policy, Plan, Guideline	Intent
Approved Conservation Advice for *Pristis zijsron* (Green Sawfish) (DEWHA 2008)	Provides advice as to the priority actions for recovery and conservation of this species in the wild. The overall objective is to aid the recovery of the species and abatement of threats (e.g. habitat degradation).
Marine mammals and their habitats	
The Action Plan for Australian Cetaceans (Environment Australia 1996)	The plan aims to provide more information on taxonomy, distribution, habitat preference, and diet in Australian waters for cetaceans as well as identify threatening processes and priority actions.
The Blue, Fin, and Sei Whale Recovery Plan 2005–2010 (DEH 2005a)	The objectives of this plan are to: • recover populations of Blue, Fin, and Sei Whales using Australian waters so that the species can be considered secure in the wild • maintain the protection of Blue, Fin, and Sei Whales from human threats.
MoU on the Conservation and Management of Dugongs (*Dugong dugon*) and their Habitats throughout their Range (CMS 2007)	Australia is a signatory to this MoU, which aims to facilitate national and transboundary actions that will lead to the conservation of Dugong populations and their habitats.
Humpback Whale Recovery Plan 2005–2010 (DEH 2005b)	The objectives of this plan are to: • recover Humpback Whale populations using Australian waters so that the species is secure in the wild • ensure the distribution is similar to the pre-exploitation distribution • maintain protection of the species from human threats.
Marine reptiles and their habitats	
Recovery Plan for Marine Turtles in Australia (Environment Australia 2003)	Aims to reduce detrimental impacts on Australian populations of marine turtles and hence promote their recovery in the wild.
Approved Conservation Advice for *Aipysurus apraefrontalis* (Short-nosed Sea Snake) (DEWHA 2010)	Provides advice as to the priority actions for recovery and conservation of this species in the wild. The overall objective is to aid the recovery of the species and abatement of threats (e.g. habitat degradation).

13.4.1.3 Identification of Species and their Habitats

The Fourth Train Proposal Area falls within the North-west Marine Region. The North-west Marine Region extends from the Western Australian–Northern Territory border to Kalbarri, south of Shark Bay in Western Australia; it covers an area of approximately 1.07 million km^2 of tropical and subtropical waters, including extensive areas of shallower waters on the continental shelf (beyond the 3 nm State Waters boundary), as well as deep areas of abyssal plain where water depths are 5000 m or more, up to 200 nm from shore (SEWPaC 2012). The North-west Marine Region is considered species-rich, but also as having low numbers of species that are endemic to the region (DEWHA 2008a). Resident, migratory, and transient marine species occur in the Fourth Train Proposal Area and include mammals, fish, reptiles, and avifauna. The Montebello/ Barrow/ Lowendal Islands Group is also an important nesting site for certain species of marine turtle and is a breeding and non-breeding site for migratory shorebirds.

Seventy-seven EPBC Act-listed threatened and/or migratory marine fauna were identified as potentially being present in the Fourth Train Proposal Area. Of these, 41 species were identified as likely to occur in the Fourth Train Proposal Area and/or were listed in the Tailored

Guidelines for assessment (Appendix E2 [Conservation-significant Species Considered for Assessment in this PER/Draft EIS] describes the species screening process) (Table 13-9). No threatened ecological communities were identified as present in the Fourth Train Proposal Area. However, habitats considered important for threatened and/or migratory marine fauna were identified within the Fourth Train Proposal Area. These habitats include:

- marine turtle feeding grounds for juveniles and adults, including nearshore habitats such as shallow subtidal limestone platform reef with macroalgal assemblages used by adult Green Turtles, and subtidal pavement with filter-feeding assemblages (e.g. soft-bodied sea pens and sea cucumbers) that may provide feeding opportunities for Flatback Turtles
- marine turtle nesting, egg development, and hatchling emergence (for some species), including:
    - high-energy, deep, steeply sloped, sandy unobstructed foreshore used for nesting by Green Turtles
    - deep sandy low-sloped beaches with wide shallow intertidal zones used for nesting by Flatback Turtles
    - small, shallow beaches characterised by coarse-grained sand or coral grit interspersed with rocks and beach wrack for nesting by Hawksbill Turtles
- shallow areas with sparse communities of seagrass that may be used by Dugongs for feeding
- extensive tidal mudflats used by feeding shorebirds
- Humpback Whale migration routes that overlap the Fourth Train Proposal Area
- foraging area for Whale Sharks; this area extends seaward of the 200 m depth contour, and latitudinal through much of the North-west Marine Region
- breeding areas for Wedge-tailed Shearwaters across continental shelf waters and islands of the southern half of the North-west Marine Region.

Across the North-west Marine Region, DotE identifies a number of Biologically Important Areas (BIAs) for threatened and/or migratory marine species. BIAs are areas that are considered to be particularly important for the conservation of protected species and where aggregations of individuals display biologically important behaviour, such as breeding, foraging, resting, or migration (SEWPaC 2012). Several BIAs for threatened and/or migratory species overlap the Fourth Train Proposal Area. Generally the habitats identified for threatened and/or migratory marine fauna within the Fourth Train Proposal Area (i.e. the habitats listed above) are consistent with the species' regional BIAs. Further environmental baseline information, including figures showing marine fauna habitats and regional BIAs, is provided in Section 6.6.2.

Table 13-9: EPBC Act-listed Threatened and/or Migratory Marine Species Potentially Affected by the Fourth Train Proposal

Species Grouping	Common Name	Scientific Name	Protected Status	Occurrence within the Fourth Train Proposal Area
Fish	Whale Shark	*Rhincodon typus*	Vulnerable and Migratory	Likely*
	Dwarf Sawfish	*Pristis clavata*	Vulnerable	Possible
	Green Sawfish	*Pristis zijsron*	Vulnerable	Possible
	Giant Manta Ray	*Manta birostris*	Migratory	Likely
Marine Mammals	Bryde's Whale	*Balaenoptera edeni*	Migratory	Likely
	Blue Whale	*Balaenoptera musculus*	Endangered and Migratory	Likely
	Sperm Whale	*Physeter macrocephalus*	Migratory	Possible
	Humpback Whale	*Megaptera novaeangliae*	Vulnerable and Migratory	Likely*
	Indo-Pacific Humpback Dolphin	*Sousa chinensis*	Migratory	Likely
	Indian Ocean Bottlenose Dolphin/ Spotted Bottlenose Dolphin (Arafura/Timor Sea populations)	*Tursiops aduncus*	Migratory	Likely
	Australian Snubfin Dolphin	*Orcaella heinsohni*	Migratory	Likely
	Dugong	*Dugong dugon*	Migratory	Likely
Marine Reptiles	Flatback Turtle	*Natator depressus*	Vulnerable and Migratory	Likely*
	Green Turtle	*Chelonia mydas*	Vulnerable and Migratory	Likely*
	Hawksbill Turtle	*Eretmochelys imbricata*	Vulnerable and Migratory	Likely*
	Loggerhead Turtle	*Caretta caretta*	Endangered and Migratory	Likely*
	Leatherback Turtle	*Dermochelys coriacea*	Endangered and Migratory	Possible
	Short-nosed Sea Snake	*Aipysurus apraefrontalis*	Critically Endangered	Possible

Species Grouping	Common Name	Scientific Name	Protected Status	Occurrence within the Fourth Train Proposal Area
Marine Avifauna	Bridled Tern	*Onychoprion anaethetus* (previously *Sterna anaethetus)*	Migratory	Likely*
	Wedge-tailed Shearwater	*Puffinus pacificus*	Migratory	Likely*
	Lesser Crested Tern	*Sterna bengalensis*	Migratory	Likely*
	Roseate Tern	*Sterna dougallii*	Migratory	Likely*
	Fairy Tern	*Sternula nereis nereis*	Vulnerable	Likely*
	Eastern Reef Egret	*Ardea (Egretta) sacra*	Migratory	Likely
	Ruddy Turnstone	*Arenaria interpres*	Migratory	Likely
	Sharp-tailed Sandpiper	*Calidris acuminata*	Migratory	Likely
	Sanderling	*Calidris alba*	Migratory	Likely
	Red Knot	*Calidris canutus*	Migratory	Likely
	Curlew Sandpiper	*Calidris ferruginea*	Migratory	Likely
	Red-necked Stint	*Calidris ruficollis*	Migratory	Likely
	Greater Sand Plover	*Charadrius leschenaultia*	Migratory	Likely
	Lesser Sand Plover	*Charadrius mongolus*	Migratory	Likely
	White-winged Black Tern	*Chlidonias leucoptera*	Migratory	Likely
	Bar-tailed Godwit	*Limosa lapponica*	Migratory	Likely
	Osprey	*Pandion cristatus*	Migratory	Likely
	Pacific Golden Plover	*Pluvialis fulva*	Migratory	Likely
	Grey Plover	*Pluvialis squatarola*	Migratory	Likely
	Little Tern	*Sterna albifrons*	Migratory	Likely
	Common Tern	*Sterna hirundo*	Migratory	Likely
	Grey-tailed Tattler	*Tringa brevipes*	Migratory	Likely
	Common Greenshank	*Tringa nebularia*	Migratory	Likely

** Fourth Train Proposal Area overlaps a BIA for the species*

13.4.2 Assessment and Mitigation of Potential Impacts

Consideration of the potential impacts on EPBC Act-listed threatened and/or migratory species has taken into account activities of the Fourth Train Proposal occurring in both State Waters and the Commonwealth Marine Area. Table 13-10 identifies the stressors due to Fourth Train Proposal activities that were considered to have the potential to impact upon listed threatened and migratory marine species or their habitat.

Not all stressors will impact equally upon each species, habitat, or across all areas. To present the worst case, the impact ratings within Table 13-10 are for those species considered most sensitive to impact from each stressor, and relate to those areas where the species may be most exposed to the potential impact. For example, the 'Medium' impact rating for artificial light reflects the level of potential impact to marine turtles within the nearshore environment.

Specific references are provided to illustrate mitigation and management measures; these measures are designed to manage the sources of the potential impact (i.e. the stressor), and are not generally species-specific. The potential impacts were assessed for species and their habitats after considering the application of mitigation and management measures to the stressors.

The level of impact from relevant stressors was assessed and discussed at an individual species' level. The potential impacts to species were assessed with consideration to DotE's species pressure analysis (where relevant). This analysis was undertaken at a regional level as part of the North-west Marine Region Bioregional Plan (SEWPaC 2012) and identified pressures within the marine environment that may be of concern to individual species. Within the assessment in Section 13.4, consideration was also given where stressors may impact additively upon an EPBC Act-listed species or associated habitat.

Additional assessment of potential impacts to threatened and/or migratory marine fauna associated with the nearshore environment from stressors associated with the Fourth Train Proposal is included in Section 10.6.3.

Table 13-10: Stressors and Potential Impacts to Listed Marine Species from the Implementation of the Fourth Train Proposal

Stressor	Fauna/Habitat Considered Most Sensitive to Stressor	Potential Impacts	Illustrative Mitigation and Management Measures	Impact Rating	
				Incremental	Additional
Atmospheric emissions (except dust)	Marine mammals and marine reptiles	• Physiological impacts and potential bioaccumulation of potentially harmful airborne contaminants as a result of increased atmospheric emissions during operation of the Fourth Train Proposal	See Section 5.2.4 and Table 13-23	Trivial	-
Artificial light	Marine reptiles (specifically marine turtles)	• Change in local abundance/distribution through either attraction or avoidance of light • Attraction of marine turtle hatchlings to light onshore or in the water, leading to increased predation risk	See Section 5.3.4, Table 10-9, and Table 13-24	Medium	Medium
Discharges to sea	Fish and marine mammals (in particular nearshore species that feed through filtering prey items from the water column (e.g. baleen whales and Whale Sharks)	• Adverse effects to individuals as a result of the introduction of additional nutrients, chemicals, or pathogens in discharges from Fourth Train Proposal marine vessels, drilling (production well and shore crossing), hydrotesting, and the discharge of reject reverse osmosis brine	See Section 5.5.4, Table 10-6, and Table 13-26	Low	Low
Noise and vibration	Marine mammals (particularly regular migrants to or through the Fourth Train Proposal Area [e.g. Humpback Whales])	• Possible disturbance to feeding, communication, orientation, and navigation of species that rely on acoustic cues	See Section 5.4.4, Table 10-10, and Table 13-27	Low	Low
Physical interaction	Fish, marine mammals and marine reptiles (in particular slow-moving, air-breathing, or surface-feeding marine fauna (e.g. Whale Sharks, marine turtles, Dugongs))	• Injury or mortality to marine fauna from physical interactions with marine vessels	See Table 10-11 and Table 13-31	Medium	Medium
Seabed disturbance	Benthic Primary Producer Habitat, marine turtle foraging, nesting and internesting areas	• Change to or permanent loss of habitat type	See Table 10-4 and Table 13-30	Low	Low

Stressor	Fauna/Habitat Considered Most Sensitive to Stressor	Potential Impacts	Illustrative Mitigation and Management Measures	Impact Rating	
				Incremental	Additional
Spills and leaks	Fish, marine mammals, marine reptiles and marine avifauna (in particular regular migrants (e.g. Humpback Whales) and species with habitat within range of a spill or leak event	• Lethal or sublethal effects through direct contact or ingestion of contaminated prey, or displacement through oiling of habitat • Displacement of fauna from important areas of habitat	See Sections 5.7.3 and 13.5.10	Medium	Medium

13.4.2.1 Potential Impacts on Listed Threatened/Migratory Fish

Four species of fish—Whale Shark, Dwarf Sawfish, Green Sawfish, and Giant Manta Ray—were identified as having the potential to be exposed to stressors from the Fourth Train Proposal (Table 13-9). The vulnerability of these fish species relates to characteristics such as slow growth, late maturity, and few offspring, making populations susceptible to decline from human-induced impacts.

13.4.2.1.1 Whale Shark

Between March and April each year, large numbers of Whale Sharks aggregate to feed in the productive waters along the Ningaloo Coast before travelling north-east along the continental shelf. Although a clear migration route for this species has not been defined (Meekan and Radford 2010), waters beyond the 200 m depth contour have been identified as providing suitable foraging habitat for their northerly migration, and have been declared a BIA; the Fourth Train Proposal Area overlaps a small proportion of the identified BIA (Figure 6-14). Individual Whale Sharks may transit through the Fourth Train Proposal Area, although no aggregation areas have been recorded.

The Fourth Train Proposal stressors (Table 13-10) that are considered relevant to Whale Sharks include physical interaction, discharges to sea, and spills and leaks. One of the stressors and its associated impacts is similar to a pressure cited by SEWPaC (2012a) for Whale Sharks within the North-west Marine Region (Table 13-11).

Table 13-11: DotE Pressure Analysis for Whale Sharks: Pressures Considered Relevant to the Fourth Train Proposal

Pressures of Concern	Pressures of Potential Concern	Pressures of Less Concern
• No pressures identified	• None considered relevant	• Physical interaction with marine vessels

Adapted from SEWPaC 2012a

The Fourth Train Proposal stressors identified for Whale Sharks are associated with the movement of marine vessels and the construction and operation of marine infrastructure. These activities will be relevant throughout construction and operation of the Fourth Train Proposal.

Discharges to Sea

Discharges to sea are anticipated to rapidly dissipate into the receiving marine environment with only localised and/or short-term observable changes to background water quality parameters. Individual Whale Sharks have the potential to demonstrate behavioural avoidance if they are in the immediate discharge vicinity. As no long-term impact to water quality within the North-west Marine Region is expected, potential impacts to the BIA defined for Whale Sharks are also not anticipated. The level of potential impact of discharges to sea from the Fourth Train Proposal on marine fauna, including Whale Sharks, was assessed as ‘Low’.

Physical Interaction

Physical interaction has the potential to occur during construction and operation of the Fourth Train Proposal. Slow-moving marine fauna, including Whale Sharks, are considered to be at greater risk of physical interaction where their movement patterns and marine vessel activity coincide. Whale Sharks are believed to forage at a range of depths, including at the surface waters; Wilson *et al.* (2006) reported that Whale Sharks tagged at Ningaloo Reef spent more than 40% of their time at depths less than 15 m. As such, there is potential for interaction to occur where the movements of Fourth Train Proposal marine vessels and Whale Sharks overlap. The implementation of the Fourth Train Proposal will result in additional construction activities within the marine environment and thus increase the associated marine vessel activities. During operations, the Fourth Train Proposal is expected to increase the level of marine vessel activity; condensate and LNG vessels are expected to increase by up to 60 to 80 vessels per year when compared to the Foundation Project alone. Port restrictions, which include controls on vessel speed, will apply within the Barrow Island Port limits.

There have been few observations of Whale Sharks during the Marine Fauna Observer (MFO) program for the approved Foundation Project. Two observations were made between 2010 and 2011 in the Commonwealth Marine Area off the west coast of Barrow Island. To date, no instances of physical interaction with Whale Sharks have occurred that are attributable to Foundation Project activities. To manage potential interactions, the Foundation Project MFO coverage will be extended, as required, to cover Fourth Train Proposal marine activities. The level of potential impact of physical interaction from the Fourth Train Proposal on marine fauna was assessed as ‘Medium’. However, Whale Sharks are not the most sensitive receptor for physical interaction; the species has a large geographic range and is not known to aggregate within the Fourth Train Proposal Area. The anticipated low density of this species within the Fourth Train Proposal Area is considered to reduce the potential for this species to be impacted by physical interaction.

Spills and Leaks

Spills and leaks have the potential to impact Whale Sharks through direct contact or indirectly due to water quality changes. The large quantities of water filtered by Whale Sharks while foraging makes this species vulnerable to hydrocarbon spills and leaks due to the possible ingestion and accumulation of hydrocarbons, including dispersed hydrocarbons. However, little empirical data exists regarding the behavioural or physiological responses of Whale Sharks to hydrocarbon spills and leaks. In the unlikely event of a large release of hydrocarbons, for example from a subsea well blowout at the Chandon Gas Field (Table 5-24), BIAs for the Whale Shark, including the BIA identified along the Ningaloo Coast could be impacted. If the spill coincided with the Whale Shark aggregation season (between March and April), a larger number of Whale Sharks have the potential to be impacted. However, the worst-case annualised probability of a spill that has the potential to result in impacts to Whale Sharks at the Ningaloo Coast is very low (Section 13.2.2.2).

The level of potential impact of spills and leaks from the Fourth Train Proposal on marine fauna was assessed as ‘Medium’. However, Whale Sharks are not the most sensitive receptor for spills and leaks; their large geographic range and the very low probability of any large spill affecting seasonal Whale Shark aggregation at the Ningaloo Coast, reduces the potential to impact this species.

Summary

The marine environment in which the Fourth Train Proposal will be implemented is similar to that associated with the Foundation Project in terms of the habitat type and associated ecosystem functions. The Fourth Train Proposal additional to the approved Foundation Project will result in additional construction, with activities moving into new geographic areas. This will increase the overall level of activity within the Fourth Train Proposal Area, and thus increase the potential for impacts to Whale Sharks. However, given their wide range and often solitary behaviour (DEC 2012), the number of individual Whale Sharks encountered or exposed to potential impacts is anticipated to be low. The probability of a spill or leak increases with the addition of the Fourth Train Proposal; however, the likelihood of potential impacts occurring to marine fauna, including Whale Sharks, remains remote. The consequence of spills and leaks to marine fauna is considered to be the same as that assessed for the Foundation Project. When considered in addition to the Foundation Project, the Fourth Train Proposal is not predicted to increase the level of potential impact to marine fauna from that assessed for the Foundation Project.

Marine construction and operations activities will only affect a relatively small proportion of the Fourth Train Proposal Area at any one time. Stressors associated with these activities are not expected to act together to result in additive impacts to Whale Sharks.

13.4.2.1.2 Dwarf Sawfish and Green Sawfish

The Dwarf Sawfish and Green Sawfish both inhabit nearshore and estuarine waters, and are primarily associated with tropical regions in northern Australia (Phillips *et al.* 2011). BIAs for both species are located north of Port Hedland, although individuals may occur further south. A sighting of a sawfish (genus confirmed as *Pristis* spp. but species unknown) occurred at Bandicoot Bay in 2011. The nearshore waters surrounding Barrow Island are believed to be the southerly limit of the range for Dwarf and Green Sawfish, although it is possible that either species could occur in the area. Because of the uncertainty surrounding the species of the individual observed at Bandicoot Bay, both species are considered in this assessment.

The Fourth Train Proposal stressors (Table 13-10) that are considered relevant to Dwarf and Green Sawfish include discharges to sea and spills and leaks. These stressors reflect the pressures identified by DotE for sawfish within the North-west Marine Region (Table 13-12). Given the similarities in distribution, habitat preference, and the current environmental threats identified for Dwarf and Green Sawfish, the following assessment considers these species together.

Table 13-12: DotE Pressure Analysis for Dwarf Sawfish and Green Sawfish: Pressures Considered Relevant to the Fourth Train Proposal

Pressures of Concern	Pressures of Potential Concern	Pressures of Less Concern
• None considered relevant	• Marine debris from shipping	• Chemical pollution from urban development • Nutrient pollution from urban development • Physical habitat modification from urban/ coastal development

Adapted from SEWPaC 2012a

The Fourth Train Proposal stressors identified for Dwarf and Green Sawfish are associated with marine activities, including the operation of marine vessels and the construction and operation of marine infrastructure (e.g. the Fourth Train Proposal Offshore Feed Gas Pipeline System), particularly in nearshore waters. These stressors will be relevant throughout the construction and operation of the Fourth Train Proposal.

Spills and Leaks

Based on hydrocarbon spill modelling completed as part of the Fourth Train Proposal, hydrocarbon spills close to Barrow Island could result in adverse impacts to any Dwarf or Green Sawfish present in the vicinity of Montebello/Barrow/Lowendal Islands at the time of the spill. Potential impacts could occur through a number of different pathways including through reduced water quality and contamination of food sources, resulting in toxic effect or a behavioural response, such as movement away from the affected areas. The likelihood of a hydrocarbon spill occurring and then impacting nearshore waters surrounding the Montebello/Barrow/Lowendal Islands is considered to be remote (Table 5-27). Although individuals have the potential to be exposed to hydrocarbons that are either entrained or dissolved in marine waters, population effects are unlikely given the small numbers of individuals likely to be encountered. In addition, as there are no BIAs for the Dwarf or Green Sawfish recorded near the Fourth Train Proposal Area, individuals that may be encountered are likely to display behavioural avoidance of the area, favouring alternative unaffected marine waters. The level of potential impact of spills and leaks from the Fourth Train Proposal on marine fauna was assessed as 'Medium'. However, the Dwarf and Green Sawfish are not the most sensitive receptor for spills and leaks. Nearshore waters surrounding Barrow Island are considered to represent the southerly limit of the species' range and only individuals may be exposed to potential impacts from spills and leaks. These factors reduce the potential for Dwarf and Green Sawfish to be impacted by spills and leaks.

Summary

The probability of a spill or leak increases with the addition of the Fourth Train Proposal; however, the likelihood of potential impacts occurring to marine fauna, including the Dwarf and Green Sawfish, remains remote. The consequence of spills and leaks to marine fauna is considered to be the same as that assessed for the Foundation Project. When considered in addition to the Foundation Project, the Fourth Train Proposal is not predicted to increase the level of potential impact to marine fauna from that assessed for the Foundation Project.

In addition, no BIAs for the Dwarf or Green Sawfish have been identified in the vicinity of the Fourth Train Proposal Area. Stressors associated with these activities are not expected to act synergistically, or result in widespread additive impacts to Dwarf or Green Sawfish.

13.4.2.1.3 Giant Manta Ray

The Giant Manta Ray is a migratory species with a geographic range that includes tropical and temperate waters around the world. Sightings of this species have been recorded in Barrow Island's nearshore waters during marine fauna surveys completed for the approved Foundation Project (Chevron Australia 2012). No BIAs for the Giant Manta Ray were identified within the vicinity of the Fourth Train Proposal Area.

Although no specific pressures were identified within the North-west Marine Region Bioregional Plan for the Giant Manta Ray, stressors identified from the Fourth Train Proposal (Table 13-10) that are considered relevant to the Giant Manta Ray include physical interaction and spills and leaks.

Physical Interaction

Giant Manta Rays are mostly observed in continental shelf areas, around upwellings, and near seamounts. Significant numbers occur in Ningaloo Coast waters each autumn, displaying foraging and mating behaviours (DEWHA 2008a). Occasionally, MFOs have observed individuals in the waters surrounding Barrow Island during the approved Foundation Project construction activities. To date, there have been no instances of physical interaction with Giant Manta Rays that are attributable to Foundation Project activities. The level of potential impact of physical interaction from the Fourth Train Proposal on marine fauna was assessed as 'Medium'. However, the anticipated low densities of Giant Manta Rays within the Fourth Train Proposal Area is considered to reduce the potential for this species to be impacted by physical interaction.

Spills and Leaks

In the unlikely event of a large release of hydrocarbons, for example from a subsea well blowout at the Chandon Gas Field (Table 5-24), the habitat and water quality of marine areas used by the Giant Manta Ray could be impacted. This could have the potential to result in direct and indirect toxic effects and behavioural responses, such as movement away from the affected areas. The likelihood of a major hydrocarbon spill or leak (e.g. a well blowout, a pipeline rupture, or a major fuel spill) resulting in widespread and/or long-term impacts on the Giant Manta Ray is considered to be remote. In addition, the Giant Manta Ray occupies an extensive range far beyond the extent of a potential spills and leaks from Fourth Train Proposal activities. The level of potential impact from spills and leaks from the Fourth Train Proposal on marine fauna was assessed as 'Medium'. However, the Giant Manta Ray is not considered to be the most sensitive receptor for spills and leaks; the often solitary nature and large geographic range of the Giant Manta Ray reduces the potential for this species to be impacted by spills and leaks. Although individuals have the potential to be impacted, adverse effects at a species level are considered unlikely.

Summary

The Fourth Train Proposal additional to the approved Foundation Project will result in additional construction activities and associated potential impacts; additional geographic areas may also be exposed to potential impacts. The probability of a spill or leak increases with the addition of the Fourth Train Proposal; however, the likelihood of potential impacts occurring to marine fauna, including Giant Manta Ray, remains remote. The consequence of spills and leaks to marine fauna is considered to be the same as that assessed for the Foundation Project. When considered in addition to the Foundation Project, the Fourth Train Proposal is not predicted to increase the level of potential impact to marine fauna from that assessed for the Foundation Project.

Marine construction and operations activities will only affect a relatively small proportion of the Fourth Train Proposal Area at any one time. Stressors associated with these activities are not expected to act synergistically to result in additive impacts to the Giant Manta Ray.

13.4.2.2 Potential Impacts on Listed Threatened and Migratory Marine Mammals

A number of EPBC Act-listed migratory and threatened species (marine mammals) were identified to be exposed to potential impacts generated by the Fourth Train Proposal (Table 13-9). These include the Dugong, Australian Snubfin Dolphin, Indo-Pacific Humpback Dolphin, and Indian Ocean Bottlenose Dolphin, which are all considered to be predominantly nearshore species. The Blue Whale, Bryde’s Whale, and Sperm Whale were identified as predominantly occurring in offshore waters, but are known to frequent nearshore waters, particularly areas of upwelling or where the continental shelf is narrow. The annual migration of Humpback Whales also occurs in both nearshore and offshore waters. The assessment of potential impacts to marine mammal species considers their predominant habitat (e.g. nearshore or offshore marine environment), as this may predispose them to particular stressors.

Several factors affect the vulnerability of marine mammals, including the time taken to reach sexual maturity, their low fecundity, and their need to surface for air, which exposes them to interaction with human activities.

13.4.2.2.1 Dugong

Dugongs are associated with seagrass meadows—the species’ main source of food—and migrate between areas of suitable habitat. No BIAs for the Dugong are identified within the Fourth Train Proposal Area, although there are areas of potential habitat, namely benthic primary producer habitat, in the nearshore waters of Barrow Island. However, Dugongs have been recorded around Barrow Island (Prince *et al*. 2001), and marine fauna observations as part of the Foundation Project have regularly recorded Dugongs off both the east and west coasts of Barrow Island. Data from the aerial surveys conducted by Chevron Australia and its Joint Venture Partners for the Wheatstone Project in 2012 and 2013 suggests the south-east area off Barrow Island is an area with a high probability of Dugong sightings.

The Fourth Train Proposal stressors (Table 13-10) that are considered relevant to Dugongs include discharges to sea, noise and vibration, physical interaction, seabed disturbance, and spills and leaks. These stressors reflect the pressures cited by DotE for Dugongs within the North-west Marine Region (Table 13-13).

Table 13-13: DotE Pressure Analysis for Dugong: Pressures Considered Relevant to the Fourth Train Proposal

Pressures of Concern	Pressures of Potential Concern	Pressures of Less Concern
• No pressures identified	• Physical interaction with marine vessels • Oil pollution from oil rigs	• Physical habitat modification from urban/ coastal development • Noise pollution from shipping, vessels, onshore and offshore construction • Oil pollution from vessels and shipping

Adapted from SEWPaC 2012b

The Fourth Train Proposal stressors identified for Dugongs are associated with marine activities, including the movement of marine vessels and the construction and operation of marine infrastructure (e.g. the Fourth Train Proposal Offshore Feed Gas Pipeline System), particularly in nearshore waters. These identified stressors will be relevant throughout construction and operations activities of the Fourth Train Proposal and are considered relevant to the nearshore waters inside and outside the Fourth Train Proposal Area (i.e. the Ningaloo Coast).

Physical Interaction

The Fourth Train Proposal will require additional construction activities within the marine environment, and increased marine vessel activity (e.g. LNG and condensate vessels) when compared to the approved Foundation Project, thus increasing the potential for physical interaction to occur. Although sirenians, including Dugongs and manatees, are considered to be slow moving, evidence from studies of Florida manatees suggest that sirenians may actively avoid approaching vessels (Nowacek *et al.* 2004), thus reducing the potential for physical interaction to occur. To date, there have been no instances of physical interaction with Dugongs attributable to Foundation Project activities. Dugongs migrate between nearshore areas of habitat and are not confined to potential habitat within the Fourth Train Proposal Area; there are also no BIAs identified for Dugongs in the vicinity of the Fourth Train Proposal Area, reducing the potential for Dugongs to be impacted by physical interaction. The level of potential impact from physical interaction to marine fauna, including Dugongs, was assessed as ‘Medium’.

Seabed Disturbance

The assessment of potential impacts from seabed disturbance to benthic primary producer habitat, which may provide foraging opportunities for Dugongs, is detailed in Section 10.7. Fluctuations in habitat availability can result from both natural (e.g. ephemerality and/or cyclone damage) and anthropogenic (e.g. nearshore development) causes, which can result in changes in Dugong distribution patterns. Although individuals may be exposed to stressors associated with the Fourth Train Proposal activities, potential Dugong habitat is associated with the nearshore waters on the east coast of Barrow Island. However, seabed disturbance as a result of the Fourth Train Proposal will occur primarily on the west coast of Barrow Island. The level of potential impacts to marine fauna, including Dugongs, due to seabed disturbance throughout the construction and operation of the Fourth Train Proposal was assessed as ‘Low’.

Spills and Leaks

The Ningaloo Coast and Exmouth Gulf contain foraging and nursing habitat (BIAs) for Dugongs. Hydrocarbon spill modelling indicates that in the event of a large-scale release of hydrocarbons (e.g. subsea well blowout within the Chandon Gas Field), hydrocarbons would remain west of Exmouth Gulf and associated Dugong habitat. However, the likelihood of a spill of hydrocarbons impacting upon the Ningaloo Coast (Section 13.2.2.2) is remote, although low concentrations (maximum 30 ppb) of dissolved aromatic hydrocarbons have the potential to reach the Ningaloo Coast. At a concentration of 30 ppb of aromatic hydrocarbons from the Chandon Gas Field, the toxic benzene components would be well within Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture Resource Management Council of Australia and New Zealand (ARMCANZ) guidelines (ANZECC and ARMCANZ 2000) for benzene concentrations; these guidelines are expected to assure protection of more than 99% of species (Section 2.1.1 of Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill]).

Long travel times from the Fourth Train Proposal Area to the Ningaloo Coast would also allow for spill response plans to be initiated and take effect, thus reducing the potential for impacts to the Ningaloo Coast. Although there is potential for individual Dugongs to be effected by spills and leaks, it is considered unlikely that individuals or areas of habitat would be impacted enough to result in adverse effects at a species level. The level of potential impact associated with spills and leaks from the Fourth Train Proposal to marine fauna was assessed as 'Medium'. However, Dugongs are not the most sensitive receptor for spills and leaks. Dugongs migrate between nearshore areas of habitat and are not confined to areas that may be affected by spills and leaks. There are also no BIAs for Dugongs in the vicinity of the Fourth Train Proposal Area. These factors reduce the potential for Dugongs to be impacted by spills and leaks.

Summary

When considered in addition to the approved Foundation Project, the Fourth Train Proposal is not predicted to increase the level of potential impact to marine fauna, including Dugongs, from that assessed under the Foundation Project. Marine construction and operation activities will only affect a relatively small proportion of the Fourth Train Proposal Area at any one time. Stressors associated with these activities are not expected to act synergistically, or result in widespread additive impacts to Dugongs.

13.4.2.2.2 Nearshore Dolphins: Australian Snubfin Dolphin, Indian Ocean Bottlenose Dolphin, and Indo-Pacific Humpback Dolphin

Populations of the Indian Ocean Bottlenose Dolphin and Indo-Pacific Humpback Dolphin reside in the shallow waters of the inner Rowley Shelf, including the nearshore waters of Barrow Island and offshore to a lesser extent. The Australian Snubfin Dolphin may also occur in nearshore (predominantly) and offshore waters. The three species may occur across the North-west Marine Region, but populations are considered to be fragmented, migrating between discrete areas of preferred nearshore habitat (SEWPaC 2012c). However, the waters surrounding Barrow Island represent the southerly limit of the Australian Snubfin Dolphin's range, except for vagrant individuals. No BIAs have been defined for any of these species within, or in the vicinity of, the Fourth Train Proposal Area.

The Fourth Train Proposal stressors (Table 13-10) that are considered relevant to the Indian Ocean Bottlenose Dolphin, Indo-Pacific Humpback Dolphin, and Australian Snubfin Dolphin include discharges to sea, noise and vibration, physical interaction, seabed disturbance, and spills and leaks. These stressors reflect the pressures cited by DotE for these nearshore dolphin species within the North-west Marine Region (Table 13-14). Given the similarities in distribution, habitat preference, and current threats identified for these three dolphin species, the following assessment considers the species together.

Table 13-14: DotE Pressure Analysis for Nearshore Dolphin Species: Pressures Considered Relevant to the Fourth Train Proposal

Pressures of Concern	Pressures of Potential Concern	Pressures of Less Concern
• None considered relevant	• Chemical pollution from urban development • Nutrient pollution from urban development • Physical habitat modification from offshore construction and installation works • Noise pollution from shipping, vessels, and onshore/offshore construction • Oil pollution from shipping, vessels, and oil rigs • Physical interaction with marine vessels	• Chemical pollution from shipping and vessels

Adapted from SEWPaC 2012c

The Fourth Train Proposal stressors identified for nearshore dolphin species are associated with the movement of marine vessels and the construction and operation of marine infrastructure (e.g. offshore wells and Fourth Train Proposal Offshore Feed Gas Pipeline System). The identified stressors will be relevant to the construction and operations activities of the Fourth Train Proposal.

Discharges to Sea

Discharges to sea will occur in both the nearshore environment and the offshore environment; these include drilling cuttings discharges, and discharges from marine vessels and onshore facilities during construction and operations activities. Discharges may elicit highly localised behavioural responses in nearshore dolphin species, such as short-term avoidance of an area; however, discharges to sea are not expected in any BIAs for these species. In addition, adverse metabolic impacts to nearshore dolphin species are not predicted due to the low toxicity of the discharges. Waters within the Fourth Train Proposal Area are generally high-energy, facilitating rapid dispersion of discharges to sea and reducing the potential to cause adverse effects. The level of potential impact to nearshore marine fauna from discharges to sea was assessed as 'Low'.

Noise and Vibration

A number of sources of noise and vibration may have the potential to impact the identified dolphin species. These sources include construction activities using marine vessels (e.g. thrusters), drilling of the shore crossing component of the Fourth Train Proposal Offshore Feed Gas Pipeline System on the west coast of Barrow Island, and the preparation and laying of the Offshore Feed Gas Pipeline System. Once the Fourth Train Proposal moves into its operations phase, noise and vibration may result from the flow of gas through the Offshore Feed Gas Pipeline System and wellheads, and movement of marine vessels to and from Barrow Island. Dolphins use high-frequency sound for communication and orientation. Noise produced by marine activities will overlap the lower frequency end of the auditory range of dolphin species (Figure 10-3), and would not be expected to result in discernible impacts to communications between individuals, or the ability of dolphins to forage and navigate. The level of potential impacts to nearshore marine fauna from subsea noise and vibration was assessed as 'Low'.

Physical Interaction

Physical interaction between marine fauna and marine vessels has the potential to occur during both construction and operations activities of the Fourth Train Proposal. The Fourth Train Proposal is anticipated to result in additional construction activities within the marine environment, and to increase marine vessel activity (e.g. LNG and condensate vessels) when compared to the approved Foundation Project, thus increasing the potential for physical interactions to occur. Indian Ocean Bottlenose Dolphins, Indo-Pacific Humpback Dolphins, and Australian Snubfin Dolphins are highly mobile and would be expected to avoid potentially adverse interactions with stationary or deployed equipment, and also with marine vessels. Dolphin observations recorded by MFOs under the approved Foundation Project included sightings of Indo-Pacific Humpback Dolphins, Indian Ocean Bottlenose Dolphins, and a small number of Australian Snubfin Dolphins. Sightings were made from both moored and active marine vessels (i.e. working or in transit). To date, no instances of physical interaction with dolphins have occurred attributable to Foundation Project activities. The level of potential impacts to nearshore marine fauna from physical interaction was assessed as ‘Medium’. However, dolphins are not the most sensitive receptor for physical interaction. The mobility of dolphin species and the absence of BIAs for these species in the vicinity of the Fourth Train Proposal Area reduces the potential for this species to be impacted by physical interaction.

Seabed Disturbance and Physical Presence of Infrastructure

Seabed disturbance and the physical presence of infrastructure has the potential to disturb habitat that may be used by dolphins for foraging/hunting. The Fourth Train Proposal will result in seabed disturbance and the physical presence of infrastructure; both stressors will result in the loss of seabed habitat. However, the associated potential impacts are predicted to be localised to the immediate vicinity of the source of disturbance and subsea infrastructure. The productivity and availability of food for dolphin species is not anticipated to be adversely impacted. No BIAs have been identified for Indian Ocean Bottlenose Dolphins, Indo-Pacific Humpback Dolphins, or Australian Snubfin Dolphin within or in the vicinity of, the Fourth Train Proposal Area. The level of potential impacts to nearshore marine fauna from the modification of habitat and physical presence of subsea infrastructure was assessed as ‘Low’.

Spills and Leaks

Hydrocarbon spill modelling indicates that a spill of hydrocarbons from Fourth Train Proposal activities has the potential to encroach on the nearshore waters of Barrow Island and surrounding islands (e.g. the Montebello Islands). Potential impacts to Indian Ocean Bottlenose Dolphins, Indo-Pacific Humpback Dolphins, and Australian Snubfin Dolphins could occur through a number of different pathways, including through reduced water quality and contamination of food sources, resulting in toxic effects or behavioural responses, such as movement away from the affected areas.

The fragmented nature of the three dolphin species’ populations within the North-west Marine Region suggests that only a proportion of the population would potentially be exposed in the event of a hydrocarbon release from the Fourth Train Proposal. The evaporative nature of the released hydrocarbons (Chandon Condensate) from a pipeline rupture reduces the potential for surface slicks and the occurrence of associated potential impacts to dolphins through inhalation (e.g. asphyxiation). Further, their high mobility and migratory nature indicates that these dolphin species could avoid areas where hydrocarbon concentrations may impair water and habitat quality, and where direct impacts associated with hydrocarbon releases (e.g. toxic effect, skin irritation) may occur. Food sources for these species, including pelagic and benthic organisms (e.g. demersal fish and cephalopods), are widely distributed through the North-west Marine Region. Given the potential geographic extent of a hydrocarbon release, the available food sources for these species would largely not be exposed to levels of hydrocarbons at which adverse impacts may occur, reducing the potential for increased competition due to food availability. In addition, modelling indicates that hydrocarbons would not be expected to partition into the sediment phase (Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill]), thus reducing the potential for exposure of benthic organisms to hydrocarbons in the event of a spill.

The likelihood of potential impacts occurring due to a substantial hydrocarbon release (e.g. a well blowout, a pipeline rupture, or a major fuel spill) is remote. In addition, the described dolphin species have a wide range, extending beyond the North-west Marine Region; there is also an absence of known BIAs within or in the vicinity of, the Fourth Train Proposal Area. Therefore, hydrocarbon spills and leaks due to the Fourth Train Proposal are not anticipated to result in adverse effects at a species level. The level of potential impact associated with spills and leaks from the Fourth Train Proposal to marine fauna, including described dolphin species, was assessed as 'Medium'. However, dolphins are not the most sensitive receptor for spills and leaks. The described dolphin species are highly mobile and not confined to areas that may be affected by spills and leaks, reducing the potential for these dolphin species to be impacted by spills and leaks.

Summary

The Fourth Train Proposal additional to the approved Foundation Project will result in additional construction activities and associated potential impacts; additional geographic areas may also be exposed to potential impacts. The timing of Fourth Train Proposal and Foundation Project marine activities are likely to overlap, increasing the overall level of activity within the Fourth Train Proposal Area and thus increasing the potential for interaction to occur with the described dolphin species. However, potential impacts associated with interactions with vessels and drilling rigs and from discharges to sea (Table 13-10) would be localised. The probability of a spill or leak increases with the addition of the Fourth Train Proposal; however, the likelihood of potential impacts occurring to marine fauna, including to the described dolphin species, remains remote. The consequence of spills and leaks to marine fauna is considered to be the same as that assessed for the Foundation Project.

Marine construction and operations activities will only affect a relatively small proportion of the Fourth Train Proposal Area at any one time. Stressors associated with these activities are not expected to act synergistically to result in widespread additive impacts to dolphin species.

13.4.2.2.3 Whales: Humpback Whale, Bryde's Whale, Pygmy Blue Whale, and Sperm Whale

The Humpback Whale occurs in both nearshore and offshore waters of the Fourth Train Proposal Area. The Pygmy Blue Whale, Bryde's Whale, and Sperm Whale also migrate through the North-west Marine Region; the migration routes for these species are generally less well known, but they are thought to occur in deeper offshore waters than those for the Humpback Whale (SEWPaC 2012c) (Figure 6-15).

The Fourth Train Proposal stressors (Table 13-10) that are considered relevant to the Pygmy Blue Whale, Bryde's Whale, Sperm Whale, and Humpback Whale include noise and vibration, physical interaction, and spills and leaks. These stressors reflect the pressures cited by DotE for Humpback Whales within the North-west Marine Region (Table 13-15). Humpback Whales were the only species directly assessed using DotE's pressure analysis. Given the similarity in terms of potential sensitivity to certain stressors, the Pygmy Blue Whale, Bryde's Whale, Sperm Whale, and Humpback Whale are considered together within the following assessment.

Table 13-15: DotE Pressure Analysis for Humpback Whales: Pressures Considered Relevant to the Fourth Train Proposal

Pressures of Concern	Pressures of Potential Concern	Pressures of Less Concern
• No pressures identified	• Noise pollution from shipping, vessels, onshore and offshore construction • Physical interaction with marine vessels	• Chemical pollution from shipping and vessels • Oil pollution from shipping, vessels, and oil rigs

Adapted from SEWPaC 2012c

The Fourth Train Proposal stressors identified for whale species are associated with the movement of marine vessels and the construction and operation of marine infrastructure (e.g. offshore wells and the Offshore Feed Gas Pipeline System). The identified stressors will be relevant throughout the construction and operation of the Fourth Train Proposal.

Noise and Vibration

The Fourth Train Proposal marine activities will result in noise and vibration being produced subsea in nearshore and offshore environments, which will add to ambient noise levels within the Fourth Train Proposal Area. Section 5.4.2.1 provides additional detail on the noise sources during construction and operation of the Fourth Train Proposal. Depending on the intensity and duration of noise and vibration and the frequency of noise produced, migratory whale species may elicit behavioural changes, including avoidance of the noise source. Noise and vibration associated with the Fourth Train Proposal marine activities, which could impact upon migratory whales, includes noise from transient marine vessels, drilling and associated vertical seismic profiling (VSP), and operation of the Fourth Train Proposal Feed Gas Pipeline System and wellheads.

No large-scale seismic survey operations are planned as part of the Fourth Train Proposal. However, VSP operations may be undertaken during drilling, and the level of noise produced has the potential to result in adverse impacts to individual cetaceans that could be in the area. Humpback and Pygmy Blue Whale migrations along the west coast of Australia occur from May to November and April to December (respectively), and could coincide with the proposed drilling (and associated VSP) activities. The Humpback Whale migration route has been identified by DotE as a Biologically Important Area, and extends up to 100 km offshore (Figure 6-15 and Figure 6-16). The Fourth Train Proposal gas fields are beyond the main migration pathways for Humpback Whales, however, the migration routes of other whale species, including the Pygmy Blue Whale may overlap the Fourth Train Proposal gas fields.

Research to date suggests that behavioural changes for cetaceans may commence when noise levels received by the species exceed 120–160 dB re 1µPa (Southall *et al.* 2007). VSP generates higher intensity noise than routine drilling operations, with peak output approximately 195 dB re 1µPa @ 1 m (Chevron Australia 2013). This may overlap with the hearing ranges of cetaceans present in the area (Figure 10-3). However, modelling of VSP shows noise output is unlikely to exceed 160 dB re 1µPa @ 1 m at distances of more than 350 m from the seismic source (Chevron Australia 2013).

Changes to normal behaviours and avoidance of areas where noise is persistent have been observed in cetaceans, as well as short-term reductions in hearing sensitivity, physical injury of ear drums, and mortality (Oslo and Paris Convention for the Protection of the Marine Environment of the North East Atlantic [OSPAR] 2009). Avoidance or behavioural changes in marine mammals may also occur where continuous industrial noise levels are above 120 dB re 1 µPa. However, drilling and VSP activities will be short term, and will occur in the immediate vicinity of the well sites within the Fourth Train Proposal gas fields.

Noise from vessels is generally described as non-impulsive, producing either broadband or more tonal frequencies; the actual noise characteristics will depend on a range of factors including the marine vessels used (e.g. engine size) and the activity being undertaken (e.g. speed, machinery present).

Due to the large numbers of Humpback Whales that migrate annually through the Fourth Train Proposal Area, more of these animals have the potential to be exposed to noise generated by Fourth Train Proposal marine activities, compared to the Pygmy Blue Whale, Bryde's Whale, or Sperm Whale. Individuals travelling alone or in aggregations may show behavioural avoidance, with mothers and calves on their southerly migration more sensitive to noise disturbance due to their protective instincts (National Research Council [NRC] 2003). Short-term changes in marine mammal behaviour may result, impacting individuals, but these changes are not anticipated to have adverse effects at the species level given the short-term nature of the Fourth Train Proposal marine activities. In addition, no calving or resting areas for threatened and/or migratory whales have been identified within the Fourth Train Proposal Area, thus whales observed within the area are expected to be transitory.

During operations, low-frequency noise (estimated at 90 dB re 1 µPa) will be generated by pipeline flow. At distances greater than 30 m from the Offshore Feed Gas Pipeline System, sound levels are expected to reduce to less than 75 dB re 1 µPa (Glaholt *et al*. 2008). Pipeline-generated noise is unlikely to materially compromise the ability of cetaceans to migrate through the region. The level of potential impacts from noise emissions on listed whale species was assessed as 'Low'. The increase in marine activity, and associated noise emissions, due to the Fourth Train Proposal when considered together with the approved Foundation Project was not assessed to change the level of potential impact associated with subsea noise.

Physical Interaction

Humpback Whales have the potential to be impacted through physical interaction during the construction and operation of the Fourth Train Proposal, as vessels will be operating in the migration BIA for Humpback Whales. Migration routes for the Pygmy Blue Whale also overlap the Fourth Train Proposal Area, although the frequency and density of individuals is expected to be less for this species, reducing the potential for physical interaction to occur during marine activities for the Fourth Train Proposal. Construction activities, particularly the construction of the Fourth Train Proposal Offshore Feed Gas Pipeline System, will be a period of increased vessel activity, which will overlap the Humpback Whale migration BIA. The installation of the Offshore Feed Gas Pipeline System is expected to take up to approximately three years (Section 1.3.6) and may coincide with approximately four annual migrations of the Humpback Whale. However, a large proportion (more than 60%) of the Offshore Feed Gas Pipeline System (both route options) is beyond the main migration route for Humpback Whales. The Fourth Train Proposal gas fields are also beyond the main migration BIA for Humpback Whales, and construction activity at these fields, including drilling and intrafield pipe-lay, is expected to be largely peripheral to Humpback Whale migrations (Figure 6-15). The timing and spatial extent of Pygmy Blue Whale, Bryde's Whale, and Sperm Whale migrations may overlap with in-field construction activities. However, the Fourth Train Proposal marine construction activities are expected to be short term, and affect only small areas of the wider Fourth Train Proposal Area, therefore reducing the potential for impact.

Under the approved Foundation Project, MFOs have recorded whale observations, with data from 2010 to 2012. Most confirmed sightings were of Humpback Whales; there were relatively few confirmed sightings of other whale species. To date, there have been no instances of physical interaction with whales that have been attributable to Foundation Project activities. Areas that are considered most sensitive to the Humpback Whale's migratory cycle, including breeding, calving, and resting areas, do not occur in the vicinity of the Fourth Train Proposal Area or its associated marine activities.

Fourth Train Proposal marine activities will increase the overall level of activity within the Fourth Train Proposal Area during the operations phase, when compared to the approved Foundation Project. However, marine vessel activity during the operations phase of the Fourth Train Proposal will be transient and over a small area. Operations phase marine vessel activity resulting from the Fourth Train Proposal additional to the Foundation Project was not assessed to change the level of potential impact ('Medium') associated with marine vessel interaction on nearshore marine fauna, which may include Humpback Whales. However, whales are not the most sensitive receptor for physical interaction. The migratory nature of these species across large geographic ranges reduces the potential for these whale species to be impacted by physical interaction. The level of potential impacts from physical interaction on marine fauna within the Commonwealth Marine Area, including whale species, was assessed as 'Low'.

Spills and Leaks

Spills and leaks have the potential to occur in nearshore and offshore waters during both construction and operation of the Fourth Train Proposal. Large, prolonged spills and leaks of hydrocarbons are considered to have the greatest potential impact to migratory whale species, as the duration of exposure to potential impacts is increased. Potential impacts include direct and indirect toxic effects and behavioural responses, such as movement away from the affected areas.

Condensate is highly volatile and rapidly evaporates into the atmosphere once it reaches the water's surface. Depending on the timing of exposure, high doses of vapours associated with hydrocarbon releases can result in respiratory damage and, in extreme cases, narcosis. Baleen whales, which include Pygmy Blue Whales, Bryde's Whales, and Humpback Whales, filter large volumes of sea water to feed and therefore may be susceptible to impacts from direct ingestion of hydrocarbons entrained in the water column, and their subsequent toxic effects. Toothed and baleen whales could indirectly ingest hydrocarbon compounds through tainted food sources.

Hydrocarbon spill modelling completed for the Fourth Train Proposal Area included a subsea well blowout within the Chandon Gas Field and also an intrafield pipeline rupture at the Jansz Pipeline Termination Structure Tie-in and at the Chandon Manifold Tie-in, resulting in releases of condensate. Modelling indicated that surface slicks (of more than 10 g/m^2) resulting from these scenarios would be likely to remain seaward of the main Humpback Whale migration corridor during the migration period. It is reasonable to assume that a similar large-scale release of hydrocarbons (i.e. due to a well blowout at the Fourth Train Proposal gas fields closer to the Humpback Whale BIA) could expose greater numbers of Humpback Whales to potential impacts. However, lower condensate-to-gas ratios at other Fourth Train Proposal gas fields, when compared to the Chandon Gas Field, indicate that released hydrocarbons would not be expected to persist. The extent of potential impacts would be restricted by the high evaporation rates of aromatic components. In the unlikely event that the Humpback Whale BIA for migration is exposed to hydrocarbons from a large-scale release of hydrocarbons, areas peripheral to the BIA are expected to allow continued migration.

Areas considered particularly sensitive to hydrocarbon exposure are those used by cetaceans for resting, breeding, and calving. Modelled hydrocarbon spill scenarios indicate that surface, entrained, or aromatic hydrocarbons are unlikely to accumulate in known Humpback Whale resting areas in Exmouth Gulf, and would not extend to known breeding and calving areas north of the Fourth Train Proposal Area (Sections 6.2.1.1 and 6.2.2 of Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill]). The feeding activity of Humpback Whales during their migrations through the North-west Marine Region is thought to be opportunistic, with primary feeding grounds located at higher latitudes, thousands of kilometres from the Fourth Train Proposal Area.

The likelihood of potential impacts occurring due to a substantial spill or leak (e.g. a well blowout, a pipeline rupture, or a major fuel spill) is remote. In addition, in the event of a hydrocarbon release, rapid weathering characteristics of the released hydrocarbons (i.e. condensate) indicates that cetaceans would only be exposed to hydrocarbons in the short term. Based on an assessment of severity of the consequence (while recognising that there is a low probability of a substantial spill or leak occurring), the level of potential impact on marine fauna from the Fourth Train Proposal due to spills and leaks during construction and operations was assessed as ‘Medium’. However, whales are not the most sensitive receptor for spills and leaks. The migratory nature of these species across large geographic ranges reduces the potential for these whale species to be impacted by spills and leaks.

Summary

The Fourth Train Proposal will increase the level of marine vessel activity in the nearshore waters of Barrow Island and offshore during construction and operations activities, when compared to the approved Foundation Project. This will increase the number of transient sources of noise emissions, add to ambient noise, and increase the potential for disturbance from noise to occur. The additional vessel activity will also increase the potential for interactions between marine vessels and migratory whales. MFO observations during the Foundation Project have included Humpback Whale sightings from vessels; no physical interactions between marine vessels and Humpback Whales have been reported to date. Potential impacts due to a substantial spill or leak are not expected. When considered in addition to the Foundation Project, the Fourth Train Proposal is not predicted to increase the level of potential impact to marine fauna from that assessed for the approved Foundation Project.

Marine construction and operation activities will only affect a relatively small proportion of the Fourth Train Proposal Area at any one time. The large geographic area used by of whale species is expected to reduce the potential for stressors to result in impacts at a species level. Stressors are not expected to act synergistically, or result in widespread additive impacts to whale species.

13.4.2.3 Potential Impacts on Listed Threatened and Migratory Marine Reptiles

Five species of marine turtles are considered under the assessment of marine reptiles. The Flatback, Green, Hawksbill, Loggerhead, and Leatherback Turtles are all listed as both threatened and migratory species under the EPBC Act. One species of sea snake is considered under the assessment of marine reptiles; the Short-nosed Sea Snake is listed as threatened (Critically Endangered) under the EPBC Act (Table 13-9).

Several factors affect the vulnerability of marine turtles, including their late sexual maturity and complex ecology (they rely on a range of different nearshore and offshore environments). These factors may expose marine turtles to a number of stressors from human activities. The vulnerability of the Short-nosed Sea Snake is related to its slow growth rate, low number of offspring, specific dietary requirements, and small habitat ranges. The availability of scientific information on many marine reptile species, including their distribution and behaviour, is limited and can make the long-term implications of an impact difficult to assess at the species level. Where this is the case, the Fourth Train Proposal has adopted a conservative approach to impact identification, assessment, mitigation, and management.

13.4.2.3.1 Marine Turtles

The Fourth Train Proposal stressors (Table 13-10) that are considered relevant to marine turtles include artificial light, discharges to sea, noise and vibration, physical interaction, and spills and leaks. These stressors reflect pressures cited by DotE for marine turtles within the North-west Marine Region (Table 13-16).

Table 13-16: DotE Pressure Analysis for Marine Turtles: Pressures Considered Relevant to the Fourth Train Proposal

Pressures of Concern	Pressures of Potential Concern	Pressures of Less Concern
• Light pollution from onshore activities • Marine debris from shipping and vessels	• Nutrient pollution from urban development • Noise pollution from onshore and offshore construction	• Chemical pollution from urban development • Light pollution from offshore activities • Oil pollution from shipping and oil rigs

Adapted from SEWPaC 2012d

The Fourth Train Proposal stressors identified for marine turtles are associated with the movement of marine vessels and the construction and operation of both onshore and marine components of the Fourth Train Proposal. The identified stressors will be relevant throughout the construction and operations activities of the Fourth Train Proposal.

Of the five marine turtle species that may be present in the Fourth Train Proposal Area, the Flatback Turtle is considered more likely to be exposed to stressors from construction and operations activities of the Fourth Train Proposal on the east coast of Barrow Island. Green Turtles are considered to have greater potential to be exposed to stressors from construction of the Fourth Train Proposal Offshore Feed Gas Pipeline System and its shore crossing on the west coast of Barrow Island, as Green Turtle rookeries are located primarily on west coast beaches.

A number of stressors are relevant mainly in the nearshore environment e.g. emissions of light from onshore facilities, discharges to sea, noise and vibration from marine vessels, and physical interaction in nearshore waters. These stressors are considered in the assessment of potential impacts on marine turtles below. Further discussion and assessment is provided in Section 10.6.3.1.

Flatback Turtle

The east coast beaches of Barrow Island are considered a regionally important nesting site for Flatback Turtles. In addition, some of the marine components of the Fourth Train Proposal Area overlap with BIAs identified for Flatback Turtle internesting and foraging (Figure 6-18). Therefore, Flatback Turtles may be exposed to impacts from both onshore and offshore Fourth Train Proposal construction and operations activities. Key stressors for the Flatback Turtle are considered to be artificial light, physical interaction, discharges to sea, and spills and leaks (Table 13-10).

Artificial Light

Light spill from onshore sources onto turtle nesting beaches has the potential to misorient turtle hatchlings, which are believed to use celestial light reflected off the water as a natural cue for orientation to the ocean. This has the potential to result in adverse effects such as increased predation. Adult marine turtles may avoid brightly lit beaches, resulting in their movement to less suitable beaches, although marine turtles have been observed to continue nesting with the introduction of light (Pendoley 2005).

Within the nearshore and offshore marine environment, marine turtles may be exposed to artificial light, including light from marine vessels during construction and operations activities. A number of onshore light sources from the Fourth Train Proposal will exist off the east coast of Barrow Island through construction and operation activities.

Fourth Train Proposal marine construction activities will mostly occur in the marine environment off the west coast of Barrow Island; therefore, these activities are not predicted to affect Flatback Turtle nesting and hatching stages, which occur primarily on the east coast beaches of Barrow Island.

Light spill modelling was completed for the operations phase of the Fourth Train Proposal Gas Treatment Plant in addition to the approved Foundation Project Gas Treatment Plant to calculate the light levels required for safe work practices, while also reducing light spill to potentially sensitive turtle nesting beaches in the area. Under most circumstances, light spill to the beaches would be between the luminance level of a quarter moon and a clear moonless night, with illuminances less than 10^{-3} lux. Experience to date from Foundation Project monitoring has shown that nesting Flatback Turtles returned in comparable numbers to Barrow Island beaches despite increases in light emissions during construction, and that the rookery is currently stable (Chevron Australia 2011a, 2013a). Despite some evidence of variation in current (versus pre-construction) sea-finding pathways, there has been no evidence of disruption causing hatchlings to either misorient landward, or become terminally disoriented (Chevron Australia 2013a). Note: The Combined Gorgon Gas Development light emissions from the operational Gas Treatment Plant are predicted to result in one to two orders of magnitudes less illuminance than those assessed and approved for the Foundation Project. This reduction in light emissions is explained by changes to Foundation Project lighting design that have resulted in reductions in Gas Treatment Plant light level emissions and by refining the light modelling design (Section 5.3.3).

The operational Fourth Train Proposal is predicted to increase the regularity of light offshore from the east coast of Barrow Island; sources of light include LNG and condensate vessels at the LNG Jetty. Marine turtle hatchlings that are attracted to areas of light spill on the ocean may be more susceptible to predation. The Foundation Project has undertaken monitoring to better understand the potential impacts of artificial light at the Materials Offloading Facility in the nearshore environment. The number of hatchlings observed at lit checkpoints was small in comparison to the numbers detected to be leaving the natal beach (using daytime track surveys), suggesting that artificial light sources did not exert a significant influence on the level of hatchling congregation. At this stage it is difficult to ascertain if the hatchlings were actively attracted to the light spill or passively dispersed into a lit area (Chevron Australia 2012a). Lohmann and Lohmann (1992) indicate that the primary cue for marine turtle hatchlings during their swim frenzy is wave direction, which may override any influence of artificial light.

Offshore, artificial light sources in the Commonwealth Marine Area will include those from marine vessel and drilling activities (Section 13.5.4). Drilling activities will occur during construction of the Fourth Train Proposal, and these activities are likely to be the longest static source of artificial light offshore. However, these activities are still expected to be short term, and will occur at locations remote to BIAs for the Flatback Turtles. Marine vessels used for the offshore construction and operations activities may be static for short periods of time, and are only expected to be an area for a short time. A level of uncertainty in predicting potential impacts to marine turtles is recognised. As a result, the Long-term Marine Turtle Management Plan (Chevron Australia 2014a) has adopted an adaptive management framework to its monitoring and incident response approaches: tiered management triggers (‘Alert’, ‘Review’, ‘Action’) provide a system where measured parameters are monitored and reviewed to identify deviation from natural variability. This tiered approach informs managers when action should be taken. The Gorgon Marine Turtle Expert Panel is consulted during this process. The level of potential impact of artificial light from the Fourth Train Proposal to marine fauna, including Flatback Turtles, was assessed as ‘Medium’.

Discharges to Sea

Discharges to sea will occur in the nearshore and offshore environments; these include discharges from marine vessels and onshore facilities during both construction and operations activities. Discharges from drilling rigs will occur offshore during construction. Discharges, such as cuttings from drilling activities or of treated hydrotest water may elicit behavioural responses from marine turtles, such as avoidance of these areas. However, the effects (e.g.

reduced water quality) of these discharges will be short term and local to the source of the discharge. In addition, discharges are not anticipated to result in adverse metabolic impacts (e.g. toxic effects) to marine turtles. The discharges are expected to dilute so that changes in water quality are not expected beyond the vicinity of the discharge source. Long-term discharges as a result of the Fourth Train Proposal will include those from the operation of the reverse osmosis facilities, which will be discharged to nearshore waters. Assessment of potential impacts has indicated that adverse effects to marine fauna, including marine turtles, are not expected as a result of the discharges from these facilities. The level of potential impact of discharges to sea from the Fourth Train Proposal on marine fauna, including Flatback Turtles, was assessed as 'Low'.

Noise and Vibration

Sources of noise and vibration in the Fourth Train Proposal Area include marine vessels, constructing the shore crossing, and drilling the offshore wells. The audible frequency range of marine turtles is considered to be between 100 and 1000 Hz; hearing occurs by vibration conducted through the skeletal system (Southwood *et al.* 2008). This audible frequency range of marine turtles overlaps with some of the marine activities for the Fourth Train Proposal (Figure 10-3). Studies (e.g. O'Hara and Wilcox 1990; McCauley *et al*. 2000) into the reaction of marine turtles to underwater noise have focused on the assessment of short-term responses to airgun arrays (e.g. during seismic surveys). These studies indicate that marine turtles may show strong initial avoidance behaviour to airgun arrays. During construction, seismic survey work may be undertaken (e.g. VSP operations during drilling); however, VSP activities will be short in duration and distant from any BIAs identified for marine turtles, including Flatback Turtles. Other marine activities, including construction of the Fourth Train Proposal Offshore Feed Gas Pipeline and the movement of marine vessels, is not anticipated to generate noise to the same intensity as seismic work. The level of potential impact of noise and vibrations from the Fourth Train Proposal on marine fauna, including Flatback Turtles, was assessed as 'Low'.

Physical Interaction

Physical interaction from marine vessels involved in construction and operations activities has the potential to result in injury or mortality to marine turtles given the vulnerability of these species when breathing or resting at the water's surface. The potential impacts from physical interaction are considered to be greatest in the nearshore environment, particularly in areas identified as BIAs where aggregations of individual marine turtles may occur. Many marine vessels (e.g. pipe-lay vessels) operate at low speeds, reducing the potential for impacts to mobile marine fauna such as marine turtles. During operations, marine vessel activities will include the operation of LNG and condensate vessels and logistics vessels. Within port limits, speed restrictions will reduce the potential for physical interactions with marine fauna. In offshore waters, the distance between vessel activities will generally increase, and the density of marine turtles will reduce with the increased distance from habitat associated with the nearshore environment, thus reducing the potential for physical interaction. To date, the Foundation Project has recorded four incidents relating to Flatback Turtles where the outcome has been recorded as either 'unknown' or 'not natural' (may be attributable, or partially attributable, to Foundation Project activities) (Chevron Australia 2009, 2010, 2011b, 2012b, 2013a). These incidents may have been the result of physical interaction with Foundation Project vessels. The level of potential impact of physical interaction from the Fourth Train Proposal to marine fauna, including Flatback Turtles, was assessed as 'Medium'.

Seabed Disturbance

Two rocky reefs are located approximately 12 km and 25 km from the west coast of Barrow Island, in 40 m and 50–55 m water depths respectively. These reefs may provide foraging opportunities for Flatback Turtles. Seabed disturbance during construction activities such as trenching and the placement of stabilisation materials (e.g. graded rock and concrete mattresses), may result in potential impacts to the availability of this area for foraging. These potential impacts will be localised, with only a small area of the total reef features directly impacted by the Fourth Train Proposal Offshore Feed Gas Pipeline System. The Fourth Train Proposal Offshore Feed Gas Pipeline System and stabilisation materials will also provide substrate of a similar nature to the rocky reef; benthic seabed communities displaced during construction are likely to recover and be recolonised once seabed disturbance ceases. The level of potential impact of seabed disturbance from the Fourth Train Proposal on marine fauna, including Flatback Turtles, was assessed as 'Low'.

Spills and Leaks

Hydrocarbon spills and leaks that encroach upon Barrow Island have the potential to adversely impact marine fauna, including Flatback Turtles, in the nearshore environment. Waters close to Barrow Island provide habitat for marine turtles and are considered sensitive to potential impacts from spills and leaks. Potential impacts to marine turtles may include direct and indirect toxic effects (e.g. from ingestion and inhalation of volatile hydrocarbons) and behavioural responses, such as movement away from the affected areas. Modelling was undertaken for a number of nearshore and offshore scenarios related to the Fourth Train Proposal. The worst-case spill scenario for marine fauna in the nearshore environment of Barrow Island is a bunker fuel oil spill due to the heavy and persistent nature of the hydrocarbon; this scenario involved a vessel grounding during the operations phase. Such a spill off the east coast of Barrow Island could cause toxic effects to marine turtles (particularly Flatback Turtles) as a result of inhalation, ingestion, and/or direct contact with fresh surface hydrocarbons. In the Commonwealth Marine Area, scenarios modelled for large-scale hydrocarbon spills (e.g. subsea well blowout at the Chandon Gas Field) indicate that hydrocarbons could spread to marine turtle habitats outside the Fourth Train Proposal Area, including internesting BIAs at Barrow Island and at the Ningaloo Coast (Table 13-4). The cyclic nature of nesting activity and the broad distribution of marine turtles, including Flatback Turtles, may reduce the potential for species-level impacts . Also, as Fourth Train Proposal condensate is not expected to partition to the seabed, foraging habitat for Flatback Turtles is unlikely to suffer long-term effects. The level of potential impact associated with spills and leaks from the Fourth Train Proposal to marine fauna, including Flatback Turtles, was assessed as 'Medium'.

Summary

To date, data collected from Terminal Beach and Bivalve Beach by the Foundation Project turtle monitoring program (Section 3.5.2.1) indicates that female Flatback Turtles return in comparable numbers to preferred beaches, nesting success is comparable to the environmental baseline, and hatchling orientation has not changed despite increases in light emissions and other disturbance generated by the Foundation Project construction activities. The Flatback Turtle population is tracked through implementation of the Long-term Marine Turtle Management Plan (Chevron Australia 2009), with oversight from the Marine Turtle Expert Panel (Section 13.4.3). The mitigation and management measures being undertaken by the Foundation Project reflect a conservative approach of population monitoring and, if necessary, adaptive management.

The Fourth Train Proposal additional to the approved Foundation Project will result in additional construction activities and associated potential impacts; additional geographic areas may also be exposed to potential impacts. Marine activities of the Fourth Train Proposal (e.g. drilling, installation, and operation of wells and the Offshore Feed Gas Pipeline System) are expected to be similar to those of the Foundation Project. Some Fourth Train Proposal and Foundation Project marine activities are likely to overlap, increasing the overall level of activity in the Fourth Train Proposal Area. The number of artificial light sources (from marine vessels) offshore may also increase, also increasing the potential for interaction between marine vessels and Flatback Turtles. However, artificial light sources associated with offshore construction activities will be short term, marine vessels will be transient, and the associated potential impacts are expected to be localised. The duration and level of artificial light produced on the east coast of Barrow Island at the Gas Treatment Plant may increase due to Fourth Train Proposal. However, modelling of illuminance from the Gas Treatment Plant at Flatback Turtle nesting beaches indicates that the increase in illumination due to the Fourth Train Proposal will be negligible when compared to the Foundation Project. The probability of a spill or leak increases with the addition of the Fourth Train Proposal; however, the likelihood of potential impacts occurring to marine fauna, including Flatback Turtles, remains remote. The consequence of spills and leaks to marine fauna is considered to be the same as that assessed for the Foundation Project. When considered in addition to the Foundation Project, the Fourth Train Proposal is not predicted to increase the level of potential impact to Flatback Turtles, from that assessed for the Foundation Project.

Marine construction and operations activities will only affect a relatively small proportion of the Fourth Train Proposal Area at any one time. Stressors associated with these activities are not expected to act synergistically, or result in widespread additive impacts to Flatback Turtles.

Green Turtle

The north-west Australian population of Green Turtles is considered regionally important, being genetically distinct from other stocks found in the wider region. The Green Turtle reproductive population at Barrow Island is estimated at around 20 000 females (Pendoley 2005), comprising an important proportion of the North West Shelf genetic stock (Prince 1994; Moritz *et al*. 2002), despite this rookery being smaller than the rookery at the Lacepede Islands. Green Turtles tend to nest on the west, north, and north-east coasts of Barrow Island; the Fourth Train Proposal Area in State Waters also overlaps foraging and internesting BIAs identified for the Green Turtle (Figure 6-17). Internesting habitat also extends into the Commonwealth Marine Area.

Fourth Train Proposal marine activities occurring off the west coast of Barrow Island may expose Green Turtles to potential impacts. Key stressors for Green Turtles were considered to be artificial light, physical interaction, noise and vibration, discharges to sea, and spills and leaks (Table 13-10). Stressors may result from activities including constructing the shore crossing for the Fourth Train Proposal Offshore Feed Gas Pipeline System, pipe-lay and associated marine vessel movements, and offshore drilling. Marine vessel activities will continue throughout the operation of the Fourth Train Proposal.

Artificial Light

Light spill from onshore activities has the potential to misorient Green Turtle hatchlings, and dissuade adult female turtles from nesting at areas of beach that receive artificial light from Fourth Train Proposal activities. On the west coast of Barrow Island, night-time construction activities associated with the shore crossing may result in artificial light emissions to North Whites Beach. Although small numbers of Green Turtles have been observed at North Whites Beach, most Green Turtle nesting activity is associated with Whites Beach, approximately 0.5 km south of the Fourth Train Proposal shore crossing location. The shore crossing has been located at North Whites Beach to avoid nesting female Green Turtles. Construction activities at North Whites Beach will be short term and are not anticipated to result in adverse effects to Green Turtles at the species level. Construction of the marine components of the Offshore Feed Gas Pipeline System will require vessels to come close to the west coast of Barrow Island, which may generate light off the beach; these marine vessel activities will be short term and are not anticipated to result in species-level effects. The level of potential impact of artificial light from the Fourth Train Proposal on marine fauna, including Green Turtles, was assessed as ‘Medium’. However, Green Turtles are not the most sensitive receptor for artificial light. Green Turtle nesting activity is predominantly associated with the west coast of Barrow Island, where the presence of onshore artificial light will be short term, reducing the potential for this species to be impacted by this stressor.

Discharges to Sea

The potential impacts from discharges to sea from the Fourth Train Proposal activities are expected to be greatest at the Green Turtle internesting and foraging grounds in the nearshore environment of Barrow Island. Discharges in these areas will include the drilling cuttings from construction of the shore crossing for the Fourth Train Proposal Offshore Feed Gas Pipeline System on the west coast of Barrow Island, and operational discharges such as reverse osmosis brine from onshore facilities on the east coast of Barrow Island. The assessment of potential impacts to marine fauna from discharges to sea suggests that adverse effects are unlikely to manifest in Green Turtles. The level of potential impact associated with discharges to sea from the Fourth Train Proposal to marine fauna, including Green Turtles, was assessed as 'Low'.

Noise and Vibration

The construction of the shore crossing has the potential cause vibrations in its immediate vicinity and has the potential to disturb Green Turtle nesting at Whites Beach. However, potential impacts resulting from vibration are not anticipated as monitoring data from both the east and west coasts of Barrow Island between 2009 and 2012 has shown no discernible noise and vibration increase with construction activities (SVT Engineering Consultants 2012). Monitoring of noise and vibration is currently suspended in consultation with the Marine Turtle Expert Panel (Chevron Australia 2013a) (Sections 3.5.5and 3.5.6).

Noise and vibration in the marine environment will occur during both construction and operations activities of the Fourth Train Proposal. Some construction activities may generate high-intensity noise; these activities may include VSP operations during drilling, which will be short in duration and will occur at the gas fields, beyond the range of potential impact to marine turtle BIAs. VSP operations are not anticipated to generate noise levels that may cause long-term harm to marine turtles (Section 13.5.6). Noise generated during operations will be from sources such as shipping and marine vessels; the level of noise generated is anticipated to be less than that for construction activities. The level of potential impact of noise and vibrations from the Fourth Train Proposal on marine fauna, including Green Turtles, was assessed as 'Low'.

Physical Interaction

Physical interaction has the potential to impact individual Green Turtles. Foraging and internesting BIAs in the nearshore waters around Barrow Island are areas where Green Turtles are at most risk from physical interaction. Construction activities are likely to include periods of increased marine vessel activity, particularly around the construction of the Offshore Feed Gas Pipeline System in the nearshore environment, where it may also be necessary to use an anchor-handling vessel. Construction vessels on the west coast of Barrow Island are expected to be slow moving or stationary when working, reducing the potential for impacts associated with physical interaction to occur. During operations, the increase in shipping activity on the east coast of Barrow Island has the potential to increase the exposure of marine fauna, including marine turtles, to physical interaction (Section 10.6.2.6). To date, the Foundation Project has recorded eight incidents relating to Green Turtles where the outcome has been recorded as either 'unknown' or 'not natural' (may be attributable, or partially attributable, to Foundation Project activities) (Chevron Australia 2009, 2010, 2011b, 2012b, 2013a). These incidents may have been the result of physical interaction with Foundation Project vessels.

The level of potential impact of physical interaction from the Fourth Train Proposal on marine fauna, including Green Turtles, was assessed as 'Medium'. However, Green Turtle nesting activity is predominantly associated with the west coast of Barrow Island, where marine vessel activity will be short term and/or transient in the nearshore environment, reducing the potential for this species to be impacted by physical interaction.

Spills and Leaks

Areas of habitat for Green Turtles that may be exposed to hydrocarbon spills and leaks from the Fourth Train Proposal include Green Turtle BIAs that surround Barrow Island, nesting habitats on the west coast and northern beaches of Barrow Island, and also BIAs occurring at the Ningaloo Coast and Muiron Islands. Potential scenarios for spills and leaks and their potential impacts on the nearshore environment are discussed further in Section 10.6.2.8. The maximum levels of hydrocarbons (entrained) that were modelled to reach the Muiron Islands and the Ningaloo Coast during spring (Section 13.2.2.2) were 2220 ppb and 2940 ppb (respectively). Springtime spills and leaks in these areas could coincide with the emergence of Green Turtle hatchlings. Exposure of Green Turtles at the Ningaloo Coast and Muiron Islands to worst-case concentrations of entrained hydrocarbons could induce injury or irritation in their soft tissues; hydrocarbons could also foul nesting, internesting, and foraging habitat. However, Green Turtles exhibit cyclic nesting patterns, typically returning to nest every three to five years, thus limiting the number of individual Green Turtles potentially affected by a spill or leak event. Therefore, it is unlikely that a substantial reduction in species-level nesting success for any marine turtle species would occur. In addition, surface slicks, which may have the potential to cause acute adverse (e.g. respiratory) effects were not predicted to exceed concentration thresholds of 10 g/m^2 for any season at the Ningaloo Coast (including BIA habitat for Green Turtles). The level of potential impact associated with spills and leaks from the Fourth Train Proposal to marine fauna, including Green Turtles, was assessed as ‘Medium’.

Summary

Although individual Green Turtles may be exposed to potential impacts from Fourth Train Proposal activities, the implementation of the Fourth Train Proposal is not anticipated to result in adverse species-level effects.

Monitoring showed high numbers of Green Turtle emergences at Barrow Island in the 2011–2012 season relative to environmental baseline data, and a low number of emergences in the 2012–2013 season, representing a continuation of a natural oscillating-cyclical trend in nesting activities observed since monitoring began (Chevron Australia 2012a, 2013a). The proportion of Green Turtles nesting within 2 km of Foundation Project activities was not significantly different in the 2012–2013 season, indicating that Green Turtle activity has not been significantly affected by the Foundation Project construction activities on Barrow Island to date (Chevron Australia 2013a).

The Fourth Train Proposal additional to the approved Foundation Project will result in additional construction activities and their associated potential impacts; additional geographic areas may also be exposed to potential impacts. Fourth Train Proposal marine activities (e.g. drilling, installation, and operation of wells and the Offshore Feed Gas Pipeline System) are expected to be similar to those of the Foundation Project. Fourth Train Proposal and Foundation Project marine activities are likely to overlap, increasing the overall level of activity in the Fourth Train Proposal Area. Artificial light sources associated with offshore construction activities will be short term, and marine vessels will generally be transient. Onshore sources of artificial light on the west coast of Barrow Island will be short term. The probability of a spill or leak increases with the addition of the Fourth Train Proposal; however, the likelihood of potential impacts occurring to marine fauna, including Green Turtles, remains remote. The consequence of spills and leaks to marine fauna is considered to be the same as that assessed for the Foundation Project. When considered in addition to the Foundation Project, the Fourth Train Proposal is not predicted to increase the level of potential impact to Green Turtles, from that assessed for the Foundation Project.

Marine construction and operations activities will only affect a relatively small proportion of the Fourth Train Proposal Area at any one time. Stressors associated with these activities are not expected to act synergistically, or result in widespread additive impacts to Green Turtles.

Hawksbill Turtle

Although Barrow Island is not considered a regionally important nesting site for Hawksbill Turtles, which tend to favour nesting sites adjacent to coral reefs, a small number are known to nest on beaches along the east and north-east coasts of Barrow Island. BIAs for Hawksbill Turtle nesting, foraging, and internesting have been identified within the State Waters surrounding Barrow Island, with internesting habitat extending into the Commonwealth Marine Area (Figure 6-19).

Nearshore and offshore marine activities associated with the Fourth Train Proposal may expose Hawksbill Turtles to similar stressors as those assessed for Flatback and Green Turtles, including artificial light, noise and vibration, discharges to sea, and physical interaction (Table 13-10). Potential impacts associated with these stressors are expected to be short term and, with the absence of significant nesting sites on Barrow Island, only low numbers of Hawksbill hatchlings are likely to be exposed to potential impacts.

Spills and Leaks

Spills and leaks resulting from the Fourth Train Proposal have the potential to impact nesting and internesting BIAs for Hawksbill Turtles located outside the Fourth Train Proposal Area. Hydrocarbon spill modelling results indicate that a large spill or leak of hydrocarbons, including due to a sustained release following a subsea well blowout in the Chandon Gas Field, has the potential to reach nesting populations associated with the Muiron Islands and the Ningaloo Coast (Table 5-27). The maximum levels of hydrocarbons (entrained) that were modelled to reach the Muiron Islands and the Ningaloo Coast during spring (Section 13.2.2.2) were 2220 ppb and 2940 ppb (respectively). Springtime spills and leaks in these areas could coincide with the emergence of Hawksbill Turtle hatchlings.

If entrained hydrocarbons reach BIAs, habitat, including foreshore nesting areas, could become contaminated. Exposure of marine turtles to worst-case concentrations of entrained condensate could induce injury or irritation in their soft tissues; hydrocarbons could also foul nesting, internesting, and foraging habitat. However, Hawksbill Turtles exhibit cyclic nesting patterns, typically returning to nest every two to four years, thus limiting the number of individual Hawksbill Turtles potentially affected by a spill or leak event. Further, the individuals arriving at the Ningaloo Coast represent only a proportion of Hawksbill Turtle populations across the North-west Marine Region. Therefore, it is unlikely that a substantial species-level reduction in nesting success or survival for Hawksbill Turtles would occur. In addition, surface slicks, which may have the potential to cause acute adverse (e.g. respiratory) effects, were not predicted to exceed concentration thresholds of 10 g/m^2 for any season at the Ningaloo Coast. The level of potential impact of spills and leaks from the Fourth Train Proposal on marine fauna was assessed as ‘Medium’. However, Hawksbill Turtles are not the most sensitive receptor for spills and leaks. Large numbers of Hawksbill Turtles do not nest on Barrow Island and are unlikely to be exposed to ecologically significant concentrations of hydrocarbons in the event of spill and leaks due to the Fourth Train Proposal, reducing the potential for Hawksbill Turtles to be impacted by this stressor.

Summary

Although individual Hawksbill Turtles may be exposed to potential impacts from Fourth Train Proposal activities, no long-term adverse effects are anticipated at a species level. Therefore, the implementation of the Fourth Train Proposal is not anticipated to interfere with the recovery of the Hawksbill Turtle species, or seriously disrupt the life cycle (breeding, feeding, migration, or internesting behaviour) of ecologically significant numbers of this species. Fourth Train Proposal activities are also not expected to fragment the existing populations of Hawksbill Turtles in the North-west Marine Region, and are unlikely to reduce the area of occupancy of this species.

The Fourth Train Proposal additional to the approved Foundation Project will result in additional construction activities and their associated potential impacts; additional geographic areas may also be exposed to potential impacts. Marine activities of the Fourth Train Proposal (e.g. drilling, installation, and operation of wells and the Offshore Feed Gas Pipeline System) are expected to be similar to those of the Foundation Project. Fourth Train Proposal and Foundation Project marine activities are likely to overlap, increasing the overall level of activity within the Fourth Train Proposal Area. Artificial light sources associated with offshore construction activities will be short term, and marine vessels will generally be transient. Light levels from additional onshore light sources at the Gas Treatment Plant site are predicted to be negligible when modelled alongside Foundation Project light sources (Section 5.3.3.3). The probability of a spill or leak increases with the addition of the Fourth Train Proposal; however, the likelihood of potential impacts occurring to marine fauna, including Hawksbill Turtles, remains remote. The consequence of spills and leaks to marine fauna is considered to be the same as that assessed for the Foundation Project. When considered in addition to the Foundation Project, the Fourth Train Proposal is not predicted to increase the level of potential impact to marine turtles, from that assessed for the Foundation Project.

Marine construction and operations activities will only affect a relatively small proportion of the Fourth Train Proposal Area at any one time. Stressors associated with these activities are not expected to act synergistically, or result in widespread additive impacts to Hawksbill Turtles.

Leatherback Turtle

Offshore marine activities (e.g. drilling, pipe-lay, marine vessel movements) associated with the Fourth Train Proposal may expose Leatherback Turtles to similar stressors as those assessed for Flatback and Green Turtles, including light, physical interaction, discharges to sea, and spills and leaks (Table 13-10).

The Leatherback Turtle is a pelagic, oceanic species; it is considered to be a non-breeding migrant to waters on the west coast of Australia, and is uncommon within its Australian range (SEWPaC 2012d). It is possible that vagrant individuals may transit through the Fourth Train Proposal Area and thus come within range of the Fourth Train Proposal stressors (Table 13-10). However, effects at a broader species level are not expected given the small number of individuals that may be encountered. In addition, no BIAs for foraging have been identified to support this species in the vicinity of the Fourth Train Proposal Area. The potential impacts from the Fourth Train Proposal are no different to those identified for the Foundation Project.

Although the Fourth Train Proposal may expose different geographic areas to potential impacts, these are not anticipated to be important areas for Leatherback Turtles. Stressors associated with the Fourth Train Proposal are not expected to act synergistically, or result in widespread additive impacts to Leatherback Turtles.

Loggerhead Turtle

Loggerhead Turtles have been observed feeding in the waters surrounding Barrow Island (Chevron Australia 2005). Occasional nesting on Barrow Island beaches occurs (Chevron Australia 2008), but Loggerhead Turtles typically breed from Dirk Hartog Island to the Muiron Islands. An internesting BIA for Loggerhead Turtles has been identified for waters around the northern end of Barrow Island; BIAs for both nesting and internesting are identified at the Lowendal and Montebello Islands and waters surrounding these islands (Figure 6-20). Offshore marine activities (e.g. drilling, pipe-lay, marine vessel movements) associated with the Fourth Train Proposal may expose Loggerhead Turtles to similar stressors as those assessed for Flatback and Green Turtles, including artificial light, physical interaction, discharges to sea, and spills and leaks (Table 13-10).

The potential for Loggerhead Turtle individuals to be impacted by discharges to sea, artificial light, and physical interaction exists within internesting areas. However, species-level impacts are considered unlikely as the Barrow Island beaches and the wider marine environment within the vicinity of the Fourth Train Proposal have not been identified as supporting significant numbers of nesting females.

Spills and Leaks

Spills and leaks resulting from the Fourth Train Proposal have the potential to impact nesting and internesting BIAs for Loggerhead Turtles located outside the Fourth Train Proposal Area. Entrained hydrocarbons released from the Chandon Gas Field during a worst-case blowout scenario were modelled to reach the Muiron Islands and the Ningaloo Coast at up to 2220 ppb and 2940 ppb (respectively) during spring, outside peak activity times for breeding and nesting, but may overlap the time when Loggerhead Turtle hatchlings emerge. If entrained hydrocarbons reach BIAs, habitat, including foreshore nesting areas, could become contaminated. Exposure of Loggerhead Turtles at the Ningaloo Coast and Muiron Islands to worst-case concentrations of entrained condensate could induce injury or irritation to their soft tissues; hydrocarbons could also foul nesting, internesting, and foraging habitat. However, Loggerhead Turtles exhibit cyclic nesting patterns, typically returning to nest every two to five years, thus limiting the number of individual Loggerhead Turtles potentially affected by a spill or leak event. Therefore, it is unlikely that a substantial species-level reduction in nesting success for any marine turtle species would occur.

Surface hydrocarbon slicks, which may have the potential to cause acute adverse (e.g. respiratory) effects, were not predicted to exceed concentration thresholds of 10 g/m^2 for any season at the Ningaloo Coast (including BIA habitat for Loggerhead Turtles). The level of potential impact of spills and leaks from the Fourth Train Proposal on marine fauna was assessed as 'Medium'. However, Loggerhead Turtles are not the most sensitive receptor for spills and leaks. Large numbers of Loggerhead Turtle do not nest on Barrow Island and are unlikely to be exposed to ecologically significant concentrations of hydrocarbons in the event of spills and leaks due to the Fourth Train Proposal, reducing the potential for Loggerhead Turtles to be impacted by this stressor.

Summary

Although individual Loggerhead Turtles may be exposed to potential impacts from Fourth Train Proposal activities, no long-term adverse effects are anticipated at a species level. Therefore, the implementation of the Fourth Train Proposal is not anticipated to interfere with the recovery of the Loggerhead Turtle species, or seriously disrupt the life cycle (breeding, feeding, migration, or internesting behaviour) of ecologically significant numbers of this species.

The Fourth Train Proposal additional to the approved Foundation Project will result in additional construction activities and their associated potential impacts; additional geographic areas may also be exposed to potential impacts. Fourth Train Proposal marine activities (e.g. drilling, installation, and operation of wells and the Offshore Feed Gas Pipeline System) are expected to be similar to those of the Foundation Project. Fourth Train Proposal and Foundation Project marine activities are likely to overlap, increasing the overall level of activity in the Fourth Train Proposal Area. The number of artificial light sources (from marine vessels) offshore may also increase, also increasing the potential for interaction between marine vessels and Loggerhead Turtles. However, artificial light sources associated with offshore construction will be short term, marine vessels will be transient, and the associated potential impacts are expected to be localised. Onshore sources of artificial light on the west coast of Barrow Island will be short term. Additional light sources on the east coast will be long term, but will be subject to mitigation and management measures, as applied under the Foundation Project (Table 13-10). The probability of a spill or leak increases with the addition of the Fourth Train Proposal; however, the likelihood of potential impacts occurring to marine fauna, including marine turtles, remains remote. The consequence of spills and leaks to marine fauna is considered to be the same as that assessed for the Foundation Project. When considered in addition to the Foundation Project, the Fourth Train Proposal is not predicted to increase the level of potential impact to Loggerhead Turtles, from that assessed for the Foundation Project.

Marine construction and operations activities will only affect a relatively small proportion of the Fourth Train Proposal Area at any one time. Stressors associated with these activities are not expected to act synergistically, or result in widespread additive impacts to Loggerhead Turtles.

13.4.2.3.2 Short-nosed Sea Snake

The Short-nosed Sea Snake is endemic to Western Australia and has been recorded from Exmouth Gulf to the reefs of the Sahul Shelf in the eastern Indian Ocean. The Sahul Shelf has been highlighted as potentially significant for this species, although no BIAs have been identified in the North-west Marine Region (SEWPaC 2012e).

The Fourth Train Proposal stressor identified as relevant to the Short-nosed Sea Snake is spills and leaks (Table 13-10). This stressor is reflected within the pressures cited by DotE for the Short-nosed Sea Snake in the North-west Marine Region (Table 13-17).

Table 13-17: DotE Pressure Analysis for Short-nosed Sea Snake: Pressures Considered Relevant to the Fourth Train Proposal

Pressures of Concern	Pressures of Potential Concern	Pressures of Less Concern
• None considered relevant	• Physical habitat modification from offshore construction • Oil pollution from oil rigs	• Oil pollution from shipping

Adapted from SEWPaC 2012e

The Fourth Train Proposal stressor identified for the Short-nosed Sea Snake is associated with marine activities, including the movement of marine vessels and the construction and operation of marine infrastructure (e.g. offshore wells and the Fourth Train Proposal Offshore Feed Gas Pipeline System). The identified stressor will be relevant throughout the construction and operation of the Fourth Train Proposal.

Spills and Leaks

Although the Short-nosed Sea Snake may be present within the Fourth Train Proposal Area, no areas indicating biologically important behaviour for the species have been recorded. Historically, the Short-nosed Sea Snake has been recorded in high numbers at Ashmore and Hibernia Reefs, although numbers have declined in these areas (DEWHA 2008a). Potential impacts associated with a large-scale spill or leak from the Fourth Train Proposal could include direct and indirect toxic effects and behavioural responses, such as movement away from the affected areas. Modelling of a well blowout from the Chandon Gas Field identified that concentrations greater than 10 ppb of entrained hydrocarbons could potentially reach as far north as the Ashmore and Hibernia Reefs; however, in the unlikely event of a well blowout occurring, the probability that hydrocarbons would reach Ashmore and Hibernia Reefs was determined to be very low (less than 1%). The level of potential impact of spills and leaks from the Fourth Train Proposal on marine fauna was assessed as 'Medium'. However, Short-nosed Sea Snakes are not considered to be the most sensitive receptor for spills and leaks. Known areas of habitat for this species are not expected to be impacted by ecologically significant concentrations of hydrocarbons in the event of a spill or leak due to the Fourth Train Proposal, reducing the potential for impact upon this species due to spills and leaks.

Summary

The Fourth Train Proposal additional to the approved Foundation Project will result in additional construction activities and their associated potential impacts; additional geographic areas may also be exposed to potential impacts. Fourth Train Proposal marine activities (e.g. drilling, installation, and operation of wells and the Offshore Feed Gas Pipeline System) are expected to be similar to those of the Foundation Project. Fourth Train Proposal and Foundation Project marine activities are likely to overlap, increasing the overall level of activity in the Fourth Train Proposal Area. The probability of a spill or leak increases with the addition of the Fourth Train Proposal; however, the likelihood of potential impacts occurring to marine fauna, including the Short-nosed Sea Snake, remains remote. The consequence of spills and leaks to marine fauna is considered to be the same as that assessed for the Foundation Project. When considered in addition to the Foundation Project, the Fourth Train Proposal is not predicted to increase the level of potential impact to marine fauna, from that assessed for the Foundation Project.

Marine construction and operations activities will only affect a relatively small proportion of the Fourth Train Proposal Area at any one time. Stressors associated with these activities are not expected to act synergistically, or result in widespread additive impacts to Short-nosed Sea Snakes.

13.4.2.4 Listed Threatened and Migratory Marine Avifauna

A number of EPBC Act-listed threatened or migratory marine avifauna are considered likely to be present within the Fourth Train Proposal Area (Table 13-9). Barrow Island is considered an important non-breeding site for many species of migratory shorebirds, with the highest abundances (over two-thirds of records for most species) found on the south-eastern and southern coasts.

The Fairy Tern, Lesser Crested Tern, and Roseate Tern have BIAs for breeding that overlap the Fourth Train Proposal Area (Figure 6-24, Figure 6-25, and Figure 6-26 respectively). A number of other species of marine avifauna are likely to occur in the Fourth Train Proposal Area, and are considered in the assessment of potential impacts (Table 13-9). However, two species of marine avifauna—the Bridled Tern and the Wedge-tailed Shearwater—are considered to be among the more vulnerable of the identified migratory marine avifauna to stressors associated the Fourth Train Proposal, and are further discussed below. A regionally significant rookery for Bridled Terns and a locally significant rookery for the Wedge-tailed Shearwater are located close to Fourth Train Proposal activities (Figure 6-23). Both bird species have populations on Double Island, approximately 1.5 km off the east coast of Barrow Island. Several factors affect the vulnerability of threatened and migratory marine avifauna, including feeding strategy and sensitivity to trophic-level changes, low fecundity, and long-term fidelity to nesting sites. Marine avifauna also use marine habitats (e.g. mud/sandflats, nearshore waters, open ocean) for foraging, making them susceptible to direct (e.g. oiling) and indirect (e.g. contamination of food source) effects from spills and leaks.

The Fourth Train Proposal stressors (Table 13-10) that are considered relevant to Wedge-tailed Shearwaters include artificial light and spills and leaks. These stressors reflect pressures cited by DotE for marine avifauna in the North-west Marine Region (Table 13-18). No pressures were identified specifically for Bridled Terns; however, due to the similarities in the rookery locations and foraging behaviour of these marine avifauna, including feeding and nesting behaviour and locations, the same stressors are considered relevant for both species. Wedge-tailed Shearwaters and Bridled Terns have the potential to be exposed to impacts between late spring and autumn (generally between September and May) when the species return to the Western Australian coastline to breed and raise their young (SEWPaC 2013).

Table 13-18: DotE Pressure Analysis for Wedge-tailed Shearwaters: Pressures Considered Relevant to the Fourth Train Proposal

Pressures of Concern	Pressures of Potential Concern	Pressures of Less Concern
• No pressures identified	• Light pollution from oil and gas infrastructure, vessels, shipping, and onshore and offshore activities • Oil pollution from oil rigs	• Oil pollution from shipping

Adapted from SEWPaC 2012f

The Fourth Train Proposal stressors identified for marine avifauna are associated with marine activities, including the movement of marine vessels and the construction and operation of both onshore and marine infrastructure (e.g. construction of offshore wells, operation of the Gas Treatment Plant). The identified stressors will be relevant throughout the construction and operation of the Fourth Train Proposal.

Artificial Light

Artificial light from onshore infrastructure on the east coast of Barrow Island and marine vessels operating in nearshore waters have the potential to misorient marine avifauna. The potential numbers of birds that could be impacted will depend on a range of factors, including the timing of operations, intensity of light, and proximity of the marine activities to migratory pathways of nocturnally migrating bird species. White and red light generated by offshore oil and gas platforms has been linked to the disruption of magnetic orientation of migrating birds and attraction of seabirds in the southern North Sea (Poot *et al.* 2008). Drilling activities, which represent the longest static sources of offshore artificial light, are anticipated to be spread over approximately two years at each gas field, and therefore may overlap multiple annual migrations (passages north and south) of birds that migrate through, or that use, the Fourth Train Proposal Area. Other sources of offshore light from the Fourth Train Proposal include pipe-lay vessels during construction. Operational shipping and maintenance activities are anticipated to be short term and transient.

Nicholson (2002) documented the attraction of fledging Wedge-tailed Shearwaters to the night lighting of the Gas Treatment Plant on Varanus Island, north of Barrow Island. Monitoring programs for Wedge-tailed Shearwater and Bridled Tern breeding colonies have not identified any significant differences between islands or the At Risk or Reference sites in nest/burrow density, breeding numbers, or breeding success of either species (Chevron Australia 2013a).

The Fourth Train Proposal will increase the frequency (i.e. regularity) of light emitted on the east coast of Barrow Island during construction and operations activities; however, the level of light emitted is not anticipated to increase. Light spill modelling for the Gas Treatment Plant concluded that the operational Fourth Train Proposal would result in a 'negligible' contribution to the light spill from the Gas Treatment Plant when compared to the Foundation Project (Section 5.3.3). As such, the potential impacts to avifauna are not expected to be any different to those already determined for the operation of the approved Foundation Project. Offshore sources of light, including at drilling rigs, have the potential to attract migrating or foraging birds. However, offshore light sources will be short term and distant from the known BIAs for threatened and/or migratory marine avifauna in the North-west Marine Region.

Spills and Leaks

Marine avifauna have the potential to be impacted from spills and leaks from the Fourth Train Proposal. Birds such as the Wedge-tailed Shearwater and Bridled Tern may have a greater potential to be exposed to potential impacts due to the close proximity of rookeries to the

Fourth Train Proposal Area. If adult seabirds are exposed to hydrocarbons from a spill or leak event (e.g. when feeding at sea), juveniles that are still dependent on food from their parents may also be impacted through subsequent loss of food supply or ingestion of contaminated food. However, the wide availability of foraging habitat for adult birds in the wider North-west Marine Region and the tendency of these species to feed in small groups is likely to reduce the potential for impacts at the local population level from spills and leaks. Any impacts to individuals are not anticipated to result in adverse species-level effects for either the Wedge-tailed Shearwater or Bridled Tern, as their distribution range extends far beyond the Fourth Train Proposal Area.

Summary

The level of potential impact from artificial light and spills and leaks from the Fourth Train Proposal on marine fauna, which includes the Wedge-tailed Shearwater and Bridled Tern, was assessed as 'Medium'. However, marine avifauna are not the most sensitive receptor for either of these stressors. The wide geographic ranges and migratory nature of these species reduces the potential for impact from these stressors. No project-attributable impacts to these species as a result of Foundation Project activities have been recorded to date (Chevron Australia 2013a) (Section 3.5.1.1).

The Fourth Train Proposal additional to the approved Foundation Project will result in additional construction activities and their associated potential impacts. The number of artificial light sources onshore and offshore may also increase, particularly during construction activities. Artificial light sources associated with offshore construction activities will be short term, and marine vessels will generally be transient. Light levels from additional onshore light sources at the Gas Treatment Plant site are predicted to be negligible when modelled alongside Foundation Project light sources. Onshore sources of artificial light on the west coast of Barrow Island will be short term and are not expected to result in any long-term effects on the behaviour of migratory seabirds. The probability of a spill or leak increases with the addition of the Fourth Train Proposal; however, the likelihood of potential impacts occurring to marine fauna, including marine avifauna, remains remote. The consequence of spills and leaks to marine fauna is considered to be the same as that assessed for the Foundation Project. When considered in addition to the approved Foundation Project, the Fourth Train Proposal is not predicted to increase the level of potential impact to marine avifauna, from that assessed for the Foundation Project.

Marine construction and operations activities will only affect a relatively small proportion of the Fourth Train Proposal Area at any one time. Stressors associated with these activities are not expected to act synergistically, or result in widespread additive impacts to marine avifauna.

13.4.3 Proposed Management

The Fourth Train Proposal is not expected to change the level of impact, or result in any different impacts assessed and approved for the Foundation Project. Therefore, the GJVs intend to manage potential impacts associated with the implementation of the Fourth Train Proposal in a manner consistent with the environmental management framework established and currently being implemented for the Foundation Project (Section 16.2). This framework provides the basis to manage potential impacts to marine fauna through a series of EMPs, including specific measures to address uncertainty over potential additive impacts on, for example, marine turtle populations.

It is anticipated that new EMPs will be developed, as required under EPBC Ministerial Conditions (Conditions 16, 16A, and 16B of EPBC Reference: 2003/1294, and Conditions 1 and 2 of EPBC Reference: 2005/2184) for the drilling and completion of Fourth Train Proposal production wells and for activities associated with the installation of the Fourth Train Proposal

Offshore Feed Gas Pipeline System[17], or equivalent Environment Plan. In addition, a new EMP covering Fourth Train Proposal horizontal directional drilling activities, locations, and potential impacts will need to be prepared and approved. The GJVs anticipate that the mitigation and management measures included within the existing Foundation Project EMPs and Subsidiary Documents for offshore drilling and completion, pipeline installation, and horizontal directional drilling will also apply to, and will prevent and manage any potential impact to marine fauna as a result of, the Fourth Train Proposal.

Where relevant, the GJVs propose to make minor changes to a number of existing Foundation Project EMPs to ensure that they also apply to the specific construction and operations activities of the Fourth Train Proposal. These changes are described in Section 16.2.3. The EMPs that are relevant to addressing potential impacts to marine fauna for the Fourth Train Proposal include:

- Coastal and Marine Baseline State and Environmental Impact Report
- Long-term Marine Turtle Management Plan
- Fauna Handling and Management Common Users Procedure
- Marine Facilities Construction Environmental Management Plan
- Horizontal Directional Drilling Management and Monitoring Plan
- Marine Environmental Quality Management Plan
- Post-Development Coastal and Marine State and Environmental Impact Survey Report
- Solid and Liquid Waste Management Plan
- Reverse Osmosis Brine Disposal Management and Monitoring Plan
- Terrestrial and Marine Quarantine Management System
- Decommissioning and Closure Plan.

Section 5.7.3 describes the proposed measures to manage and mitigate the occurrence and impact of potential spills and leaks. These measures include a range of engineering controls and systems aimed at preventing a spill or leak, and the implementation of response measures in the unlikely event of a spill or leak.

To ensure that risks to cetaceans associated with VSP are mitigated, the requirements of *EPBC Act Policy Statement 2.1: Interaction between offshore seismic exploration and whales* (DEWHA 2008) Part A: Standard Management Procedures will be followed when acquiring VSP data.

13.4.4 Predicted Environmental Outcome

The Fourth Train Proposal Area falls within a marine region that is biologically diverse, and that provides habitat for a number of EPBC Act-listed threatened and/or migratory marine fauna.

Construction activities and associated impacts are expected to be short term, although impacts relating to some stressors, including noise and physical interaction will continue into the operations phase. Potential impacts through the construction and operation of the Fourth Train Proposal are also expected to be localised. The Fourth Train Proposal will result in additional construction activities in the Fourth Train Proposal Area, when compared to the approved Foundation Project. The Fourth Train Proposal will also extend the geographic area over which impacts could occur during construction and operations.

[17] Given the establishment of NOPSEMA on 1 January 2012, it is acknowledged that these conditions may be changed for the Fourth Train Proposal and the requirement with respect to petroleum activities covered under a Subsidiary Document requiring NOPSEMA approval.

The Fourth Train Proposal is not expected to change or represent different risks to EPBC Act-listed threatened and/or migratory marine fauna compared to those assessed and approved for the Foundation Project. The levels of potential incremental and additional impacts were assessed to be no greater than the levels assessed and approved under the Foundation Project. Habitats of listed marine fauna potentially impacted by the Fourth Train Proposal are well represented outside the areas anticipated to be exposed to potential impacts from the Fourth Train Proposal. Habitat modifications resulting from the construction of the Fourth Train Proposal are expected to be localised and therefore are not anticipated to adversely impact upon the health of listed marine fauna populations or result in a decline in population numbers. The potential consequence of a spill or leak from the Fourth Train Proposal could result in severe impacts to marine fauna or their habitat; however, the likelihood of a spill or leak occurring that could result in such impacts is predicted to be remote. In addition, first-strike spill response procedures will be in place.

Stressors identified for marine fauna (Table 13-10) are also not anticipated to act synergistically to result in a greater level of potential impact than when considered individually, given the localised nature of impacts in relation to the geographic range of EPBC Act-listed threatened or migratory marine fauna and the availability of habitat, both within and outside the Fourth Train Proposal Area.

With the proposed management framework in place, the Fourth Train Proposal is not anticipated to affect the abundance, diversity, or geographic distribution of marine fauna found within or adjacent to the Fourth Train Proposal Area. The Fourth Train Proposal, together with the Foundation Project and other considered actions, is also not anticipated to result in any unacceptable cumulative impacts to EBPC Act-listed marine threatened and/or migratory species, communities, or their habitats (Section 15.5.2).

The mitigation and management measures that the GJVs intend to adopt for the Fourth Train Proposal reflect a conservative approach, noting that some potential impacts on listed threatened and migratory species are poorly understood. For example, the monitoring being undertaken as part of the Long-term Marine Turtle Management Plan (Chevron Australia 2009) acknowledges scientific uncertainty of the potential impacts of the Foundation Project on populations of marine turtles.

With the implementation of the proposed management measures (Table 13-10), the GJVs consider that the potential impacts identified for listed marine species and their habitat will be adequately managed such that the impacts are environmentally acceptable and the environmental objective for this controlling provision (Section 13.4.1) is met. Implementation of the Fourth Train Proposal in conjunction with the approved Foundation Project is also not predicted to conflict with, or be inconsistent with, the objects and principles of the EPBC Act, or the objectives, strategies, and plans (Table 13-8) for the protection and recovery of relevant listed threatened marine species and their communities.

13.5 Commonwealth Marine Environment

13.5.1 Assessment Framework

13.5.1.1 Assessment Objective

The objectives established in this PER/Draft EIS for the assessment of potential impacts on the Commonwealth Marine Area are listed in Table 13-19.

Table 13-19: Objectives Relevant to Impacts in the Commonwealth Marine Area

Factor	Environmental Objective
Emissions, Discharges, and Wastes	
Atmospheric emissions (except dust) and air quality	To avoid or mitigate any adverse effects of atmospheric emissions on environmental values or the health, welfare, and amenity of people and land uses
Emissions of light	To avoid or mitigate potential impacts from light overspill
Discharges to sea (including run-off)	To avoid or mitigate any adverse effects of discharges on the environmental values of the marine environment or the health, welfare, and amenity of people and sea uses
Noise and vibration	To avoid adverse noise and vibration impacts to marine fauna
Spills and leaks	To handle and store hydrocarbons and other chemicals in a manner that reduces the potential for leaks, spills, and emergency situations to impact on the environment to as low as reasonably practicable
Marine Environment	
Marine fauna, including protected species and benthic faunal communities	• To maintain the abundance, diversity, geographic distribution, and productivity of marine fauna (including EPBC Act-listed threatened or migratory species) at species' and ecosystems' levels through the avoidance or management of adverse impacts and improvement in knowledge • To avoid, reduce, and/or mitigate against impacts on the ecological functions and environmental values of marine benthic habitats
Marine water quality	To maintain the quality of marine water so that existing and potential environmental values, including ecosystem functions and integrity, are maintained
Seabed (subtidal)	To maintain the integrity, ecological functions, and environmental values of the seabed
Sea use	To avoid adversely interfering with, or compromising, other economic uses of the Commonwealth Marine Area
Cultural heritage	To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation
Commonwealth Marine Reserves	To avoid adversely interfering with, or compromising, the environmental values of areas identified as having significant environmental attributes

13.5.1.2 Relevant Policy, Plan, and Guideline Documents

Table 13-20 lists policies, plans, and guidelines relating to the Commonwealth Marine Area that are relevant to the Fourth Train Proposal.

Table 13-20: Policies, Plans, and Guidelines Relevant to the Fourth Train Proposal's Commonwealth Marine Area

Policy, Plan, Guideline	Intent
Australia's Biodiversity Conservation Strategy 2010–2020 (National Biodiversity Strategy Review Task Group 2009)	Sets a national direction for biodiversity conservation
National Water Quality Management Strategy Water Quality Management (ANZECC and ARMCANZ 1994)	Aims to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development

Policy, Plan, Guideline	Intent
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000)	Provides an authoritative guide for setting water quality objectives required to sustain current or likely future environmental values for natural and semi-natural water resources in Australia and New Zealand. Trigger values are provided for a range of organic and inorganic compounds that, if exceeded, should result in action
Australian Ballast Water Management Requirements (version 5, 2013) (Department of Agriculture 2013)	Provides requirements to reduce the risk of introducing harmful aquatic organisms into Australia's marine environment through ballast water from international marine vessels
Montebello Commonwealth Marine Reserve – fact sheet (SEWPaC 2012g)	Provides characterisation of this proposed Marine Reserve, and proposed categorisation as a Multiple Use Zone (IUCN Category VI – Managed resource protected area). The management definition for IUCN Category VI is: 'Managed to ensure long-term protection and maintenance of biological diversity with a sustainable flow of natural products and services to meet community needs'
North-west Marine Region Bioregional Plan (SEWPaC 2012) and associated Conservation Value Report Cards	Aims to strengthen the operation of the EPBC Act in the Commonwealth Marine Area of the North-west Marine Region to help ensure that the marine environment of the region remains healthy and resilient Conservation Value Report Cards for this region summarise the scientific information on the distribution, conservation status, and pressures on the conservation values in the region including the Commonwealth Marine Environment, existing heritage places, and a range of species. They also present information about existing management arrangements

13.5.2 Assessment Overview

The Commonwealth Marine Area stretches from the seaward boundary of State waters out to 200 nautical miles, and includes the seabed under these waters, the airspace over these waters, waters over the continental shelf, and any other area of sea or seabed included in a Commonwealth reserve. The Commonwealth Marine Environment relevant to the scope of the Fourth Train Proposal falls within the North-west Marine Region of the Commonwealth Marine Area (Figure 13-1). The Commonwealth Marine Area is defined in Section 24 of the EPBC Act as any waters of the sea inside the seaward boundary of Australia's Exclusive Economic Zone except where rights have been vested in a State or in the Northern Territory.

The biophysical and social/cultural characteristics of the North-west Marine Region are described in Section 6. A number of potential sensitivities were identified within the Commonwealth Marine Area associated with the Fourth Train Proposal; these include marine fauna, water and air quality, the seabed, and the Montebello Commonwealth Marine Reserve. This reserve is a Multiple Use Zone (IUCN Category VI), which overlaps the Fourth Train Proposal Area. In addition, three key ecological features identified for the North-west Marine Region overlap the Fourth Train Proposal Area; these are the ancient coastline at 125 m depth contour, continental slope demersal fish communities, and the Exmouth Plateau (Table 13-21).

Table 13-21: Key Ecological Features Overlapping the Fourth Train Proposal Area

Key Ecological Feature	Summary of Ecological Values
Ancient coastline at 125 m depth contour	• Provides areas of hard substrate that may contribute to higher diversity and enhanced species-richness relative to soft sediment habitat • Faunal assemblages here are considered representative of fauna of hard substrates in the North West Shelf bioregion • May also facilitate increased availability of nutrients off the Pilbara by interacting with internal waves and enhancing vertical mixing of water layers • Increased productivity at the key ecological feature may attract marine megafauna
Continental slope demersal fish communities	• Limited sampling to date indicates a high diversity of fish and high numbers of endemic species
Exmouth Plateau	• Enhanced productivity along the northern and southern boundaries of the Plateau, suggesting that the plateau is a significant contributor to the productivity of the region • Likely to be an important area for biodiversity as it provides an extended area offshore for communities adapted to depths of around 1000 m

Adapted from SEWPaC 2012h

Stressors identified to have the potential to impact upon the environmental and socioeconomic factors of the Commonwealth Marine Area were:

- atmospheric emissions (except dust)
- artificial light
- discharges to sea
- noise and vibration
- seabed disturbance
- physical presence of infrastructure
- physical interaction
- spills and leaks.

A summary of the impact assessment results for each relevant factor of the Commonwealth Marine Area is presented in Table 13-22, with the results of the environmental risk assessment for the Fourth Train Proposal activities in the Commonwealth Marine Area provided in Appendix F2 [Consolidated Risk Assessment Results].

The relevance of Fourth Train Proposal activities and stressors to key ecological features was considered in relation to a pressure analysis undertaken by DotE on key ecological features across the North-west Marine Region (SEWPaC 2012h). In the unlikely event of a large-scale spill or leak, a number of additional key ecological features could be exposed to potential impacts from the Fourth Train Proposal (Section 13.5.9).

Table 13-22: Stressors and Potential Impacts to the Commonwealth Marine Environment from the Implementation of the Fourth Train Proposal

Stressor	Factor(s) Potentially Affected	Potential Impacts	Illustrative Mitigation and Management Measures	Impact Rating	
				Incremental	Additional
Atmospheric emissions (except dust)	• Air quality	• Reduction in air quality and subsequent amenity of the Commonwealth Marine Environment • Damage to atmospheric ozone layer from leak of ozone depleting substances (ODSs)	Section 5.2.4 and Table 13-23.	Trivial	-
Artificial light	• Marine fauna	• Changes in local abundance/distribution of marine fauna through alteration in behaviour (e.g. through avoidance or attraction) • Increased incidents of physical interaction with marine vessels and equipment	Section 5.3.4, Table 10-9, and Table 13-24.	Low	Low
Discharges to sea	• Water quality • Seabed • Marine fauna and their habitats (including marine benthos)	• Reduction in water quality (e.g. through increased turbidity, nutrient and oxygen availability, and the introduction of toxic substances) • Changes to sediment quality (e.g. physical and/or chemical attributes) • Direct and indirect effects to marine fauna including acute effects (e.g. due to acute toxicity of discharges and/or smothering of sessile or slow-moving marine fauna and their habitats) and chronic metabolic effects (e.g. through the bioaccumulation of possible contaminants).	Section 5.5.4, Table 10-6, and Table 13-26.	Low	Low
Noise and vibration	• Marine fauna (particularly cetacean species)	• Disturbance of marine fauna, inducing behavioural changes (e.g. avoidance or attraction) • Masking of communications between individuals or groups • Potential to have short-term and long-term effects on auditory systems, which could impact marine fauna that rely on acoustic cues for feeding, communication, orientation, and navigation	Section 5.4.4, Table 10-10, and Table 13-27.	Low	Low

Stressor	Factor(s) Potentially Affected	Potential Impacts	Illustrative Mitigation and Management Measures	Impact Rating	
				Incremental	Additional
Seabed disturbance	• Water quality • Seabed • Marine fauna and their habitats (particularly benthic marine fauna) • Marine protected areas • Key ecological features	• Increase in turbidity and resuspension of nutrients/ contaminants • Changes to physical structure of the seabed • Alteration to, or smothering of, sessile or slow-moving marine fauna and their habitats • Reduced ecological value of marine protected areas and key ecological features, e.g. through changes to seabed quality/integrity, which may have secondary impacts to sessile benthic communities and mobile marine species that use the areas	Table 10-7 and Table 13-30.	Low	Low
Physical interaction	• Marine fauna (particularly slow-moving, air-breathing or surface-feeding marine fauna (e.g. Dugongs, marine turtles, Whale Sharks) • Cultural heritage (e.g. shipwrecks) • Other users of the marine environment	• Physical interaction between marine vessels and listed marine fauna resulting in injury or fatality to individuals • Interaction with Fourth Train Proposal marine activities offshore (e.g. offshore construction) leading to the damage of cultural heritage artefacts (assessed in Section 14.3.2.2) • Interaction between Fourth Train Proposal marine activities offshore and fishing industry causing damage to, or loss of, fishing equipment (assessed in Section 14.5.2.1).	Table 10-11 and Table 13-31.	Low	Low
Physical presence of infrastructure	• Seabed • Marine fauna and their habitats (particularly marine benthos) • Other users of the marine environment • Marine protected	• Changes to seabed sediment (re)supply regimes • Changes to available habitat that may impact on community structure and diversity • Access restrictions to certain areas of the marine environment • Reduced ecological value of marine protected areas and key ecological features, e.g. through changes to seabed habitat, which may have secondary impacts to sessile benthic communities and mobile marine species that use the areas.	Table 10-14 and Table 13-31.	Low	Low

Stressor	Factor(s) Potentially Affected	Potential Impacts	Illustrative Mitigation and Management Measures	Impact Rating	
				Incremental	Additional
	areas • Key ecological features				
Spills and leaks	• Water quality • Seabed • Marine fauna and their habitats • Other users of the marine environment • Marine protected areas • Key ecological features	• Reduction in water quality • Sedimentation of hydrocarbons and contamination of sediments • Direct and indirect effects to marine fauna including acute effects (e.g. due to acute toxicity of spills and leaks) and chronic metabolic effects (e.g. through the bioaccumulation of possible contaminants) • Tainting of fisheries resources and equipment (assessed in Section 14.5.2.3) • Reduced ecological value of marine protected areas and key ecological features, e.g. through changes to water quality, which may have secondary impacts to marine fauna species that use the areas • Changes to photic depth and light attenuation within the water column, which could reduce primary production	Sections 5.7.3 and 13.5.10.	Medium	Medium

** Assessed in Section 12*

13.5.3 Atmospheric Emissions (except dust)

Atmospheric emissions (except dust) can contribute to a decline in local and regional air quality. A reduction in air quality has the potential to reduce the amenity of the Commonwealth Marine Area for other sea users and for marine flora and fauna.

This Section discusses the potential impacts associated with air pollutants and air toxics, as well as ozone depleting substances that are relevant to the Commonwealth Marine Area. Section 5.2 provides additional information on the atmospheric emissions associated with the Fourth Train Proposal. The characterisation of greenhouse gas emissions relevant to the Commonwealth Marine Area, and their management, is discussed in Section 11.

Ozone depleting substances (ODSs) are synthetic gases including halons, chlorofluorocarbons, and hydrochlorofluorocarbons. Any emission of ODSs has the potential to contribute to the degradation of the Earth's stratospheric ozone layer.

Although not specifically generated by the Fourth Train Proposal, ODSs may already be integrated into older marine vessel systems. While no routine emission of ODSs is expected, there is a possibility of leakage. Marine vessels will be used throughout the construction and operation of the Fourth Train Proposal, but any leakage of ODS would be considered a discrete event, and the potential for impacts to arise are not considered likely given the illustrative measures to manage emissions (Table 13-23).

Atmospheric emissions will also be generated from the combustion of fuels and waste streams, and are expected to include emissions of carbon dioxide (CO_2), carbon monoxide (CO), oxides of nitrogen (NO_x), sulfur dioxide (SO_2), ozone (O_3) methane (CH_4), and volatile organic compounds (VOCs). Routine sources of atmospheric emissions due to the Fourth Train Proposal are likely from marine vessels, offshore drilling rigs, and the operation of the Gas Treatment Plant.

The greatest quantities of atmospheric emissions due to the Fourth Train Proposal are expected to be generated during the operations phase, and will be associated with the Gas Treatment Plant. Modelling indicated that atmospheric pollutants, including SO_2, NO_x, and O_3 emitted during routine operations are not expected to exceed National Environment Protection Measures (NEPM) Criteria for Ambient Air Quality (Ambient Air NEPM; NEPC 2003) on Barrow Island, or across the wider Commonwealth Marine Area, based on deposition rates modelled for both Barrow Island and the Ningaloo Coast.

An inventory for construction-related combustion emissions generated by the Fourth Train Proposal, in relation to the activities that are planned for the Commonwealth Marine Area, is provided in Section 5.2.3.1. Emissions from marine vessel and helicopter engine exhausts will also be generated within both the Commonwealth Marine Area and State Waters. Vessel engine exhaust emissions are estimated to account for approximately 57% of emissions, with 43% being attributable to drilling activities, including clean-up well flow tests.

Illustrative measures for this stressor taken from Foundation Project EMPs are presented in Table 13-23 for assessment purposes (see Section 8.3.5 for an explanation of the status of the measures).

Table 13-23: Illustrative Mitigation and Management Measures for Atmospheric Emissions in the Commonwealth Marine Area

Relevant Activity		Illustrative Measures
Production Drilling	**Pipeline Installation**	
✓	✓	• Emissions from marine vessels and drilling rigs will be in accordance with the guidelines of MARPOL Annex VI – Regulations for the Prevention of Air Pollution from Ships. Additionally, equipment (on marine vessels and drilling rigs) will be maintained in accordance with the manufacturers' specifications to ensure optimal efficiency
✓		• Use of 'green-type' burners during clean-up well flow testing to help maximise burning efficiency
✓		• Adherence to flaring procedures during clean-up well flow test
	✓	• Ensuring that vessels comply with the requirements for ODS specified in Regulation 12 of MARPOL Annex VI, including the prohibition of deliberate release of ODS
	✓	• Ensuring that any personnel handling ODS are certified and hold the necessary permits and licenses required under the Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995 (Cth) to reduce the potential for ODS escape
	✓	• Ensuring adherence to the requirements for recording and reporting the use and disposal of ODS under the Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995 (Cth), including reporting the release of any ODS (e.g. from firefighting or refrigeration systems)

Emissions due to the Fourth Train Proposal are likely to be rapidly dispersed within the high-energy offshore environment and are not predicted to result in unacceptable impacts to air quality within the Commonwealth Marine Area, either locally or regionally. As a result, the potential incremental impact to air quality within the Commonwealth Marine Area was assessed as 'Trivial'.

The atmospheric emissions due to the Fourth Train Proposal are on a smaller scale than those of the Foundation Project, and are not considered to change the level of impact assessed and approved for the Foundation Project. Atmospheric emissions from the Fourth Train Proposal additional to the approved Foundation Project are not expected to result in a substantial change to air quality in the Commonwealth Marine Area. Adverse impacts on biodiversity, ecological integrity, social amenity, or human health due to the Fourth Train Proposal additional to the Foundation Project are not expected. The potential impacts are determined to be acceptable and the objective established for atmospheric emissions and air quality (Table 13-19) is determined to be met. Furthermore, given their limited volume and anticipated dispersion, atmospheric emissions associated with the Fourth Train Proposal are expected to result in acceptable impacts that are consistent with the policy and plan documents listed in Table 13-20.

13.5.4 Artificial Light

Artificial light has the potential to impact marine fauna found within the Commonwealth Marine Area that rely on visual cues as part of their life cycle. Behavioural response to light can alter foraging and breeding activity in marine turtles, seabirds, fish, marine mammals and their prey, giving competitive advantage to some species and reducing reproductive success and/or survival in others (Chevron Australia 2005). The attraction of individual fauna to artificial light may also expose those individuals to stressors associated with human activity within the offshore environment, e.g. physical interaction with marine vessels.

EPBC Act-listed marine fauna species (pelagic fish, cetaceans, avifauna, and marine turtles) that may respond to direct light sources or to light glow (Appendix D3 [Gorgon Light Emission Study – Fourth Train Proposal]) have been identified in the Commonwealth Marine Area associated with the Fourth Train Proposal Area. The most sensitive of these marine species are also listed as threatened and/or migratory under the EPBC Act; these species were assessed in Section 13.4.

The potential impacts of light emissions will depend on the nature of the light source, such as wave length and intensity, extent of light spill and duration, as well as the sensitivity of location (e.g. breeding/foraging area), the resilience of the marine faunal group, and the nature of their response (Chevron Australia 2005).

Artificial lighting will be required on marine vessels (including drilling rigs) for safety and navigation, resulting in artificial light generation during the construction and operations activities of the Fourth Train Proposal. Section 5.3.3 describes the Fourth Train Proposal light sources that will be additional to those of the approved Foundation Project.

Night activities on marine vessels close to the Barrow Island coastline have the potential to result in the attraction/aggregation of marine turtle hatchlings, which can lead to increased predation risks. However, the potential for attraction of marine turtle hatchlings by marine vessels operating within the Commonwealth Marine Area is not expected as marine turtle hatchlings disperse widely once they enter nearshore waters; the effects of surface and tidal current flows followed by magnetic fields are considered a greater influence on their direction of travel (Section 13.4.2.3.1). There is little evidence to suggest that light cues influence adult migration while at sea, although there are anecdotal reports of adult turtles observed near oil platforms feeding on animals attracted to the platform lights (Kebodeaux 1994, cited in Chevron Australia 2009).

Seabirds and migratory birds that migrate and/or forage nocturnally may be affected by artificial light on marine vessels and drilling rigs through disorientation or attraction. Offshore drilling facilities are likely to represent the longest static sources of light in the Commonwealth Marine Area. Drilling activities may include flaring; however, flaring will be short in duration and the use of drilling rigs for a single well will be short term. All permanent infrastructure for the Fourth Train Proposal in the Commonwealth Marine Area will be subsea and without artificial lighting. No discernible impact on the long-term behavioural patterns or adverse species-level effects to seabirds or migratory birds is expected. Potential impacts to species of marine avifauna are discussed and assessed further in Section 13.4.2.4.

Modifications in localised migration and settlement of marine invertebrates, including crustacean larvae, have been linked to artificial light produced within the marine environment (Porter *et al.* 2008). Lindquist *et al.* 2005 also reported high abundance of juvenile fish, particularly clupeid fish (e.g. sardines) and engraulids (e.g. anchovy) in surface waters at night around oil and gas production platforms in the Gulf of Mexico. These fish, as well as some marine zooplankton species, are thought to be particularly photopositive and may be attracted to artificial light. The attraction of these organisms at lower trophic levels to artificial light sources has the potential to attract predator species such as large fish and cetaceans. Potential impacts to marine plankton communities and their predators are likely to be short term and localised, and are not expected to have wider implications for populations of marine species or associated ecological communities, which are considered to be well represented across the North-west Marine Region.

Illustrative measures for this stressor taken from currently approved Foundation Project EMPs are presented in Table 13-24 for assessment purposes (see Section 8.3.5 for an explanation of the status of the measures).

Table 13-24: Illustrative Mitigation and Management Measures for Artificial Light in the Commonwealth Marine Area

Relevant Activity		Illustrative Measures
Production Drilling	Pipeline Installation	
✓	✓	• Lighting minimum required for safe operational requirements and safety regulations
✓	✓	• Compliance with Australian Petroleum Production and Exploration Association [APPEA] Code of Environmental Practice 2008 (APPEA 2008)
✓		• Limiting the duration of flaring for work requirements and safe operation

The potential incremental impact of artificial light from the Fourth Train Proposal to marine fauna within the Commonwealth Marine Area is expected to be short term and isolated from other light sources, and was assessed as 'Low'.

The Fourth Train Proposal, additional to the approved Foundation Project, will result in an increase in the overall likelihood of exposure and potential attraction of marine fauna to artificial light in the Commonwealth Marine Area. The potential impacts from artificial light emissions occurring from Fourth Train Proposal construction activities are likely to be the same in nature and magnitude as those predicted for the Foundation Project. Although new geographic areas may be subject to artificial light due to the Fourth Train Proposal, the potential sensitivity of marine fauna to artificial light is not considered any greater than within those areas affected by the Foundation Project. During operations, an increase in the regularity of light emissions occurring in the Commonwealth Marine Area is anticipated due to increased shipping (LNG and condensate marine vessels) and other offshore marine vessel activities (e.g. logistics and supply vessels). Artificial light emissions associated with these activities will be intermittent and transitory. The potential additional impacts associated with artificial light in the Commonwealth Marine Area were assessed as 'Low', and as such, are not expected to have an adverse effect on marine fauna at species or ecosystem levels.

The potential impacts are determined to be acceptable and the objective established for the emissions of light within the Commonwealth Marine Area is determined to be met (Table 13-19). The implementation of the Fourth Train Proposal is considered to be consistent with the policy and plan documents listed in Table 13-20.

13.5.5 Discharges to Sea

Table 13-25 lists the types of discharges that are expected to occur in the Commonwealth Marine Area associated with the Fourth Train Proposal activities. Additional detail on discharges to sea due to the Fourth Train Proposal is included in Section 5.5; an inventory of the main liquid waste discharges associated with the Fourth Train Proposal and the disposal strategies for those discharges is included in Table 5-19.

Table 13-25: Types of Discharges Occurring within the Commonwealth Marine Area

Discharge Type	Related Activity/Discharge Source	Further Characterisation
• Drilling cuttings and fluids • Cement • Completion brine • Hydraulic fluid	Offshore drilling and completions	Section 5.5.3.2.1

Discharge Type	Related Activity/Discharge Source	Further Characterisation
• Hydrotest water	Construction/commissioning of the Fourth Train Proposal Offshore Feed Gas Pipeline System	Section 5.5.3.3
• Deck drainage • Bilge water • Sewage, greywater, and putrescibles • Engine cooling water	Offshore marine vessel activity (including drilling rigs)	Section 5.5.3.1

13.5.5.1 Discharges from Offshore Drilling and Completion activities

The potential impacts of discharges from drilling and completion operations may result in changes to both the physical structure and physicochemical properties of the seabed where the discharged material settles, thus altering benthic communities, and potentially favouring species that are more tolerant to disturbance. Discharges may also result in water column impacts, causing short-term reductions in light penetration, which may also affect primary productivity (Table 13-22).

Construction discharges to sea from offshore drilling and completion activities will include:

- Drilling cuttings and fluids – expected to occur from the drilling of tophole (riserless) sections with discharges to the seabed. Cuttings from lower sections of the wells (those that are drilled with a riser) will be sent to the surface for processing prior to discharge to surface waters.
- Small volumes of cement may be unavoidably discharged to the seabed when cement mixtures are circulated to the seabed during grouting of the surface casing strings. The discharge of cement may also occur at the sea surface when surplus fluids require disposal after cementing operations during drilling, or during abandonment operations when decommissioning the well.
- Completion brine, which is used downhole to facilitate completion of the well, and synthetic-based cleaning fluids (e.g. rig wash) will be discharged to sea.
- Water-soluble, low-toxicity hydraulic fluid, which is used with well control systems, may be discharged to sea during the testing and functioning of these systems.

Discharges of drilling cuttings, completion brines, hydraulic fluids, and synthetic-based cleaning fluids (e.g. rig wash) may affect marine water quality and light penetration in the vicinity of the discharge point. Reductions in water quality may impact marine fauna through adverse metabolic effects. At well sites, dilution and dispersion are expected to be rapid, depending on water depth and the marine environment. Thus, the potential effects are expected to be limited to the immediate vicinity of the well and for a very short period following discharge. Given the discrete nature of the potential discharges, and the depth of the water column at the Fourth Train Proposal production wells, it is anticipated that marine planktonic flora and fauna, rather than marine nekton, may be more exposed to the potential toxicity effects in the vicinity of the discharge point. Marine plankton that may be impacted are expected to be well represented throughout the Commonwealth Marine Area in the North-west Marine Region.

Drilling cuttings discharged during riserless drilling, and also larger cuttings particles discharged during drilling with a riser are expected to settle on the seabed closer to the wellhead (Hinwood *et al.* 1994). The drilling fluids to be used in the upper hole sections will be a sea water/high viscosity sweeps (bentonite) mixture. Bentonite is an inert natural clay of low toxicity and there is considered to be a low potential for adverse impact (e.g. through toxic effect) within the marine environment (Swan *et al*. 1994). Although both cuttings and water-based drilling fluids discharged during the drilling of upper hole sections may contain traces of heavy metals, these traces are not expected to be available for uptake by organisms (OSPAR Commission 2009a). The settlement of cuttings and associated drilling fluids on the seabed may cause direct and indirect impacts to benthic marine fauna from smothering or from creation of anoxic environments as the cuttings veneer may reduce the penetration of oxygen to the sediment layers. The potential impacts of cuttings deposition around the well, including displacement and/or smothering of benthic fauna, are considered to be localised, occurring within approximately 50 m to 100 m of the wellhead (Neff 2005; OSPAR Commission 2009a). Processes such as bioturbation and current-driven sediment transport would be expected to reduce the physical presence of cuttings veneers on the seabed over time. Bakke *et al.* (1986), cited in Neff 2010, reported recolonisation of sediments with cuttings (and associated water-based drilling fluid) deposits of a thickness of 10 mm during experiments undertaken in cold sea environments. Similarly, it is anticipated that benthic organisms will recolonise areas disturbed by cuttings in the Fourth Train Proposal Area.

Although reduced water quality, seabed disturbance, and mortality of marine organisms may occur in small, isolated areas in the vicinity of the drilling activity, no special habitats are expected to occur in these areas. Environmental and seabed surveys of the gas fields associated with the Foundation Project indicate that the offshore pelagic and benthic environments are likely to be indicative of continental slope environments across the North-west Marine Region, and suggest low diversity and species-richness. No BIAs for EPBC Act-listed threatened or migratory Species have been identified in the Fourth Train Proposal gas fields.

13.5.5.2 Discharges from the Fourth Train Proposal Offshore Feed Gas Pipeline System

The Fourth Train Proposal includes the option of discharging hydrotest water to the Commonwealth Marine Area during construction activities and commissioning of the Fourth Train Proposal Offshore Feed Gas Pipeline System and elements of onshore infrastructure, including the third LNG tank. The discharge of hydrotest water could result in impacts on water quality parameters with potentially acute toxic effects on marine organisms, particularly marine plankton, in the vicinity of the discharge location. Modelling of hydrotest discharges from the Foundation Project Offshore Feed Gas Pipeline System installation program indicates that the discharge of hydrotest fluids would reach 'no effect' concentrations within a few hours of the cessation of the discharge; only pelagic organisms that remained in the discharge plume for an extended period would be exposed to levels of biocide sufficient to cause an acute toxic response. The treatment chemicals and discharge parameters (i.e. discharge rate) used for the Fourth Train Proposal are anticipated to be comparable to those assessed and approved for the Foundation Project (Section 5.5.3.3).

Discernible effects upon salinity stratification of the water column are not anticipated given the depth of water in which larger hydrotest discharges are expected to occur (offshore and in deep water towards the gas fields), and the volume of ambient sea water in the receiving environment, which will serve to buffer salinity differences with the discharged media.

Operational discharges associated with the Fourth Train Proposal Offshore Feed Gas Pipeline System in the Commonwealth Marine Area are expected to include the discharge of small quantities of control fluid from the open-loop controls system. The control fluid is expected to be water-based (with glycol), which has been designed and selected to be suitable for release to the marine environment and which is not expected to result in a discernible adverse impact on either sediment or water quality in the Commonwealth Marine Area

13.5.5.3 Discharges from Marine Vessels

Routine discharges to sea from marine vessels and drilling rigs will occur in the Commonwealth Marine Area, including the Montebello Commonwealth Marine Reserve. These discharges include deck drainage and bilge water, sewage, engine cooling water, and ballast water (Section 5.5.3.1). Discharges from marine vessels have the potential to cause impacts including:

- entrainment and/or toxic impact from traces of chemicals or hydrocarbons (e.g. from deck drainage), which could affect less mobile marine fauna and also marine flora (e.g. zooplankton and phytoplankton)
- changes to water quality parameters such as nutrient availability and biological oxygen demand (BOD) (e.g. from sewage, greywater, and putrescibles). These effects could promote changes in the composition of the marine plankton communities.

Marine vessel movements will be transient, and potential impacts from marine vessel discharges are predicted to be highly localised and abated by the dispersive nature of the receiving environment. The water depth through much of the Commonwealth Marine Environment precludes the establishment of substantial areas of benthic primary production; benthic flora are not anticipated to be impacted by marine vessel discharges within the Commonwealth Marine Area. Mobile marine fauna are not anticipated to be adversely affected by discharges from marine vessels. However, marine phytoplankton and zooplankton, which could be become entrained within the discharges, could be impacted. Although marine phytoplankton and zooplankton are a fundamental food source for other marine fauna, including listed threatened and/or migratory fish (e.g. Whale Shark) and cetaceans (e.g. Humpback Whale), impacts to marine plankton are expected to be highly localised, as the dispersive characteristics of the Commonwealth Marine Area will rapidly dilute discharges from marine vessels. Discharges to the Commonwealth Marine Area are not expected to impact upon the wider abundance or distribution of planktonic organisms or adversely impact upon their predators.

13.5.5.4 Summary

Illustrative measures for drilling discharges, taken from Foundation Project EMPs, are presented in Table 13-26 for assessment purposes (se Section 8.3.5 for an explanation of the status of the measures).

Table 13-26: Illustrative Mitigation and Management Measures for Planned Discharges to Sea in the Commonwealth Marine Area

Activity	Discharge Type	Illustrative Measures
Drilling, completion, and maintenance of production wells	Drilling and completion discharges	• The volume of drilling fluid residues on the cuttings will be minimised through the use of vibrating screens and shakers, and cuttings dryers for hole sections where non-aqueous drilling fluid (NADF) is used • Use of cuttings dryer to achieve ≤10% by dry weight of base fluid on discharged cuttings • Management of the potential effects of drilling fluids will be achieved through selection of fluids with high environmental performance, and by minimising the volumes of fluids lost to sea during operations • Discharge of cuttings at surface (when a riser is in place) to maximise dispersion • System for cleaning of NADF tanks to ensure minimal loss of NADF • Recycle water and separate through drain systems where possible • At the completion of each well, there will be no discharge of NADF, with remaining fluids either stored for use on subsequent wells or transferred to the mainland for appropriate onshore disposal or recycling

Activity	Discharge Type	Illustrative Measures
	Hydraulic fluid discharges	Use of biodegradable, low-toxicity, and highly diluted hydraulic fluids
Installation of the Offshore Feed Gas Pipeline System	Hydrotesting	• Chemical additives used to treat the hydrotest water have been chosen carefully to ensure that they will not only meet the required technical performance but also have minimum potential environmental impacts • Chemicals intended to be discharged to the environment are subject to the Chevron Australia chemical approval process, or similar Chevron Australia-approved contractor processes • Chemicals are selected based on criteria that will ensure they will not persist for long periods or bioaccumulate in biota once discharged
Marine vessels contracted or operated by the GJVs (including drilling rigs) during construction and operation	Deck drainage	• Drilling rig floor drainage treated and discharged in accordance with MARPOL 73/78 • High standards of housekeeping will be maintained in all areas, including keeping the area litter-free • Only limited and fit-for-purpose hazardous and dangerous materials will be kept on the vessels and they will be stored and handled in accordance with relevant legal requirements, industry standards, and Material Safety Data Sheets (MSDS) requirements • A complete inventory of all hazardous materials stored will be maintained on board, together with a complete up-to-date set of MSDSs for each hazardous or dangerous goods substance • Maintenance activities on vessels that have the potential to result in leaks or spills will be contained • Spill containment and recovery equipment will be provided where spills are possible; equipment will be maintained to ensure that it is readily available and in working condition • In the event of a spill or leak on deck and if it is safe to do so, vessel scuppers will be closed to ensure any contaminants on deck are not discharged into the ocean • In the event of a spill or leak on deck, spilled materials will be cleaned and removed prior to any deck washdown activities
	Bilge water	• Equipment and machinery spaces on the vessels will be fully contained and have dedicated drains leading to the bilge water system for oily waste products • Compliance with MARPOL 73/78 for oily water discharge • Bilge water passed through oil-water separator to <15 ppm oil in water • Drainage collection system maintained operational • Coamings will be provided on drilling rigs around the refuelling storage tanks to contain all spilled fluids • Drain holding tanks will be fitted with individual high and low level alarms linked to the Vessel Management System
	Sewage, greywater, and putrescibles	• Galley waste to be macerated to less than 25 mm before discharge to sea, in accordance with MARPOL 73/78 • Sewage to be treated in accordance with MARPOL 73/78 • Inspection and maintenance of waste (sewage, greywater, and food scraps) treatment systems will be conducted regularly to confirm operability and performance

Discharges to sea are likely to be most frequent in the Commonwealth Marine Area during construction activities, due to increased vessel activity during this time. Although discharges from operations activities will occur in the Commonwealth Marine Area, these are likely to be less frequent. The potential incremental impacts on water quality associated with planned discharges to sea are predicted to be short term, and, as the offshore environment is highly dispersive, any reduction in water quality is also expected to be short term. Effects on sediment characteristics may be long term in some cases (e.g. from the settlement of drilling cuttings); however, discharges will be localised and benthic communities in the affected areas are expected to be well represented across the wider North-west Marine Region. As a result the potential incremental impact of discharges to sea on marine water quality, sediments, and marine fauna was assessed as 'Low'.

The types of discharges due to the Fourth Train Proposal are consistent with those of the approved Foundation Project, although additional areas will be subject to discharges from the Fourth Train Proposal. Increases in marine vessel activity during construction activities will be short term, and increases in marine vessel activity during operation of the Fourth Train Proposal will represent only a small increase on that approved for the Foundation Project. Discharges to sea are expected to be discrete and/or short-term events, and are expected to disperse quickly in the deep waters and high-energy environment of the Commonwealth Marine Area. Any potential additional impacts that may occur to marine water quality, the seabed, and marine flora and/or fauna are likely to be localised. In addition, the receiving environments are not assessed as being any more sensitive than those considered under the Foundation Project. Discharges due to the Fourth Train Proposal additional to the approved Foundation Project are not considered to change the level of impact assessed and approved under the Foundation Project. The additional potential impacts of Fourth Train Proposal discharges within the Commonwealth Marine Area were assessed as 'Low'.

Discharges to sea from the Fourth Train Proposal additional to the Foundation Project are not expected to result in substantial adverse changes to water quality, the seabed, or ecological communities, including marine fauna. The identified discharges to sea are also not anticipated to adversely affect human health, or the social amenity of the Commonwealth Marine Area. Therefore, the potential impacts are determined to be acceptable and the objectives established for discharges to sea are determined to be met (Table 13-19). The implementation of the Fourth Train Proposal is considered to be consistent with the policy and plan documents listed in Table 13-20.

13.5.6 Noise and Vibration

Anthropogenic marine noise has the potential to impact marine fauna through interference with their communication and orientation systems, which may subsequently affect an individual's ability to navigate, socialise, and forage. The level of potential impact to marine fauna from anthropogenic marine noise depends on factors such as the frequency and the intensity of the sound at the source, the species of fauna exposed to the noise, its distance from the source, and its response threshold (Nowacek *et al.* 2007). The assessment of impacts from anthropogenic marine noise focuses on those groups of species considered to be most vulnerable to impact, and considers aspects including physiology, behaviour, and potential for exposure to anthropogenic marine noise generated by the Fourth Train Proposal.

Naturally occurring marine noise sources, such as wind and wave activity occur as ambient noise in the Commonwealth Marine Area. Anthropogenic activities, including marine vessel usage and air transport, also contribute to ambient noise levels. Within the Fourth Train Proposal Area and associated Commonwealth Marine Area, a number of sources of anthropogenic marine noise were identified that related to construction activities of the Fourth Train Proposal. These sources include dynamic positioning (DP) of marine vessels, drilling and associated seismic activities (e.g. VSP), and helicopter transfers. Sections 5.4.3.1 and 5.4.3.2 provide additional information on the sources of noise associated with the Fourth Train Proposal.

During operations, anthropogenic marine noise sources will also include marine vessels (e.g. shipping and logistics vessels), although the regularity of marine vessels operating in the Commonwealth Marine Area due to the Fourth Train Proposal is likely to be less than during construction. The operation of the Offshore Feed Gas Pipeline System and associated subsea facilities may also result in the generation of anthropogenic marine noise. These operational sources of noise would be a long-term addition to natural ambient noise, and may be associated with different geographic areas than the Foundation Project sources of anthropogenic marine noise.

Figure 10-3 summarises previously reported frequencies and intensities for noise from anthropogenic activities, together with estimated hearing and calling ranges (frequency and intensity) previously reported for groups of marine fauna. The figure illustrates the potential overlap between the frequency and the intensity of sounds produced by offshore marine activities, and the auditory and/or vocalisation ranges previously reported for marine fauna.

Impacts to fish from noise can include increased stress levels, disruption to acoustic cues, changes in behaviour (e.g. attraction or avoidance). Disturbance to fish from noise may occur from low-frequency (20 to 500 Hz) emissions above 180 dB re 1 µPa (Department of Industry and Resources [DoIR] 2007); this falls within the general intensity and frequency parameters of noise produced by the marine vessels that may be used during construction and operation of the Fourth Train Proposal (Figure 5-6 and Figure 5-7). Both bony fish and elasmobranches may avoid marine vessel activities due to the associated anthropogenic marine noise, although the behaviour of elasmobranches in the presence of marine noise is less well understood (Casper *et al.* 2012). Offshore marine vessel activities due to the Fourth Train Proposal will be short term and transient and would not be expected to affect broader species distributions, movements, or community structures in the Commonwealth Marine Area associated with the Fourth Train Proposal, or across the wider North-west Marine Region. Seismic surveys (e.g. potential VSP activities during drilling) generally produce noise at higher intensities than other anthropogenic marine noise likely to be generated by Fourth Train Proposal activities. Fish are considered to be most vulnerable during early life stages; however, studies indicate that seismic-induced effects do not hinder recruitment of fish to fisheries. Turnpenny and Nedwell (1994) found seismic sources at intensities of 230 dB re 1 µPa did not cause injury to fish eggs at a distance of 10 m. Seismic source levels from Fourth Train Proposal activities in the Commonwealth Marine Area (including potential VSP operations) are expected to be below those reported by Turnpenny and Nedwell (1994). In addition, VSP operations are planned to be in offshore areas where fish are likely to be highly mobile pelagic and demersal species that can move away from or avoid the noise source. Therefore, noise and vibration generated by Fourth Train Proposal activities is not anticipated to result in adverse effects on the recruitment of fish.

Some marine mammal species, including Humpback Whales, were identified as being more likely to occur in the Fourth Train Proposal Area within the Commonwealth Marine Area, and therefore may be exposed to potential impacts of anthropogenic marine noise by the implementation of the Fourth Train Proposal offshore activities (Table 13-22). Section 13.4.2.2 further describes and assesses the potential impacts to those marine mammals that are considered to be most vulnerable to exposure to anthropogenic marine noise.

A number of marine turtle species are likely to occur in the Fourth Train Proposal Area; the potential impacts to marine turtles from anthropogenic marine noise are discussed in Section 13.4.2.3.1.

Illustrative measures for this stressor, taken from currently approved Foundation Project EMPs, are presented in Table 13-26 for assessment purposes (see Section 8.3.5 for an explanation of the status of the measures).

Table 13-27: Illustrative Mitigation and Management Measures for Anthropogenic Marine Noise in the Commonwealth Marine Area

Relevant Activity		Illustrative Measures
Production Drilling	Pipeline Installation	
✓		• Sequential increase in intensity of 'warning' pulses over 20 minutes initiated at the lowest setting at the commencement of operations will be used to deter fauna from entering the zone of influence during VSP
✓	✓	• Maintaining helicopter height in accordance with Part 8 of the Environment Protection and Biodiversity Conservation Regulations 2000
✓	✓	• Avoid leaving engines, thrusters and auxiliary plants in standby or running mode unnecessarily
✓	✓	• Compliance with appropriate industry and equipment noise and vibration standards
✓	✓	• Regular maintenance of vessels and equipment according to manufacturers' specifications

Anthropogenic marine noise generated during the Fourth Train Proposal offshore construction and operations phases in the Commonwealth Marine Area is not expected to result in long-term behavioural changes or direct adverse health effects that could manifest in population-level effects to marine fauna. As a result, the potential incremental impact to marine fauna in the Commonwealth Marine Area was assessed as 'Low'.

Although the sources of anthropogenic marine noise from the Fourth Train Proposal are largely consistent with those assessed for the approved Foundation Project, new or additional geographic areas may potentially be affected. Should offshore construction activities (e.g. production well drilling) overlap between the Fourth Train Proposal and the approved Foundation Project, the Fourth Train Proposal activities will add to the overall geographic coverage of anthropogenic marine noise generated in the Commonwealth Marine Area. However, the higher intensity sources of noise and vibration (e.g. VSP) will be limited to a short period of time in offshore waters, reducing the potential for impact. Individual fauna and groups of fauna that may be impacted are expected to be widespread throughout the Commonwealth Marine Area of the Fourth Train Proposal Area. Any impacts that may occur are likely to be short term and localised, and would not be expected to have wider implications for populations of marine species or associated ecological communities. Anthropogenic marine noise from the Fourth Train Proposal is not expected to have a substantial adverse effect on a population of a marine species, including their life cycle (e.g. breeding, feeding, migration behaviour, life expectancy) or distribution. The potential additional impact associated with anthropogenic marine noise on marine fauna of the Commonwealth Marine Area as a result of the Fourth Train Proposal was assessed as 'Low'.

Anthropogenic marine noise from the Fourth Train Proposal additional to the approved Foundation Project is not expected to result in adverse effects to marine fauna at the species or ecosystem level. The potential impacts are determined to be acceptable and the objective established for noise and vibration emissions within the marine environment is determined to be met (Table 13-19). The implementation of the Fourth Train Proposal is considered to be consistent with the policy and plan documents listed in Table 13-20.

13.5.7 Seabed Disturbance

Seabed disturbance has the potential to impact upon a number of environmental factors, including the physicochemical characteristics of the seabed, benthic communities, and indirectly upon demersal marine fauna through the resuspension of sediments and changes in water quality. The extent and longevity of the potential impacts can be related to the nature, scale, and timing of the activities causing the disturbance, as well as the seabed substrate, habitat type, and benthic communities in the vicinity of the disturbance.

The implementation of the Fourth Train Proposal has the potential to impact a number of environmental factors that are associated with the seabed and benthic environments (Table 13-22). The key Fourth Train Proposal activities that may result in seabed disturbance include:

- construction of the Fourth Train Proposal Offshore Feed Gas Pipeline System
- offshore drilling
- placement of temporary structures and anchoring during construction.

Additional description of the Fourth Train Proposal subsea infrastructure in the Commonwealth Marine Area is provided in Section 4.3; Section 1.3.6outlines the schedule anticipated for the construction of this infrastructure. Within the Commonwealth Marine Area, offshore drilling and the construction of the Fourth Train Proposal Offshore Feed Gas Pipeline System are the activities expected to cause the greatest seabed disturbance. Potential impacts to the seabed due to Fourth Train Proposal operations phase activities (e.g. the maintenance of offshore infrastructure) are expected to be localised and short term or intermittent.

Decommissioning of the Fourth Train Proposal offshore infrastructure is also expected to result in seabed disturbance, although the scale of disturbance is not anticipated to exceed that created during construction. The assessment of potential impacts from decommissioning will be further characterised and assessed closer to the time of cessation of production, accounting for project-specific conditions, and the regulatory framework at the time.

13.5.7.1 Installation of the Fourth Train Proposal Offshore Feed Gas Pipeline System

Preparation for, and installation of, the Fourth Train Proposal Offshore Feed Gas Pipeline System will lead to long-term or permanent physical loss of the seabed habitat over which the pipeline system is laid. This disturbance will occur in the Commonwealth Marine Area associated with the Fourth Train Proposal Area (Figure 13-1).

Two alignment options—a northern route and a southern route—are being considered by the GJVs for the Fourth Train Proposal Offshore Feed Gas Pipeline System. The Southern Pipeline Route option in the Commonwealth Marine Area has previously been considered and approved under the Jansz Offshore Feed Gas Pipeline System; the potential impacts associated with this route were assessed as being well characterised and manageable through the implementation of established industry practices for mitigation. The assessment concluded that the pipeline system and its associated construction, operation, and decommissioning activities would have limited impact on the marine environment, including upon controlling provisions in the vicinity of the proposed activities (Mobil Australia Resources 2005; Mobil Exploration and Producing Australia 2005a). The Southern Pipeline Route as proposed under the Jansz Offshore Feed Gas Pipeline System project was not constructed due to an alternative option being implemented; however, the route (within the Commonwealth Marine Area) was approved by the Commonwealth Minister for Environment and Water Resources on 22 March 2006 (EPBC Reference: 2005/2184), and the approval of the project transferred in 2009 to Chevron Australia Pty Ltd under section 145B of the EPBC Act (DEWHA 2009a).

This PER/Draft EIS assesses both the southern and northern pipeline route options for the Fourth Train Proposal Offshore Feed Gas Pipeline System.

The Offshore Feed Gas Pipeline System route options differ in length and the geographic area traversed. Table 13-28 provides an estimate of the disturbance footprint of the two pipeline route options out to the Fourth Train Proposal gas fields. The indicative seabed disturbance footprints include estimates of the quantities of materials required for primary stabilisation (e.g. concrete coating) and secondary stabilisation (e.g. and graded rock), which will be required to provide long-term operational stability and span correction at locations along the Offshore Feed Gas Pipeline. The potential impacts associated with both route options are expected to be similar due to the similar benthic environments. Benthic surveys undertaken to support planning of the Jansz Offshore Feed Gas Pipeline System indicated that the seabed along the proposed Southern Pipeline Route was typical of the low abundances of benthic fauna, species-richness, and diversity observed in other deep areas of the North-west Marine Region (Mobil Exploration and Producing Australia 2005a).

Within the Commonwealth Marine Area, the Fourth Train Proposal Northern Pipeline and Southern Pipeline routes traverse the Montebello Commonwealth Marine Reserve multiple use area (Section 6.7.1.1) for a distance of approximately 12 km and 11 km respectively. The Montebello Commonwealth Marine Reserve encompasses part of the ancient coastline at 125 m depth, identified as a key ecological feature under the bioregional plan for the North-west Marine Region (SEWPaC 2012). The Montebello Commonwealth Marine Reserve is noted as an area of enhanced biological productivity, which may provide foraging opportunities for marine fauna, including a number of threatened and/or migratory species. The installation of the Fourth Train Proposal Offshore Feed Gas Pipeline System and associated materials is expected to directly disturb up to approximately 0.25 km^2 of the seabed in the Montebello Commonwealth Marine Reserve, equivalent to <0.01% of the available seabed within the reserve.

Several other features within the North-west Marine Region will be traversed by the Offshore Feed Gas Pipeline System route options:

- Both route options will traverse continental slope demersal fish communities; this key ecological feature supports a high diversity of fish, including species thought to be endemic to this area (SEWPaC 2012h). Analysis of potential environmental pressures undertaken by DotE (SEWPaC 2012h) cited offshore construction as a pressure of 'less concern' for this key ecological feature. The continental slope demersal fish communities extend across a large area of the North-west Marine Region; only a small proportion of this key ecological feature will be exposed to seabed disturbance due to the Fourth Train Proposal.
- The northern route option will traverse an escarpment approximately 80 km from Barrow Island; the escarpment is located at approximately 600 m water depth. This is the same escarpment traversed by the Foundation Project Jansz Offshore Feed Gas Pipeline System. The scarp face comprises mainly over-consolidated silt; these sediments provide structural diversity to an otherwise flat benthos, and support more abundant benthic fauna, including solitary sea pens, holothurians, hydroids, and soft corals (RPS 2009). Similar to the approved Foundation Project, pipe-laying for the northern pipeline route is likely to require pre-pipelay works on the escarpment to manage the potential freespan of the Offshore Feed Gas Pipeline System where it crosses the scarp. Although the scarp is considered to be of higher conservation significance than the more widespread soft sediments, bathymetry data indicates that the scarp feature extends in a latitudinal orientation at least 5 to 10 km).
- The northern route option would cross two rocky reef systems at approximately 12 km (located in the Montebello Commonwealth Marine Reserve) and 25 km west of Barrow Island, at approximately 40 m and 50–55 m water depth, respectively. These reefs support benthic epifauna communities, which include encrusting sponges, scattered soft corals, as well as fish fauna (Chevron Australia 2005, technical appendix C8). Pre-pipelay works may be required to negotiate a route through the rocky reef systems, and may involve the placement of artificial substrate such as concrete mattresses over the natural substrate to mitigate pipeline spanning. Conventional industry trenching techniques such as cutting, jetting, and/or ploughing may be used through some sections of the rocky reef systems; however, trenching will mostly occur in water depths greater than 70 m, and therefore beyond the rocky reef systems. Although the rocky reefs are considered to be of higher conservation value than the more widespread soft sediments that are common

to the region, bathymetry data indicates the reefs are well represented, being part of more extensive reef systems that extends in a latitudinal orientation approximately 5 km.

Subsea survey data will be used to help determine the most suitable routes through these seabed features such that potential impacts will be avoided where practicable.

Table 13-28: Indicative Length and Area of Disturbance for the Fourth Train Proposal Offshore Feed Gas Pipeline System Route Options

Offshore Feed Gas Pipeline Route Options		
Indicative Footprint Dimensions	**Northern Route**	**Southern Route**
Indicative length (total)*	140 km	185 km
Indicative marine disturbance area (total)	1.74 km^2	2.28 km^2
Indicative length (Commonwealth Marine Area)	134.67 km	178.57 km
Indicative marine disturbance area (Commonwealth Marine Area)	1.96 km^2	2.453 km^2
Indicative length (Montebello Commonwealth Marine Reserve)	12 km	11 km
Indicative marine disturbance area (Montebello Commonwealth Marine Reserve)	0.231 km^2	0.219 km^2
Indicative disturbance footprint as a % of available seabed within the North-west Marine Region**	<0.001%	<0.001%
Indicative disturbance footprint as a % of available seabed within the Montebello Commonwealth Marine Reserve***	<0.01%	<0.01%

* *approximate from horizontal directional drilling exit point in State Waters*

** *an area of approximately 1 070 000 km^2 is reported for the entire North-west Marine Region (DEWHA 2008a)*

*** *an area of 3413 km^2 is reported for the Montebello Commonwealth Marine Reserve (SEWPaC 2012g)*

The water depth along much of the pipeline system route options in the Commonwealth Marine Area precludes the establishment of substantial areas of benthic primary producer habitat. However, some benthic marine fauna, including infauna (e.g. burrowing worms) and small numbers of sessile and mobile epifauna (e.g. soft corals and decapods), may be present, and could be smothered or displaced within the direct footprint of the Fourth Train Proposal Offshore Feed Gas Pipeline System during its installation.

Excavation of seabed sediments along sections of the Offshore Feed Gas Pipeline System route options in the Commonwealth Marine Area may be required as a method of secondary stabilisation in water depths up to 200 m. For the northern route option, the escarpment crossing may also require pre-lay preparation, and may use a range of seabed profiling techniques including trenching, cutting, jetting, and the use of grabs. Excavated seabed materials will be deposited directly on the seabed alongside the trenches. A short-term plume of suspended sediments is likely to be created, increasing the turbidity in the water column and potentially impacting upon light-sensitive benthic habitats by directly smothering them. Coarse particles, such as sands and gravels, usually settle back to the seabed very rapidly, while fine particles such as silts and clay may be dispersed over a greater distance (Department of Business Enterprise and Regulatory Reform 2008). Increased sediment loading of the water column may impact marine fauna by clogging or damaging sensitive gill structures, preventing proper egg and larval development, and potentially interfering with particle-feeding activities. The extent of the zone affected by the turbid plumes will depend on a number of factors, including the volume of materials disturbed, the rate of sediments released into the water column, particle sizes, and current velocity.

A turbidity survey conducted as part of the Wheatstone LNG Project, recorded variations in the turbidity levels during trenching operations. The trenching trial was conducted offshore from Onslow, Western Australia, which is also within the North-west Marine Region. Survey results indicated that a turbid plume may be evident during trenching up to 70 m from the trenching area depending on environmental conditions. However, results also indicated that within two hours of ceasing trenching operations, the turbidity level could be expected to return almost to background levels within this zone (Chevron Australia 2010a, 2010b).

In 2011, the Foundation Project undertook pre-lay preparation activities at the escarpment for the approved Jansz Feed Gas Pipeline. An internal audit identified that the activities were conducted in line with the environmental plan, and that standards and objectives required under the environment plan were met. This involved ensuring compliance with MARPOL for all emissions and discharges from marine vessels, education of personnel on the health, safety and environmental requirements of the project, and correct recording and reporting of incidents.

The GJVs propose that the potential environmental impacts associated with trenching of the scarp during construction of the Fourth Train Proposal Offshore Feed Gas Pipeline System will be managed in line with the environmental management framework described in Section 16. Elements of this framework that are relevant to the management of trenching at the scarp include Conditions 1 and 2 of EPBC Reference: 2005/2184, which require the submission of a plan (or plans) to manage the potential impacts offshore and during pipeline construction:

1. *The person taking the action must submit, for the Minister's approval, a plan (or plans) for managing the offshore impacts of the action.*
2. *The person taking the action must submit for the Minister's approval, a plan or plans to address pipeline installation measures for minimising the potential for impacts on EPBC Act-listed threatened turtles and cetaceans during pipeline construction.*

The management of potential impacts in the Commonwealth Marine Area from Fourth Train Proposal activities are discussed further in Section 13.5.10.

The potential impacts associated with the Fourth Train Proposal construction activities for the Offshore Feed Gas Pipeline System will be limited to the immediate vicinity of the pipeline route footprint. Trenching of the seabed is expected to occur across only certain sections of the pipeline system, at the scarp crossing, and in shallower regions of the Commonwealth Marine Area (up to approximately 200 m water depth). No habitats that are unique to the region have been identified in the estimated disturbance footprints for either pipeline route option, or general locations of the intrafield infrastructure. The seabed features and associated faunal assemblages that may be impacted are considered to be well represented outside the areas that may be disturbed. The small proportion of affected seabed within the Montebello Commonwealth Marine Reserve and also the wider North-west Marine Region, would not be expected to result in any discernible adverse impacts to ecosystem health, or the overall productivity in these areas. Disturbance to benthic communities is also expected to be short term, with displaced communities likely to be replaced by the migration of motile individuals and the settlement of planktonic phases of sessile fauna upon hard substrate placed in the area. Other mobile fauna, such as fish and mobile benthic epifauna, may avoid the areas disturbed by the stabilisation works during construction of the Offshore Feed Gas Pipeline System, but would be expected to move back into the impacted areas shortly after installation and associated stabilisation works are completed.

The long-term presence of the Fourth Train Proposal Offshore Feed Gas Pipeline System and associated infrastructure is assessed within Section 13.5.8.

13.5.7.2 Installation of the Fourth Train Proposal Intrafield Flowlines

Beyond the termination of the Offshore Feed Gas Pipeline System, intrafield infrastructure is expected to comprise a number of subsea manifolds and up to approximately 140 km of intrafield flowlines, with associated utility, umbilical, and monoethylene glycol (MEG) pipelines (Section 4.3.3).

Preparation for, and installation of, the Fourth Train Proposal intrafield flowlines will lead to long-term or permanent physical loss of seabed habitat over which the flowlines are laid. This disturbance will occur in the Commonwealth Marine Area associated with the Fourth Train Proposal Area (Figure 13-1). The seabed disturbance footprint associated with the intrafield flowlines will cover an area of approximately 5.7 km^2 (Table 13-29).

Table 13-29: Indicative Length and Area of Disturbance for the Fourth Train Proposal Intrafield Flowlines

Indicative Footprint Dimensions – Intrafield Flowlines	
Indicative length of flowlines	140 km
Indicative marine disturbance area (total)	5.7 km^2
Indicative disturbance footprint as a % of available seabed within the North-west Marine Region*	<0.001%

* *an area of approximately 1 070 000 km^2 is reported for the entire North-west Marine Region (DEWHA 2008a)*

Subsea infrastructure including intrafield flowlines will also overlap the Exmouth Plateau. The topography of this key ecological feature promotes upwelling of deeper-water nutrients, supporting sporadic high primary production within open water (Brewer *et al.* 2007). Analysis of potential environmental pressures undertaken by DotE (SEWPaC 2012h) did not cite offshore construction as a pressure 'of potential concern' for the Exmouth Plateau. The seabed within the Exmouth Plateau provides habitat for benthic scavengers, filter feeders, and epifauna; however, habitats and communities in this area are considered to be of low heterogeneity. The installation of the intrafield flowlines may increase the heterogeneity of the seabed by introducing hard substrate; this may result in changes to the structure of the benthic community in the direct footprint of the installed pipeline; however, such changes would be localised and would be considered negligible in the context of the overall extent of the Exmouth Plateau.

13.5.7.3 Installation of Subsea Facilities, Drilling, and from Temporary Structures (including anchors)

Subsea facilities will comprise a number of subsea structures, including manifolds and wellheads (Section 4.5.1.2). The general relief of the subsea facilities, such as manifolds mean that they are exposed to currents above the seabed, and to interaction with other marine users (e.g. fishing equipment and anchors). The natural transport and deposition of sediment at the ocean floor may also alter the seabed profile and undermine the stability of subsea facilities.

Two options—suction piles or skirt foundations—are being considered to ensure manifolds have adequate stability on the seabed. Suction piles penetrate the seabed to a greater depth than skirt foundations, although only the upper layers of the seabed are disturbed in either case. Skirt foundations may come into direct contact with a greater surface area of the seabed when compared to suction piles and both options may influence sediment transport at the sea floor. This may lead to scouring and/or deposition of sediment (e.g. sand) around the facilities over time. However, this disturbance is expected to be local, limited to the immediate vicinity of the facilities, and no unique habitats are expected to be affected by their installation or long-term presence.

The placement of temporary structures such as acoustic transponders to aid the accurate positioning of subsea facilities, or the short-term laydown of subsea system components will also disturb the seabed. Marine vessels and drilling rigs may require the use of anchors or may use DP, depending on environmental conditions and the technical constraints associated with the activity. Dynamic positioning uses thrusters to maintain position in relation to external forces and therefore, unlike anchors, there is no direct contact with the seabed.

However, the use of anchors in the Commonwealth Marine Area may be necessary throughout the implementation of the Fourth Train Proposal.

Changes in the seabed structure and the direct loss of habitat and benthic organisms in the contact zone may occur at locations where anchors or temporary structures are laid. Anchor handling may also cause sediment resuspension and associated turbidity in the water column when the anchor is lowered onto the seabed, when it is dragged through the seabed to achieve holding power, and when it is retrieved from the seabed (Nord Stream AG 2009). Previously reported observations have suggested that anchor handling generally generates two short-term (approximately one hour or less duration) sediment pulses during deployment and recovery, and that indirect impacts associated with turbidity are limited to the immediate vicinity of the disturbed area (BHP Billiton 2010). Within the Commonwealth Marine Area, the composition of the seabed across most of the Fourth Train Proposal Offshore Feed Gas Pipeline route options is expected to comprise soft sediments of varying grain size. These sediments are mobile, which should aid the recovery of areas affected by disturbance from installation activities and temporary structures.

Drilling is expected to result in direct impacts on the seabed through the shearing of sediments and subsequent physical changes to seabed structure. The discharge of drilling cuttings and adhered drilling fluids also have the potential to affect the physicochemical composition of the seabed following their discharge and settlement. These effects may include the creation of shallow anoxic environments within the underlying seabed with subsequent impacts on existing benthic communities, particularly benthic infauna that may be in the immediate vicinity. These potential effects are expected to be limited to the immediate vicinity of the well location (Section 13.5.5.1).

13.5.7.4 Summary

Illustrative mitigation and management measures for this stressor, taken from currently approved Foundation Project EMPs, are presented in Table 13-30 for assessment purposes (see Section 8.3.5 for an explanation of the status of the measures).

Table 13-30: Illustrative Mitigation and Management Measures for Seabed Disturbance in the Commonwealth Marine Area

Relevant Activity		Illustrative Measures
Production Drilling	**Pipeline Installation**	
✓	✓	• Pre-lay surveys will be conducted to identify any potentially sensitive habitats or historic shipwrecks along the proposed pipeline route or around well sites
	✓	• To reduce the impacts to as low as reasonably practicable, the [pipe-]lay corridor will be restricted where the route traverses the reef sections
	✓	• Stabilisation materials used will be very coarse, so that any sediment spill will be related to suspension of the local sediment caused by the momentum of the rock materials placed on the seabed
	✓	• A fall-pipe vessel will be used [to install rock stabilisation material on the pipelines], allowing accurate placement of rock, thus impacts will be confined to an area equal to the footprint where rocks are installed
✓	✓	• Adherence to anchoring and drilling procedures and relevant guidelines
✓		• For drilling rigs and other significant moorings, mooring analysis will be undertaken to ensure correct anchor type for seabed conditions to prevent excessive anchor drag once set

Relevant Activity		Illustrative Measures
Production Drilling	Pipeline Installation	
✓		• Where practicable, batch drilling and batch completion from subsea manifolds will reduce the number of anchor moves and settings, reducing impact on benthic environment
✓		• Selection of low-toxicity tophole drilling fluid additives
✓	✓	• Use of dynamically positioned vessels where practicable. With respect to drilling activities, only the rig will be moored; the support vessel will be dynamically positioned

Seabed disturbance from the Fourth Train Proposal in the Commonwealth Marine Area is expected to occur in the immediate vicinity of the Fourth Train Proposal marine facilities. The overall spatial extent of the affected areas is small compared to the overall scale and nature of the seabed and its habitats in the Commonwealth Marine Area of the Fourth Train Proposal Area and the wider North-west Marine Region. Seabed disturbance will increase as a result of the Fourth Train Proposal construction activities. Although seabed disturbance is likely to occur during operations, this disturbance relates to anchor use in designated areas, which will have been already disturbed by the Foundation Project. Modifications to the seabed and associated habitats may occur, including over small areas within key ecological features identified for the North-west Marine Region (Section 13.5.7.1). However, no discernible adverse impact is expected on the diversity of seabed features or productivity of the benthos in the Commonwealth Marine Area. As such, the potential incremental impact to the seabed, to water quality, and to marine fauna was assessed as ‘Low’.

The Fourth Train Proposal is not expected to change the level of impact to the Commonwealth Marine Area as a result of seabed disturbance from that predicted for the approved Foundation Project. Additional geographic areas will be affected by implementation of the Fourth Train Proposal; however, the habitats and ecological communities in these areas are expected to be broadly similar to those found throughout the Commonwealth Marine Area within the North-west Marine Region. Any impacts that may occur are likely to be localised. Given the limited spatial extent of the Fourth Train Proposal activities in the Commonwealth Marine Area, the potential additional impacts associated with seabed disturbance in the Commonwealth Marine Area as a result of the Fourth Train Proposal were assessed as ‘Low’.

Seabed disturbance due to the Fourth Train Proposal additional to the approved Foundation Project is not predicted to compromise the integrity, ecological functions, or environmental values of the seabed. The potential impacts are determined to be acceptable and the objective established for the seabed is determined to be met (Table 13-19). The implementation of the Fourth Train Proposal is considered to be consistent with the policy and plan documents listed in Table 13-20.

13.5.8 Physical Presence of Infrastructure and Physical Interaction

The presence of infrastructure in the Commonwealth Marine Area has the potential to impact upon a number of environmental factors, including benthic and pelagic marine fauna, through changes to physicochemical parameters of the seabed and displacement or attraction of certain marine fauna to an area. The presence of marine vessels, drilling rigs, and associated subsea equipment/temporary structures (including anchors and installation aids) can also result in potential impacts through physical interaction with marine fauna, cultural heritage sites (e.g. shipwrecks), and other sea users (Table 13-22).

Elements of the Fourth Train Proposal that will have a physical presence in the Commonwealth Marine Area include subsea facilities and associated infrastructure, as well as marine vessels and associated subsea equipment. Drilling rigs will also be present offshore in the Commonwealth Marine Area associated with the Fourth Train Proposal Area.

Fourth Train Proposal subsea infrastructure will traverse three key ecological features for the North-west Marine Region—the ancient coastline, continental slope demersal fish communities, and the Exmouth Plateau (Section 13.5.7.1). The physical presence of the Fourth Train Proposal Offshore Feed Gas Pipeline System and associated infrastructure may result in changes to the benthic environment, including to hydrological regimes and sediment seabed transport. Around the subsea infrastructure, seabed scouring and/or increased deposition of suspended solids may occur, which may have a localised impact on sediment loading within the water column, thus altering the availability of suspended food particulates and deposition rates. Marine fauna that occur in the North-west Marine Region and that are considered sensitive to changes in hydrodynamic regimes include sessile benthic filter-feeding organisms. However, the seabed and associated marine faunal communities along the pipeline route options are well represented through the North-west Marine Region. In addition, these potential changes may occur at discrete locations, closely associated with the subsea infrastructure locations, and would not be expected to result in any unacceptable impacts to the wider diversity and productivity of benthic communities in the North-west Marine Region, or to the values or broader functioning of key ecological features.

Subsea infrastructure and associated stabilisation materials will provide hard substrate; this is anticipated to increase the heterogeneity of much of the sea floor in the vicinity of the subsea facilities, which is predominately sand and gravel on the continental shelf, becoming finer with depth. Introduced hard substrate may encourage the establishment of communities usually associated with rocky reef environments, including sessile encrusting marine fauna. Higher-profile subsea structures such as subsea cluster manifolds, wellheads, and drilling rigs may attract and provide shelter for demersal and pelagic marine fauna (McGinnis *et al.* 2001). However, given the remote locations and low numbers of drilling activities, and of the subsea structures to be installed, no adverse effects would be expected on the wider diversity and productivity of the Commonwealth Marine Area associated with the Fourth Train Proposal Area. Most of the Fourth Train Proposal subsea infrastructure, such as the pipeline and associated stabilisation materials (e.g. graded rock), will have a relatively low relief. Studies undertaken in the United States suggest that complex artificial low-relief structures can provide nursery habitat for marine fauna including commercial fish species, and may create local areas of increased diversity and productivity (McGinnis *et al.* 2001).

Marine vessels have the potential to impact marine fauna through physical interaction. Assessment of this stressor on those marine fauna considered most vulnerable to interaction with marine vessels is provided in Section 13.4.

Assessment of potential socioeconomic impacts (e.g. to commercial marine vessels, shipwrecks, or relics) in relation to physical presence and physical interaction, including in the Commonwealth Marine Area, due to the Fourth Train Proposal is provided in Section 14.

Illustrative mitigation and management measures for this stressor, taken from currently approved Foundation Project EMPs, are presented in Table 13-31 for assessment purposes (see Section 8.3.5 for an explanation of the status of the measures).

Table 13-31: Illustrative Mitigation and Management Measures for Physical Presence and Physical Interaction in the Commonwealth Marine Area

Relevant Activity		Illustrative Measures
Production Drilling	Pipeline Installation	
✓	✓	• Seabed surveys around drill sites and Offshore Feed Gas Pipeline System route to identify sensitive marine ecosystems such as reefs, sponge beds, and seagrasses, and historic shipwrecks, and selection of the drill sites and Feed Gas Pipeline System route to avoid impacts to these [1]
✓	✓	• Compliance with the APPEA Code of Environmental Practice 2008 (APPEA 2008)
✓		• Mooring analysis will be undertaken to ensure correct anchor type for seabed conditions to prevent excessive anchor drag once set. Batch drilling and batch completion from subsea manifolds will reduce the number of anchor moves and settings, reducing impact on benthic environment
✓		• During drilling, only the rig will be moored; the associated support vessel will be dynamically positioned
✓	✓	• Drilling rig and vessels will display all required navigation lighting to minimise any navigation hazard to passing vessels
✓	✓	• Anchor lines will be deployed with sufficient tension to minimise entanglement. Additionally, structures and equipment will be deployed using taut/rigid lines so there will be negligible risk of entanglement by marine fauna
✓	✓	• Project personnel will not be permitted to feed, harass, capture, disturb, harm, or kill marine fauna on or near the worksite
✓	✓	• Marine megafauna (whales, dolphins, turtles, Whale Sharks) sighting observations will be recorded and reported to DotE
	✓	• Responsibility for marine fauna observation will be allocated to appropriate personnel (such as the Vessel Master or delegate) on the installation vessels, who will maintain watch for marine fauna during daylight hours when the vessels are moving at speeds greater than 5 knots
	✓	• If marine megafauna are spotted, vessels moving >6 knots will adjust their speed to <6 knots or adjust their direction to avoid impacting the animal, if safe to do so
	✓	• Use of a fall-pipe vessel will allow accurate placement of rocks, thus the installation of rock can be closely managed to reduce the spread of rocks beyond the target area

1 *This mitigation measure is a requirement under Condition 16A of EPBC Reference: 2003/1294 and Condition 1 of EPBC Reference: 2005/2184.*

The Fourth Train Proposal will result in additional geographic areas and habitats being subject to potential impacts associated with the physical presence of infrastructure and physical interactions with this infrastructure and marine vessels, when compared to the impacts assessed for the approved Foundation Project. However, potential incremental impacts are not expected to result in any unacceptable impacts to marine fauna (including listed species) at a species or ecosystem level. The potential incremental impacts associated with the physical presence of Fourth Train Proposal infrastructure and with physical interactions with Fourth Train Proposal infrastructure and marine vessels in the Commonwealth Marine Area were assessed as 'Low'.

The Fourth Train Proposal is not expected to change the level of potential impacts to the Commonwealth Marine Area as a result of physical presence and/or interactions from that predicted for the approved Foundation Project. Additional geographic areas, including the habitats and communities for marine fauna, may be impacted; however, these are expected to be broadly similar to those found throughout the Commonwealth Marine Area of the North-west Marine Region. Any impacts that may occur are likely to be localised and would not be expected to have wider implications for populations of those marine species or associated communities. The potential for additional impacts to other users of the marine environment is considered unlikely as the Fourth Train Proposal activities and infrastructure will be spread across a wide area. Given the limited spatial extent of the Fourth Train Proposal operations in the Commonwealth Marine Area, including in the Montebello Commonwealth Marine Reserve, the potential additional impacts associated with physical presence and/or interactions in the Commonwealth Marine Area as a result of the Fourth Train Proposal were assessed as 'Low'.

The physical presence of Fourth Train Proposal infrastructure and the potential for physical interaction through the implementation of the Fourth Train Proposal, additional to the approved Foundation Project, is not predicted to result in widespread impacts to marine fauna or compromise the integrity, ecological functions, or environmental values of the Commonwealth Marine Area. The potential impacts are determined to be acceptable and the objectives established for the marine environment are determined to be met (Table 13-19). The implementation of the Fourth Train Proposal is considered to be consistent with the policy and plan documents listed in Table 13-20.

13.5.9 Spills and Leaks

A spill or leak of hydrocarbons or hazardous materials has the potential to cause adverse impacts in the Commonwealth Marine Area through reduced water and sediment quality, which may then have secondary impacts upon the amenity of the area and upon marine biodiversity. The level of impact from spills and leaks depends on a number of factors, including the magnitude and type of spill or leak (e.g. condensate or diesel), oceanographic conditions, and the sensitivity of the receiving environment. Hydrocarbons may impact water quality in the form of surface sheens (slicks), entrained oil in the water column, or dissolved aromatic hydrocarbons. Chemicals that could be used to treat spills (e.g. surfactants) also have the potential to impact water quality in terms of changes to chemical and physical characteristics of the receiving water body.

Hydrocarbon spill trajectory modelling was undertaken for a number of scenarios relevant to the construction and operations phases of the Fourth Train Proposal, including a worst-case 11-week subsea well blowout occurring in the Chandon Gas Field, an Offshore Feed Gas Pipeline System rupture, and a number of marine vessel spill scenarios. The likelihood of an Offshore Feed Gas Pipeline System rupture has been reduced through the design of the Offshore Feed Gas Pipeline System, which includes stabilisation and protection to withstand extreme weather events, including cyclones (Section 4.3.4.6). Considerations for the selection of the Chandon Gas Field as representing the worst-case subsea well blowout scenario for the Fourth Train Proposal included its condensate-to-gas ratio, which is high relative to other Fourth Train Proposal gas fields. Hydrocarbon spill trajectory modelling was undertaken using established models recognised within the industry and by regulators. Additional discussion on the scenarios modelled, modelling assumptions, results, and proposed management is provided in Section 5.7. The locations of spill and leak scenarios used for the modelling are illustrated in Figure 13-2.

An ecological risk assessment was undertaken using the results of the hydrocarbon spill trajectory modelling to assess the likely ecological consequences in the Commonwealth Marine Area and to evaluate the overall potential impact associated with each spill scenario (Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill]); this risk assessment included details of the modelling methods, assumptions, and limitations. Results of the ecological risk assessment relevant to the Commonwealth Marine Area are discussed here. Assessment of potential socioeconomic impacts (e.g. to commercial marine vessels, shipwrecks, or relics) in relation to spills and leaks, including in the Commonwealth Marine Area, due to the Fourth Train Proposal is provided in Section 14.

In relation to potential chemical spills, the Foundation Project previously considered the potential impacts resulting from the release of the MEG, and concluded that there was negligible risk of significant environmental consequences (Section 1.4 of Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill]); therefore, this scenario has not been re-examined.

In the unlikely event of a subsea well blowout from the Chandon Gas Field, or a high-pressure release from the Fourth Train Proposal Offshore Feed Gas Pipeline System, a crater in the seabed could be created as a result of the escape of high-pressure gas, with possible suspension and redistribution of seabed sediments and loss of benthic fauna and habitat. However, the area affected is expected to be localised to the immediate vicinity of the well or pipeline rupture site, and, as no sedimentation is anticipated, the area is expected to recolonise once the release is stemmed. The Commonwealth Marine Area, including the Montebello Commonwealth Marine Reserve, provides habitat for benthic marine fauna, including foraging habitat for marine turtles; however, these habitats are not unique to the Montebello Commonwealth Marine Reserve or the North-west Marine Region. The hydrocarbons potentially released due to either a well blowout or pipeline rupture would have high volatility and solubility, and high evaporation rates; a low proportion of the hydrocarbons would be considered persistent (Section 2.0 of Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill]). Modelling scenarios involving condensate or diesel indicated that no sedimentation (i.e. adhesion of hydrocarbons to seabed sediments) of residual hydrocarbons would be expected to occur in any season.

The potential impacts of a hydrocarbon spill or leak on water quality and pelagic marine fauna largely depend on the characteristics of the hydrocarbons involved, which govern their behaviour and persistence within the water column. Typically, the potential impacts of condensate and diesel on biological resources is restricted to acute toxicity of fresh hydrocarbons, rather than the physical coating of plumage and skin that occurs with heavier oils. This acute toxicity is primarily associated with aromatic hydrocarbons (Section 2.1 of Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill]). Chandon condensate has an aromatic hydrocarbon content of approximately 5%, mostly in the benzene, toluene, ethylene, and xylene (BTEX) group (Section 2.1.1 of Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill]). The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000) indicate that levels of benzene (the only BTEX for which there is a guideline criteria) of less than 500 mg/L (500 ppb) in marine waters would assure protection of more than 99% of species.

Modelled scenarios for large-scale hydrocarbon releases (i.e. well blowout and pipeline rupture scenarios) indicate that hydrocarbons have the potential to reach Commonwealth Marine Areas associated with the Ningaloo Coast (Section 13.2.2.2) and could encroach upon numerous BIAs and potential habitat for EPBC Act-listed threatened and/or migratory marine species (Section 13.4). In terms of the potential geographic spread of aromatic, surface, and entrained hydrocarbons in the Commonwealth Marine Area, the scenario predicted to have the most extensive range was a well blowout from the Chandon Gas Field. Modelling predicted that there is a low probability of hydrocarbons greater than 10 g/m^2 occurring on the water surface around the blowout location in any season, and a less than 1% probability of dissolved aromatic concentrations exceeding 50 ppb in waters surrounding the release location (within 1.5 km^2) during any season. This is an order of magnitude below the ANZECC/ARMCANZ (2000) guideline for aromatic benzene. Modelling predicted that dissolved aromatics >5 ppb would occur in a limited area immediately to the east of the release location, with low to moderate probabilities (less than 30%) of extending to more distant areas (Section 3.2.1.3 of Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill]).

Modelling predicts that entrained hydrocarbons are more likely to spread across a greater geographic range than surface and aromatic components of released hydrocarbons. Changes to marine plankton community compositions and/or mortality may occur as a result of toxic effects and changes to the physicochemical properties of the water column due to entrained hydrocarbons, although the effects from spills on plankton are likely to be minimal or transient (Volkman *et al.* 1994). Adverse effects on fish are considered less likely, as fish are more mobile and are less likely than marine plankton to become entrained in patches of hydrocarbons in the water column. It is conceivable that vibrations and pressure changes in the water column (e.g. due to a subsea well blowout at the Chandon Gas Field, or rupture of the Offshore Feed Gas Pipeline System) could affect fish. Shock waves in the water column could also possibly cause some fish mortality; however, the extent of such impacts are expected to be limited to a few individuals.

Modelling also considered spills and leaks of diesel (up to 80 m^3) from Fourth Train Proposal marine vessels operating in the Commonwealth Marine Area. Hydrocarbons from diesel spills are predicted to remain at the surface and would be expected to evaporate rapidly. Approximately 40 % to 50 % of the original mass of a diesel spill is predicted to evaporate in first two days, with further evaporation slowing over time (Section 2.2.2 of Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill]). Modelling indicated that entrained hydrocarbon concentrations (>10 ppb threshold concentrations) could occur up to 250 km from the spill site for 90 % of conditions. However, dissolved aromatic concentrations were not predicted to exceed 50 ppb beyond the immediate vicinity of a major diesel spill, suggesting widespread toxicity effects to pelagic marine life would be very unlikely (Section 6.2.3.1 of Appendix D5 [Assessment of Environmental Risk – Hydrocarbon Spill]). Although fauna present in the vicinity of the diesel spill could be exposed to acute toxicity or oiling effects, the duration and spatial extent of these effects are predicted to be limited owing to the natural degradation and dispersion of diesel in the open ocean. The potential for unacceptable impacts to individuals or at the species or ecosystem level from oiling and/or toxicity from spills of diesel due to the Fourth Train Proposal is considered to be low.

There are a number of key ecological features identified as being of potential concern to oil pollution (SEWPaC 2012h) that occur within range of exposure to hydrocarbons from large-scale spills and leaks from the Fourth Train Proposal. Table 13-32 identifies the values of these key ecological features and describes the potential for ecological effect from a well blowout at the Chandon Gas Field.

Table 13-32: Potential Impacts to Key Ecological Features of the North-west Marine Region Following an 11-week Subsea Well Blowout in the Chandon Gas Field

Key Ecological Feature	Summary of Ecological Values*	Nature of Potential Exposure to Hydrocarbons due to a Well Blowout from the Chandon Gas Field
Ashmore Reef and Cartier Islands and surrounding Commonwealth Waters	• Area of high primary productivity • High diversity of coral species • Habit for breeding and feeding seabirds, shorebirds, and other marine fauna	Modelling indicated that the Ashmore Reef and Cartier Island and surrounding Commonwealth Waters would not be exposed to any surface, entrained, or dissolved aromatic hydrocarbons as a result of a well blowout at the Chandon Gas Field.
Seringapatam Reef and Commonwealth Waters in the Scott Reef complex	• Relatively high primary productivity • Diverse aggregations of marine life	Only low concentrations of entrained oil (10 ppb) were predicted to reach the Seringapatam Reef and Commonwealth Waters in the Scott Reef Complex, with very low probability (1%). This concentration represents 'no effect' concentrations for entrained oil and therefore is highly unlikely to cause substantial impacts to the values of this key ecological feature.
Mermaid Reef and Commonwealth Waters surrounding Rowley Shoals	• High species diversity • Enhanced productivity • Aggregations of marine life	Modelling predicted with very low probability (5%) that only low concentrations (10 ppb) of entrained oil would reach the Mermaid Reef and Commonwealth Waters surrounding the Rowley Shoals. Entrained hydrocarbons at this concentration are considered highly unlikely to impact the values of this key ecological feature.
Commonwealth Waters adjacent to Ningaloo Reef	• Seasonal aggregation site for Whale Sharks • Supports high productivity and species-richness of Ningaloo Reef	Surface concentrations of hydrocarbons from a Chandon Gas Field well blowout would be unlikely reach the Commonwealth Waters adjacent to Ningaloo Reef during any season, with a very low probability (1%) of a visible rainbow sheen (>1 µm thick) predicted by the modelling. Modelling also predicted low probabilities (10%) of dissolved aromatic hydrocarbons, which were not predicted to reach concentrations within this area that could result in acute toxic effects on fauna. Entrained condensate from a spill would be present in the area in low concentrations (<100 ppb) during any season, with low probabilities (10% during summer and spring, 5% during winter, and 1% during autumn) of elevated concentrations (>500 ppb) predicted. This suggests that any potential adverse impacts to marine fauna known to occur in the waters would be unlikely. Section 13.2.2.2 provides further assessment of the potential impacts to the Ningaloo Coast.

** Adapted from SEWPaC 2012h*

The likelihood of potential impacts occurring from a substantial spill or leak (e.g. a well blowout, a pipeline rupture, or a major fuel spill) is remote; the large distances between identified key ecological features and the Fourth Train Proposal Area further reduces the probability of released hydrocarbons reaching ecologically significant levels at the reef environments and their surrounding waters listed in Table 13-32. Low levels of hydrocarbons that may reach the reefs would not be expected to persist given the volatile nature of the modelled hydrocarbons, or result in discernible long-term adverse effects to the reefs. Mitigation and management measures for spills and leaks are presented in Section 5.7.3. These measures are designed to manage the primary risk associated with a spill event occurring, thus avoiding any associated potential impacts to environmental factors, and are also designed to ensure appropriate responses are undertaken if a spill occurs, thus reducing the potential for widespread impacts in the Commonwealth Marine Area.

The likelihood of widespread impacts to environmental factors in the Commonwealth Marine Area due to a spill or leak from the Fourth Train Proposal is remote. Accounting for response strategies that would be implemented in the event of a spill, the potential incremental impacts for this stressor were assessed as 'Low' to 'Medium'. The potential impact level of 'Medium' was allocated with respect to substantial spills and leaks (e.g. a well blowout, a pipeline rupture, or a major fuel spill), which have the potential to effect elements of the Commonwealth Marine Area that are considered particularly sensitive, such as the Montebello Commonwealth Marine Reserve, which is overlapped by Fourth Train Proposal subsea infrastructure.

The implementation of the Fourth Train Proposal increases the probability of a spill or leak occurring, when compared to the approved Foundation Project. This increase in probability relates to the additional construction activities and the additional movements of marine vessels during construction, as well as an increase in fluid inventories and condensate and LNG vessel movements through the Commonwealth Marine Area during the operations phase. However, the likelihood of potential impacts occurring due to a substantial spill or leak (e.g. a well blowout, a pipeline rupture, or a major fuel spill) remains remote. No different activities will be undertaken as part of the Fourth Train Proposal when compared to the Foundation Project. The potential environmental sensitivities that could be exposed to hydrocarbons in the event of a spill or leak are also broadly similar for both the Foundation Project and Fourth Train Proposal Area. The potential impacts to the Commonwealth Marine Environment as a result of Fourth Train Proposal activities are also not anticipated to be of any greater consequence than those for the Foundation Project. When considered in addition to the approved Foundation Project, the level of potential impact for spills and leaks in the Commonwealth Marine Area due to the Fourth Train Proposal remains 'Low' to 'Medium'.

13.5.10 Proposed Management

The Fourth Train Proposal is not expected to change the level of impact or result in any different impacts assessed and approved for the Foundation Project. Therefore, the GJVs intend to manage potential impacts associated with the implementation of the Fourth Train Proposal in a manner consistent with the environmental management framework established and currently being implemented for the Foundation Project (Section 16.2). This framework includes management of the Fourth Train Proposal Offshore Feed Gas Pipeline System installation, offshore drilling activities, operations, and the potential impacts associated with these activities.

It is anticipated that new EMPs will be developed, as required under EPBC Ministerial Conditions (Conditions 16, 16A, and 16B of EPBC Reference: 2003/1294, and Conditions 1 and 2 of EPBC Reference: 2005/2184) for the drilling and completion of Fourth Train Proposal production wells and for activities associated with the installation of the Fourth Train Proposal

Offshore Feed Gas Pipeline System[18], or equivalent Environment Plan. The GJVs anticipate that the mitigation and management measures included in the existing Foundation Project EMPs and Subsidiary Documents for offshore drilling and completion and pipeline installation will also apply to, and will prevent and manage any potential impact within, the Commonwealth Marine Area as a result of the Fourth Train Proposal.

Where relevant, the GJVs propose to make minor changes to the existing Foundation Project EMPs to ensure that they also apply to the specific construction and operations activities of the Fourth Train Proposal, including exact locations, routes, and designs of infrastructure in the Commonwealth Marine Area, as they are developed and optimised. As the assessment is considered conservative, none of these variations is expected to change the overall impact assessment conclusions. Anticipated changes to EMPs are described in Section 16.2.3.

The existing EMPs that are relevant to addressing potential impacts to the Commonwealth Marine Environment for the Fourth Train Proposal include:

- Offshore Feed Gas Pipeline Installation Management Plan (or equivalent Environment Plan)
- Marine Facilities Construction Environmental Management Plan
- Best Practice Pollution Control Design
- Decommissioning and Closure Plan.

In addition to the relevant EMPs and Subsidiary Documents (requiring regulatory approval) listed above, a number of the existing Foundation Project Ministerial Conditions include requirements relevant to the management of potential impacts on the controlling provisions, including in the Commonwealth Marine Environment (Section 13.6).

Section 5.7.3 describes the proposed measures to manage and mitigate the occurrence and impact of potential spills and leaks. These measures include a range of engineering controls and systems aimed at preventing a spill or leak occurring, and also the implementation of response measures in the unlikely event of a spill or leak.

To ensure that risks to cetaceans associated with VSP are mitigated, the requirements of *EPBC Act Policy Statement 2.1: Interaction between offshore seismic exploration and whales* (DEWHA 2008) Part A: Standard Management Procedures will be followed when acquiring VSP data.

13.5.11 Predicted Environmental Outcome

The Fourth Train Proposal Area falls within the North-west Marine Region, and encompasses an area that is characterised by a number of key ecological features including the Montebello Commonwealth Marine Reserve multiple use area. This region is considered biologically diverse; it includes areas of high productivity and provides habitat for a range of marine fauna.

Construction activities and associated impacts are expected to be short term. Potential impacts relating to some stressors, including the physical presence of infrastructure, will continue throughout the implementation of the Fourth Train Proposal; however, these potential impacts are expected to be localised. The Fourth Train Proposal will result in additional construction activities in the Fourth Train Proposal Area, from those approved for the Foundation Project. The Fourth Train Proposal will also extend the geographic area over which impacts could occur during construction and operations.

The Fourth Train Proposal is not considered to change or represent different potential impacts when compared to the approved Foundation Project. The levels of potential incremental and additional impacts were assessed to be no greater than the levels assessed and approved

[18] Given the establishment of NOPSEMA on 1 January 2012, it is acknowledged that these conditions may be changed for the Fourth Train Proposal and the requirement with respect to petroleum activities may be covered under a Subsidiary Document requiring NOPSEMA approval.

under the Foundation Project. The overall footprint of the Fourth Train Proposal in the Commonwealth Marine Area will be relatively small; the potential impacts associated with this footprint are expected to be localised. In addition, no long-term adverse effects as a result of the Fourth Train Proposal are predicted for the wider North-west Marine Region including to the functioning and inherent values of key ecological features, which are well represented outside the areas that may be exposed to potential impacts from the Fourth Train Proposal. Similarly, habitat modifications resulting from the implementation of the Fourth Train Proposal are expected to be localised and therefore are not anticipated to adversely impact upon the health of listed marine fauna populations or result in a decline in their diversity or productivity.

The potential consequence of a spill or leak from the Fourth Train Proposal could result in adverse impacts to the Commonwealth Marine Area, including in the Montebello Commonwealth Marine Reserve; however, the likelihood of a spill or leak occurring that could result in such impacts is predicted to be remote. In addition, first-strike spill response procedures will be in place to manage the potential impacts in the Commonwealth Marine Area in the unlikely event of a substantial spill or leak.

The stressors identified for the Commonwealth Marine Area (Table 13-22) are not anticipated to act synergistically to result in a greater level of potential impact than when considered on their own. Potential impacts of the Fourth Train Proposal on the Commonwealth Marine Area are expected to be greatest during construction when Fourth Train Proposal activities are more intense. However, given the expected short-term duration and limited geographic extent of the construction activities, the additive impacts of each stressor are not anticipated to culminate in adverse impacts on the integrity or ecological functioning of key ecological features, the Montebello Commonwealth Marine Reserve, or the wider Commonwealth Marine Area. The Fourth Train Proposal, together with the approved Foundation Project and other considered actions, are also not anticipated to result in any unacceptable cumulative impacts in the Commonwealth Marine Area (Section 15.5.2).

With the implementation of the proposed management framework and illustrative mitigation and management measures, the GJVs consider that the potential impacts identified for the Commonwealth Marine Environment will be adequately managed such that the impacts are environmentally acceptable and the environmental objectives for this controlling provision (Table 13-19) are met. Implementation of the Fourth Train Proposal in conjunction with the approved Foundation Project is also not predicted to conflict with, or be inconsistent with, the objects and principles of the EPBC Act, or the objectives, strategies, and plans relevant to the Commonwealth Marine Areas of the North-west Marine Region.

13.6 Management Framework Relevant to the Controlling Provisions

The potential environmental impacts to the controlling provisions due to the approved Foundation Project activities are currently managed using a hierarchy of corporate processes; these incorporate Chevron Australia and regulatory requirements, including Commonwealth and State Government Ministerial Conditions. In addition, potential impacts are managed through a number of EMPs and Subsidiary Documents (Section 3.4). Since the Foundation Project commenced construction in late 2009, no Serious or Material Environmental Harm has been recorded outside that approved under the Ministerial Conditions. Adaptive management strategies, which are built into the overall management framework, allow for the modification of mitigation and management measures as appropriate (e.g. Section 3.5.2.1.5) to ensure that potential impacts are managed throughout the implementation of the approved Foundation Project.

It is intended that the potential impacts of the Fourth Train Proposal on the controlling provisions discussed in this Section will be managed by extending the existing environmental management framework for the Foundation Project to encompass the Fourth Train Proposal

(Section 16). In this respect, the GJVs propose that the relevant Ministerial Conditions equivalent to, or consistent with, those approved for the Foundation Project, when applied in conjunction with current regulations, are sufficient to adequately manage the potential impacts of the Fourth Train Proposal despite the Fourth Train Proposal including an additional controlling provision compared to the Foundation Project (i.e. National Heritage Places). The existing Ministerial Conditions (relevant to the activities being undertaken by the Fourth Train Proposal) and Subsidiary Documents (requiring regulatory approval) for the Foundation Project regulate several key aspects that would be relevant to the EPBC Act controlling provisions of the Fourth Train Proposal. These key aspects include:

- prevention of, and response to, hydrocarbon spills and leaks that have the potential to impact the controlling provisions (e.g. Conditions 16 and 16A of EPBC Reference: 2003/1294, Condition 1 of EPBC Reference: 2005/2184, Environment Plans required under the Offshore Petroleum and Greenhouse Gas Storage Regulations 2009 (Cth) for operations in the Commonwealth Marine Area, and required under the Petroleum (Submerged Lands) (Environment) Regulations 2012 (WA) in State Waters, as described in Section 13.5.10)[19]
- operational atmospheric emissions and the reduction of emissions and their associated impacts on the controlling provisions (Conditions 28 and 29 of Statement No. 800)
- management and monitoring of potential impacts on EPBC Act-listed threatened terrestrial species and their communities through:
  - various EMPs, which establish a baseline and define how potential impacts on listed terrestrial species and their habitats on Barrow Island will be mitigated, managed, and monitored (Conditions 5, 6, 7, 8, 9, 12, 15, 19, 20, and 21 of EPBC Reference: 2003/1294 and 2008/4178, and Conditions 11, 29, 32, and 33 of Statement No. 800)
  - a monitoring program for the Carbon Dioxide Injection System to identify seepage of injected carbon dioxide to environments that may support listed subterranean fauna, and a requirement to act if leakage is found to be occurring (Condition 19 of EPBC Reference: 2003/1294 and 2008/4178)
- management and monitoring of potential impacts on EPBC Act-listed threatened and/or migratory marine species and their communities through:
  - various EMPs, which define how potential impacts on listed nearshore species and their habitats in State Waters will be mitigated, managed, and monitored (Conditions 8, 12, and 21 of EPBC Reference: 2003/1294 and 2008/4178, and Condition 23A of Statement No. 800)
  - identification of sensitive marine habitats in the Commonwealth Marine Area associated with well sites and proposed pipeline routes through sea floor surveys and selection of pipeline routes and production well sites to avoid impacting these (Condition 16A of EPBC Reference: 2003/1294 and Condition 1 of EPBC Reference: 2005/2184)[3]
  - plans requiring specific measures to mitigate, manage, and monitor potential impacts on cetaceans and marine turtles in the Commonwealth Marine Area (Conditions 16A and 16B of EPBC Reference: 2003/1294 and Condition 1 and 2 of EPBC Reference: 2005/2184)
  - establishment of a Marine Turtle Expert Panel to oversee marine turtle monitoring and management (Condition 15 of Statement No. 800), annual audits of the effectiveness of marine turtle mitigation and management measures, and the requirement to undertake contingency measures if significant adverse project-

[19] Given the establishment of NOPSEMA on 1 January 2012, it is acknowledged that these conditions may be changed for the Fourth Train Proposal and the requirement with respect to petroleum activities may be covered under a Subsidiary Document requiring NOPSEMA approval.

attributable effects on marine turtles are determined by the Minister to be occurring (Condition 12 of EPBC Reference: 2003/1294 and 2008/4178)

- interaction procedures for aircraft, marine supply, and construction vessels to manage impacts to cetaceans, consistent with part 8 of the EPBC Regulations 2000, and which must be implemented and cetacean sightings reported (Condition 16A of EPBC Reference: 2003/1294 and Condition 1 of EPBC Reference: 2005/2184)
- sea floor surveys around production well sites[3] and the Offshore Feed Gas Pipeline System route to identify and select a route that avoids impacts on sensitive marine ecosystems such as reefs, sponge beds, and seagrasses, and historic shipwrecks must be undertaken (Condition 16A of EPBC Reference: 2003/1294 and Condition 1 of EPBC Reference: 2005/2184)
- activities with the potential to impact on marine turtles and cetaceans must be conducted in accordance with the Offshore Feed Gas Pipeline Installation Management Plan in the Commonwealth Marine Area (Condition 16B of EPBC Reference: 2003/1294 and Conditions 1 and 2 of EPBC Reference: 2005/2184).

- management of potential impacts on the Commonwealth Marine Area associated with the construction of offshore facilities in the Commonwealth Marine Area (Conditions 16A and 16B of EPBC Reference: 2003/1294 and Conditions 1 and 2 of EPBC Reference: 2005/2184)[3].

The EMPs required under existing Ministerial Conditions for the approved Foundation Project are described in Section 3.4.2.3. Table 3-1 outlines the scope and objectives of these EMPs. The EMPs approved to date can be accessed from Chevron Australia's website at: http://www.chevronaustralia.com/our-businesses/gorgon/environmental-responsibility/environmental-approvals.

Minor modifications will be incorporated into these EMPs and relevant Subsidiary Documents, as described in Sections 16.2.3.3 and 16.2.4 to ensure that these management tools appropriately address the potential impacts of the Fourth Train Proposal.

The requirements and objectives of the Ministerial Conditions are included in the EMPs and have been considered in the assessment objectives of this PER/Draft EIS. Illustrative mitigation and management measures derived from these EMPs and Subsidiary Documents are presented in this Section. As described in Section 8.3.5, changes to relevant EMPs, including to their associated mitigation and management measures, may be approved for the Foundation Project during the approval process of the Fourth Train Proposal. This means that the mitigation and management measures in approved versions of EMPs and relevant Subsidiary Documents would take precedence over the mitigation and management measures presented in this PER/Draft EIS. This should not affect conclusions of the assessment of potential impacts presented, as any amendments to EMPs or Subsidiary Documents requiring regulatory approval must still meet the objectives and specific requirements in the Ministerial Conditions.

The existing relevant management mechanisms for the Foundation Project that the Fourth Train Proposal intends to adopt, reflects the objects and principles of the EPBC Act, including the adoption of a conservative approach to impact identification, assessment, mitigation, and management where potential impacts to the controlling provisions are not fully understood or are unknown. Table 1-1 describes in more detail how the Fourth Train Proposal has considered the objects and principles of the EPBC Act. The environmental management framework currently being implemented for the approved Foundation Project is considered to provide effective mitigation and management; further description of this management framework is provided in Section 3.4.

Provision for auditing is included in the existing environmental management framework for the Foundation Project; this will be extended to include the Fourth Train Proposal. Audits and/or inspections undertaken by external regulators will be facilitated by the GJVs. The findings of external regulatory audits will be recorded and actions and/or recommendations will be addressed and tracked. Chevron Australia may also undertake independent external auditing.

The costs associated with implementing mitigation and management measures for the Fourth Train Proposal are part of normal project costs, and are included in broader project cost estimates.

13.6.1 Environmental Offsets

The GJVs have a clear objective in the development of the Fourth Train Proposal to avoid, mitigate, rectify, and reduce impacts on the controlling provisions. As such, the Fourth Train Proposal has been designed to avoid, prevent, or reduce the potential for unacceptable adverse impacts to the extent possible. The GJVs are confident that incremental, additional, and cumulative impacts can be managed within the context of the existing Foundation Project environmental management framework such that they are acceptable and the objectives established for this assessment are met. The Fourth Train Proposal has been assessed to have no unacceptable impacts on the controlling provisions and therefore no environmental offsets are considered to be required (Section 16.3).

13.7 Conclusion

The assessment presented in this Section has considered the likely and relevant direct, indirect, and facilitated incremental, additional, and cumulative (Section 15.6) impacts of the Fourth Train Proposal on the four EPBC Act controlling provisions determined as being relevant by the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities.

The conclusions drawn about potential impacts of the Fourth Train Proposal on the controlling provisions are based on the application of scientific knowledge, the use of subject matter expertise, and information available at the time of assessment. However, due to gaps in scientific knowledge, uncertainties exist with respect to the specific impacts predicted. For this reason, a conservative approach was taken in conducting the impact assessment, by building various conservative elements into the predictions of consequence and probability (e.g. worst-case scenarios). The management framework proposed for the Fourth Train Proposal encompasses further conservative and precautionary elements; for example, through monitoring to understand if impacts are occurring, and through adaptive management to implement or modify measures as appropriate (Section 13.6).

As described in Section 1.7, Chevron Australia, as proponent and operator of the Fourth Train Proposal on behalf of the GJVs, is committed to developing the Fourth Train Proposal in a way that contributes to the community's aspiration for sustainable development. This includes continuing to protect the conservation values of Barrow Island; managing environmental, health, and safety requirements responsibly; and implementing responsible practices throughout the duration of the Fourth Train Proposal. Chevron Australia has demonstrated this commitment by operating in an environmentally responsible manner on Barrow Island and Thevenard Island for approximately 40 years. Chevron Australia has complied with its commitments under relevant Ministerial Conditions for the approved Foundation Project and no Material or Serious Environmental Harm outside approved impacts, nor any material non-compliance that resulted in environmental harm, have occurred since construction of the Foundation Project began in 2009. Chevron Australia has not been subject to any proceedings under Commonwealth, State, or Territory law for the protection of the environment or the conservation and sustainable use of natural resources.

The Fourth Train Proposal will increase the overall footprint currently approved for the Gorgon Gas Development in the marine environment and, to a much lesser extent, on Barrow Island. The Fourth Train Proposal will also extend the duration over which some controlling provisions may be exposed to potential impact as a result of construction activities. However, the assessment has determined that because the Fourth Train Proposal activities are consistent with and at no greater scale than those assessed and approved for the Foundation Project (and in many cases of lesser scale), no incremental, additional, or cumulative impacts on the controlling provisions are determined to be greater than those assessed and approved for the Foundation Project. No potentially unacceptable incremental, additional, or cumulative impacts are anticipated for any controlling provisions for the Fourth Train Proposal.

While it is acknowledged that the inscription of the Ningaloo Coast to the National Heritage list occurred after Foundation Project approval, the assessment of potential impacts of the Fourth Train Proposal on the Ningaloo Coast presented in this Section has determined that no unacceptable impact is likely on the values for which this area has been protected. The adoption of relevant management mechanisms already in place for the Foundation Project (via both Commonwealth and State Ministerial Conditions and other Subsidiary Documents that require regulatory approval) by the Fourth Train Proposal are considered to provide a sufficiently robust mechanism to prevent any unacceptable impacts of the Fourth Train Proposal on the Ningaloo Coast National Heritage values.

Potential social and economic impacts of the Fourth Train Proposal are discussed in Section 14. That assessment concludes that no unacceptable adverse impacts on public or workforce health and safety, cultural heritage, livelihoods, communities, other users of the land and sea, or on the national, state, or local economy are predicted to occur, largely because of the remote and isolated location of the Fourth Train Proposal. In addition, the implementation of the Fourth Train Proposal is expected to result in significant economic and employment impacts that positively influence Australia's Gross Domestic Product.

No potential impacts on the controlling provisions are determined to be irreversible. While some stressors (e.g. physical presence of subsea infrastructure on the seabed) may occur through the productive life—and perhaps beyond—of the Fourth Train Proposal, such stressors and associated potential impacts have the potential to be finite if such infrastructure is removed during decommissioning. The specific approach to decommissioning will be determined in the future, and will reflect legislation, industry practice, and options assessments current at that time.

The implementation of the Fourth Train Proposal is not likely to result in any unacceptable direct, indirect, facilitated, or cumulative impacts on its relevant controlling provisions, and is not expected to change the level of impacts assessed for the approved Foundation Project. All aspects of the Fourth Train Proposal are determined to be consistent with the objects and principles of the EPBC Act, or the policies and plans relevant to its controlling provisions. This includes the plans prepared for the management of the Ningaloo Coast, conservation advice for listed species, and policies and commitments covering the protection and management of listed migratory species and the Commonwealth Marine Area.

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Section 14: Table of Contents

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14. Social, Cultural, and Economic Impacts and Management

14.1 Introduction

The social, cultural, and economic environment (social environment) relevant to the Fourth Train Proposal is described in Section 6.8. Factors of this environment with the potential to be affected by the Fourth Train Proposal, and the stressors have been identified as potentially impacting them, are shown in Figure 14-1. For an explanation of this identification process, refer to Section 8.2.2.

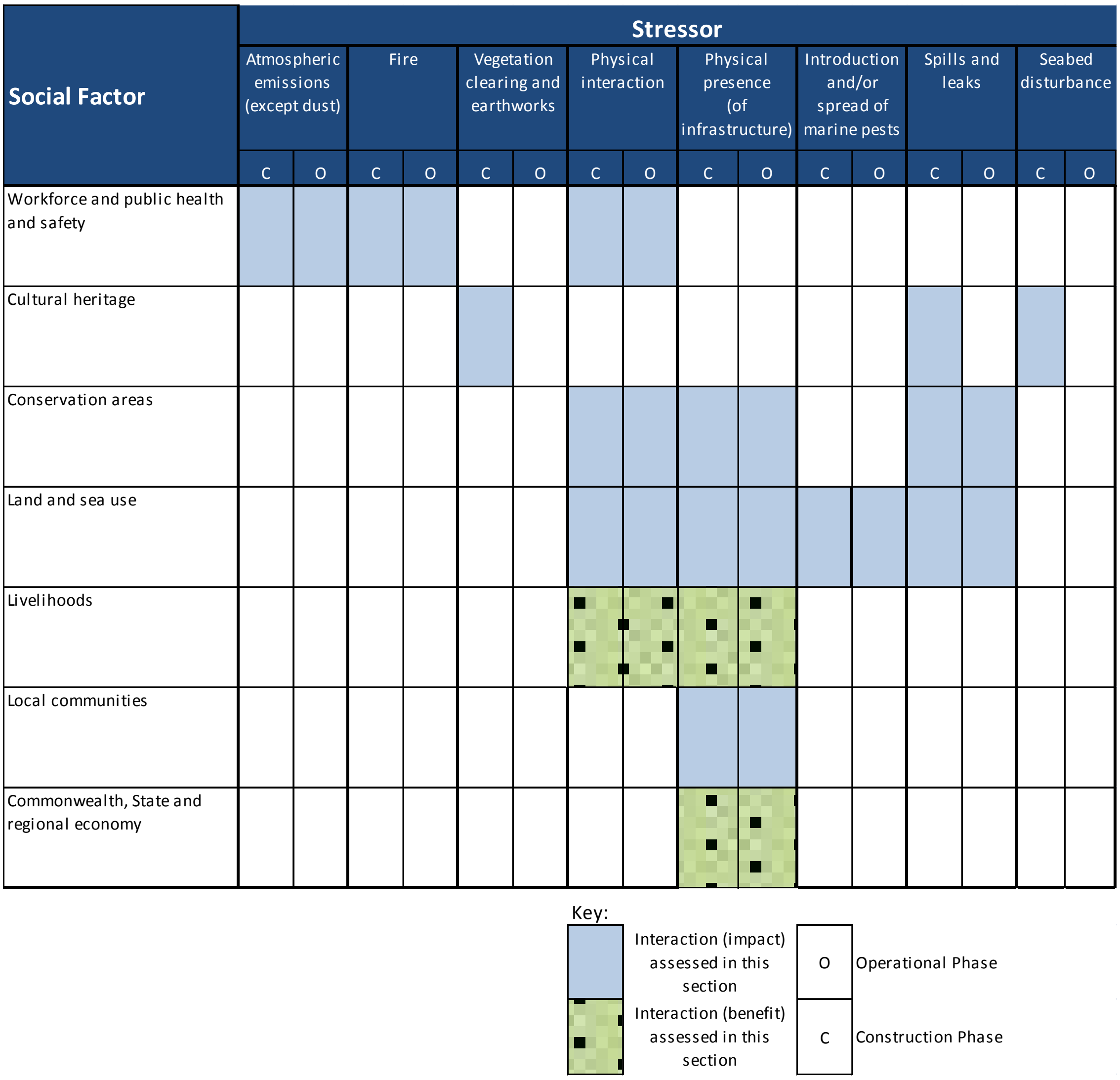

Figure 14-1: Factors of the Social Environment and Identified Stressor Interactions

Those stressors where the potential impacts on the social environment were considered 'Trivial' were screened out of the assessment and are not discussed further within this section. Refer to Section 8.3.3 for further details. The exception is the atmospheric emissions (except dust) stressor that was identified as potentially impacting on workforce and public health and safety; which has been included due to stakeholder interests.

Table 14-1 lists Commonwealth and Western Australian (State) legislation for the social environment. Additional legislation, policies, and guidelines relevant to specific factors are detailed in Section 2 and the following sections.

Table 14-1: Legislation Relevant to the Social Environment

Legislation	Intent
Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act)	Provides for the protection of the environment, especially those aspects that are matters of National Environmental Significance (NES). The EPBC Act provides a legal framework and decision-making process to promote ecological sustainable development, protect and conserve heritage, promote a cooperative approach to the protection and management of the environment and to recognise and promote indigenous peoples involvement.
Environmental Protection Act 1986 (WA) (EP Act)	Provides for the prevention, control, and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement, and management of the environment in Western Australia. The term 'environment' is defined in the EP Act as living things, their physical, biological and 'social surroundings' and interactions between all of these. Social surroundings are defined in the EP Act to include aesthetic, cultural and economic values to the extent that they directly affect or are affected by physical and biological surroundings.

14.2 Workforce and Public Health and Safety

14.2.1 Assessment Framework

14.2.1.1 Social Objective

The objective established in this PER/Draft EIS for workforce and public health and safety is:

> *To avoid adverse impacts on the health and/or wellbeing of the workforce and/or public or their access to health care services.*

14.2.1.2 Relevant Legislation, Policies, Plans, and Guidelines

Commonwealth and State government policy and framework documents relating to workforce and public health and safety are listed in Table 9-3.

Table 14-2: Legislation, Policies, Plans, and Guidelines Relevant to Workforce and Public Health and Safety

Legislation, Policies, Plans, Guidelines	Intent
Occupational Safety and Health Act 1984 (WA)	Provides a framework to promote and improve the standards for occupational safety and health and establishes the Commission for Occupational Safety and Health.
Occupational Safety and Health Regulations 1996 (WA)	Deals with matters prescribed under the *Occupational Safety and Health Act 1984* (WA) including workplace safety, plant requirements, hazardous substances, and performance of high-risk work.
Offshore Petroleum and Greenhouse Gas (Safety) Regulations 2009 (Cth)	Provides guidance on matters relating to occupational health and safety on offshore facilities in Commonwealth Marine Areas.
Petroleum and Geothermal Energy Resources (Occupational Safety and Health) Regulations 2010 (WA)	Provides guidance on matters relating to occupational health and safety for operators of, and personnel working on, petroleum and/or geothermal projects.

Legislation, Policies, Plans, Guidelines	Intent
Petroleum Pipelines (Management of Safety of Pipeline Operations) Regulations 2010 (WA)	Requires the preparation of a safety case which contains descriptions about the facility, the hazard identification and safety assessment undertaken and the safety management system in place.
Petroleum Pipelines (Occupational Safety and Health) Regulations 2010 (WA)	Provides guidance on matters relating to occupational health and safety for personnel working on petroleum pipelines.
Petroleum (Submerged Lands) (Occupational Safety and Health) Regulations 2007 (WA)	Provides guidance on matters relating to occupational health and safety for personnel working in submerged environments.

14.2.2 Assessment and Mitigation of Potential Impacts

Atmospheric emissions (except dust), a major emergency (e.g. fire or an extreme weather event) and physical interaction associated with the Fourth Train Proposal were identified as the key stressors that may affect workforce and public health and safety.

14.2.2.1 Atmospheric Emissions (Except Dust)

Atmospheric emissions have the potential to impact workforce and public health and safety by altering ambient air quality, creating a hazard to human health and wellbeing. Impacts of atmospheric pollutants and air toxics on the workforce on Barrow Island and the public were assessed with reference to relevant criteria, including the Ambient Air Quality National Environment Protection Measure (Ambient Air NEPM; National Environment Protection Council [NEPC] 2003), the National Exposure Standards [NOHSC:1003–1995] (as amended – Safe Work Australia [SWA] 1995), and the World Health Organization (WHO) Air Quality Guidelines for Europe (WHO 2000).

The workforce on Barrow Island are the closest human receptors to the source of atmospheric emissions from the Fourth Train Proposal. Construction of the Fourth Train Proposal will require additional onshore construction activities on Barrow Island; however, these activities are expected to be short term and are not expected to contribute a substantial proportion of the atmospheric emissions produced by the Fourth Train Proposal.

Results of the Air Quality Assessment and the Acid Gas Vent Dispersion Modelling undertaken for the operation of the Fourth Train Proposal indicate an incremental increase in ambient concentrations of atmospheric pollutants and air toxics at worksites including the Gas Treatment Plant and Butler Park (Construction Village). The ambient air quality resulting from the operation of the Fourth Train Proposal in addition to the Foundation Project is predicted to be within relevant criteria, including the occupational criteria and the residential criteria (Table 5-10 and Table 5-11) and therefore unlikely to pose a health risk to the workforce.

Potential impacts to wider public health from atmospheric emissions from the Fourth Train Proposal additional to the approved Foundation Project were assessed on a regional scale, given public access to Barrow Island is restricted. Regional modelling predicted that the regional ambient air quality will be within the Ambient Air Quality NEPM with the addition of the Fourth Train Proposal to the Foundation Project and other regional sources. Section 5.2 describes the expected atmospheric emissions over the life of the Fourth Train Proposal. Table 5-12 describes the key mitigation and management measures that will be implemented during operation of the Fourth Train Proposal for each major emissions source, as provided in the Air Quality Management Plan. One of the objectives of the Air Quality Management Plan, as stated in Condition 29.2(ii) of Ministerial Implementation Statement No. 800, is to ensure that air quality meets appropriate standards for human health in the workplace (Chevron Australia 2011). Relevant mitigation and management measures to workforce and public health and safety for major emission sources are presented in Table 14-3.

14.2.2.2 Fire

There are a number of measures, detailed in the Fire Management Plan (Chevron Australia 2014), to prevent, suppress, and manage fire. These measures involve a combination of training, implementation of firebreaks, reporting, provision of firefighting equipment, response procedures, and the design and construction of infrastructure to the relevant fire standards and regulations. Certain activities with the potential to ignite fires, such as smoking, waste storage, and refuelling, have been managed with specific management measures.

In the event of an emergency (e.g. explosion, large fire), the medical facilities on Barrow Island provide the workforce with first aid treatment and primary care. If further medical care is required, personnel are medically evacuated to Perth for treatment. A major emergency involving a number of personnel could place pressure on public medical services in Perth, although the likelihood of such an event occurring is remote.

14.2.2.3 Extreme Weather Events

Extreme weather events, including tropical cyclones and thunderstorms, have the potential to impact the workforce. Tropical cyclones can result in high rainfall which may produce flood events, and high speed winds which can potentially damage infrastructure and restrict transport in the region. An average of five tropical cyclones per year occur in the Pilbara Region (BOM 2011), with an average of two per year passing through the Barrow Island area (Chevron Australia 2005; Section 6.4.1). Section 6.4.10.5 discusses projected changes in extreme weather events due to climate change. Although difficult to predict, Australian regional studies indicate a likely increase in the proportion of tropical cyclones in the more intense categories, but a possible decrease in the total number of cyclones (CSIRO and BOM 2007).

Management of activities during extreme weather events are governed by Foundation Project contingency plans. Contingency plans are integrated into operating procedures to cover extreme weather, including staged responses for Barrow Island (i.e. tie down and securement, and evacuation of required personnel), marine activities, and supply bases, where relevant (Chevron Australia 2012).

14.2.2.4 Physical Interaction

Physical interaction, such as an incident between marine vessels associated with the Fourth Train Proposal and a third-party marine vessel (e.g. fishing boat), could potentially occur during the construction, operations, and decommissioning phases. This could result in injuries to the public or workforce. Additional offshore construction activities, during which there will be heightened marine vessel activity, are required for the Fourth Train Proposal. During the operations phase, the Fourth Train Proposal will increase the frequency of LNG vessels, condensate vessels, and logistics vessels within the Fourth Train Proposal Area. To date, no marine vessel-to-vessel interactions have been reported between the approved Foundation Project and third-party marine vessels.

Traffic incidents between local road users and traffic associated with the Fourth Train Proposal could potentially occur on the Australian mainland. The risk of an incident occurring would be greatest during construction of the Fourth Train Proposal, when trucks may be transporting equipment, materials, and supplies to and from mainland supply bases. The Fourth Train Proposal may require additional periods or extend the duration that the local roads around supply bases will be used compared to the duration assessed and approved for the Foundation Project.

The recreational activities of the fly-in-fly-out (FIFO) workforce for the Foundation Project are restricted to designated areas and times, and this along with the remote location of Barrow Island has the potential to reduce opportunities for recreation. However, Chevron Australia is committed to managing potential impacts to the workforce, through the provision of recreation resources, communication facilities, and development opportunities. Induction programs are held for the Barrow Island workforce, which includes information to raise awareness amongst the workforce about the potential impacts from FIFO employment. A number of recreational facilities such as tennis courts, cricket nets, a gymnasium, and a lap pool are provided. Wellness-focused sporting events and other social activities have previously been held on Barrow Island. Communication facilities and support initiatives such as counselling, an information hotline, and an established Family Network Program are provided to the workforce. These initiatives promote both physical and psychological health and wellbeing of the workforce.

Potential impacts from FIFO employment will also be managed through the implementation of Chevron Corporation's OEMS and the Chevron Australasia Business Unit Policy 530 – Operational Excellence. The OEMS and Policy 530 apply to all Chevron Australia capital projects and operational activities including the Foundation Project and the GJVs propose that they will be extended and/or revised to reflect the Fourth Train Proposal. Together the OEMS and Policy 530 systematically manage safety, heath, environment, reliability and efficiency to achieve world-class performance. Chevron Australia also requires its contractors and suppliers to implement a document management system that fully embraces the policies and objectives of the OEMS. Contractors and suppliers are required to develop and implement their own activity and/or site-specific environmental management plans (EMPs), procedures, and work method statements, as relevant. These measures will help manage physical interactions between marine vessels and traffic for the Fourth Train Proposal and the public.

Illustrative measures to mitigate and manage potential impacts to workforce and public health and safety taken from Foundation Project EMPs [and relevant Subsidiary Documents] are presented in Table 14-3 for assessment purposes (Section 8.3.5 explains the status of the Illustrative Measures).

Table 14-3: Illustrative Measures to Manage Impacts to Workforce and Public Health and Safety

Approved Foundation Project EMP	Illustrative Measures
Air Quality Management Plan	For acid gas venting at the Acid Gas Removal Units: • workforce inductions and education packages to be developed and rolled-out where appropriate • area gas leak detection to be used where appropriate • area delineation and signage to be used where appropriate • use of Permit to Work system for activities being carried out in the vicinity of the Acid Gas Removal Units • personal protective equipment as required by procedures, or as required by the Permit to Work system • Job Hazard Analyses to be undertaken for activities being carried out in the vicinity of the Acid Gas Removal Units
Horizontal Directional Drilling Management and Monitoring Plan	These controls will be in place to minimise interference with fishing, aquaculture, and shipping: • communication and navigation procedures will be in place at all times • up-to-date maps and charts will be used, which include other infrastructure, zoning, and areas of environmental sensitivity • all construction and support vessel navigation crews shall be duly certified and competent under the appropriate regulations • speed limits will be in place and will be adhered to • safety systems (including emergency response procedures) will be in place and approved by the relevant authorities.
Offshore Feed Gas Pipeline System	To reduce the risk of marine vessel collisions, these measures will be implemented:

Approved Foundation Project EMP	Illustrative Measures
Installation Management Plan	• Notice to Mariners lodged • adherence to maritime standards and procedures, including maintaining specific lights configuration and radar/watch • personnel will attend inductions and training relevant to their role • equipment function tests (e.g. dynamic positioning trial) conducted to ensure that the equipment will adequately perform their functions.

Based on the experience gained from the approved Foundation Project and the application of mitigation and management measures, the incremental and additional impacts of the Fourth Train Proposal to workforce and public health and safety is assessed as 'Low'. This assessment is lower than that predicted for the Foundation Project, which was assessed as 'Medium'. This decrease is due to the experience gained from the Foundation Project to date, which demonstrates that the measures in place are effective.

14.2.3 Proposed Management

The GJVs consider that the potential impacts to workforce and public health and safety by the Fourth Train Proposal can be effectively managed under the relevant Ministerial Conditions for the Foundation Project. No measures or controls additional or different to those required for the Foundation Project have been assessed as being necessary to manage the incremental or additional potential impacts to workforce and public health and safety from the Fourth Train Proposal.

Therefore, the GJVs intend to manage potential impacts associated with the implementation of the Fourth Train Proposal in a manner consistent with the environmental management framework established and currently being implemented for the Foundation Project (Section 3.4). Tier 1 of this framework includes Chevron Corporation's OEMS, as discussed above, and the Chevron Australasia Business Unit Policy 530 – Operational Excellence. The GJVs propose that the OEMS will be extended and/or revised to reflect the Fourth Train Proposal. The OEMS and Policy 530 apply to all Chevron Australia capital projects and operational activities, including the Foundation, and involves the systematic management of safety, health, environment, reliability, and efficiency to achieve world-class performance (Section 1.7). As previously discussed, Chevron Australia requires its contractors and suppliers to align with the OEMS. This approach is described further in Section 16.2.4.7.

The GJVs also propose that minor changes are included in the various Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations phase activities of the Fourth Train Proposal. New plans covering the Fourth Train Proposal's horizontal directional drilling and offshore Feed Gas Pipeline installation activities, locations and potential impacts will also need to be prepared and approved as described in Section 16.2.3.3. However, the GJVs anticipate that the mitigation and management measures included within the existing Foundation Project Horizontal Directional Drilling Management and Monitoring Plan (Chevron Australia 2011a) and Offshore Feed Gas Pipeline Installation Management Plan (Chevron Australia 2014a) will also apply and will prevent and manage any potential impacts to the relevant social factors as a result of the Fourth Train Proposal.

The EMPs that are relevant to addressing potential impacts to workforce and public health and safety for the Fourth Train Proposal are:

- Horizontal Directional Drilling Management and Monitoring Plan
- Offshore Feed Gas Pipeline Installation Management Plan (or equivalent Environment Plan)
- Air Quality Management Plan

- Best Practice Pollution Control Design Report
- Fire Management Plan.

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

14.2.4 Predicted Social Outcome

The potential incremental impacts to workforce and public health and safety from atmospheric emissions (except dust), physical interaction, and/or a major emergency (e.g. fire) are predicted to be managed by the approved Foundation Project environmental management framework, which will be revised as necessary to encompass the Fourth Train Proposal. Workforce health and safety is considered to be managed through the effective implementation of Chevron Corporation's OEMS, Chevron Australasia Business Unit Policy 530 – Operational Excellence, and Chevron Corporation's incident- and injury-free culture. The remote location and spatial separation of the Fourth Train Proposal from the general public minimises the potential impacts to public health and safety. The Fourth Train Proposal will result in an extended time within which potential impacts may take place compared with the approved Foundation Project. However, no different impacts to workforce and public health and safety were identified.

Potential impacts are not predicted to result in any adverse impacts on the health and/or wellbeing of the workforce and/or public or their access to health care services. Potential impacts on workforce and public health and safety are considered to be able to be managed to acceptable levels by implementation of the EMPs that have been approved for the Foundation Project (with minor amendments). The GJVs consider that the stressors to workforce and public health and safety will be adequately managed such that the potential impacts are socially acceptable and the social objective (Section 14.2.1.1) is met.

14.3 Cultural Heritage

14.3.1 Assessment Framework

14.3.1.1 Social Objective

The objective established in this PER/Draft EIS for cultural heritage is:

> *To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and that such changes comply with relevant heritage legislation.*

14.3.1.2 Relevant Legislation, Policies, Plans, and Guidelines

Commonwealth and State government policy and framework documents relating to cultural heritage are listed in Table 14-4.

Table 14-4: Legislation, Policies, Plans, and Guidelines Relevant to Cultural Heritage

Legislation, Policies, Plans, Guidelines	Intent
Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Cth)	Provides a legal framework to preserve and protect objects and areas of particular significance to Aboriginal people in accordance with Aboriginal tradition.
Historic Shipwrecks Act 1976 (Cth)	Provides a framework to protect shipwrecks and relics.

Legislation, Policies, Plans, Guidelines	Intent
EPA Guidance Statement No. 33: Environmental Guidance for Planning and Development (EPA 2008)	Specifies that changes to the biophysical environment do not adversely affect historic and cultural associations, and that such changes comply with heritage legislation.
EPA Guidance Statement No. 41: Guidance for the Assessment of Environmental Factors – Assessment of Aboriginal Heritage (EPA 2004)	Describes the EPA's position on the assessment of Aboriginal heritage and information, which will be considered by the EPA when Aboriginal heritage is a relevant environmental factor.
Aboriginal Heritage Act 1972 (WA)	Provides a framework to preserve places and objects traditional to, or customarily used by, the original inhabitants of Australia or their descendants.
Aboriginal Heritage Regulations 1974 (WA)	Applies to any Aboriginal site etc. under the *Aboriginal Heritage Act 1972* (WA) and specifies activities that require approval.
Coroners Act 1996 (WA)	Provides a legal framework to investigate reportable deaths such as Aboriginal remains.
Aboriginal Heritage Due Diligence Guidelines Version 3.0 2013 (Department of Indigenous Affairs and Department of Premier and Cabinet 2013)	Provides guidance in identifying activities that may adversely impact on Aboriginal heritage and provides advice to land users on how to meet their statutory obligations as part of the *Aboriginal Heritage Act 1972* (WA)
Heritage of Western Australia Act 1990 (WA)	Provides a legal framework that conserves cultural heritage places of significance and facilitates development in harmony with cultural heritage values.
Maritime Archaeology Act 1973 (WA)	Provides a legal framework that preserves the remains of ships and their relics (pre 1900).

14.3.2 Assessment and Mitigation of Potential Impacts

Cultural heritage encompasses Aboriginal cultural heritage and maritime heritage. Aboriginal cultural heritage includes both archaeological sites and anthropological sites. Archaeological sites are places where material associated with past Aboriginal land use remains. Anthropological sites are places of spiritual importance and significance to Aboriginal people (Department of Indigenous Affairs 2010). No Aboriginal people reside on Barrow Island and there are no Native Title claims over Barrow Island. Maritime heritage refers to historical shipwrecks and their associated relics which are older than 75 years (SEWPAC 2012).

14.3.2.1 Aboriginal Cultural Heritage

Vegetation clearing and earthworks, and spills and leaks associated with the Fourth Train Proposal were identified as the key stressors that may affect Aboriginal cultural heritage. Aboriginal cultural heritage surveys to date have not identified any sites (ethnographic or historical) within the approved Foundation Project Footprint or the Fourth Train Proposal Footprint on Barrow Island. A 2009 survey detected an archaeological site approximately 300 m east of the Foundation Project horizontal directional drilling site (Figure 6-28). As such, the Fourth Train Proposal horizontal directional drilling site has been designed to avoid this archaeological site.

Due to the history of Barrow Island and the existence of other Aboriginal cultural heritage sites elsewhere on Barrow Island, cultural heritage materials and human remains (both Aboriginal and non-Aboriginal) may be discovered during the construction or decommissioning of the Fourth Train Proposal. Areas considered to have the potential to host human remains or other surface or subsurface cultural heritage materials on Barrow Island typically include claypans, coastal dunes, and areas adjacent to drainage lines. The Fourth Train Proposal additional to the approved Foundation Project will result in an extended area of vegetation clearing and earthworks, as described in Section 9.5. Therefore, this will extend the area over which cultural heritage material may be inadvertently discovered. However, the approved Foundation Project Aboriginal Cultural Heritage Management Plan, which will be implemented for the Fourth Train Proposal, requires that prior to commencement of construction activities, Chevron Australia will ensure that the area has been surveyed for Aboriginal cultural heritage sites (Chevron Australia 2014b) so that any Aboriginal cultural heritage sites located within the area can be identified and avoided.

Accidental spills and leaks or hydrotest water discharges have the potential to affect a buried archaeological site in the claypan area located east of, and outside, the horizontal directional drilling site area. Construction of the Fourth Train Proposal horizontal directional drilling site will require additional construction activities during which spills and leaks could occur.

During stakeholder consultation for the approved Foundation Project, Chevron Australia sought input from the Thalanyji People (based in Onslow), Kuruma Marthudunera People (based in Roebourne/Karratha), and the Yaburara Mardudhunera People (based in Roebourne/Karratha) on the Aboriginal Cultural Heritage Management Plan (Chevron Australia 2014b). The Aboriginal Cultural Heritage Management Plan developed for the approved Foundation Project (in consultation with these Aboriginal groups) will require minor amendments so that it applies to the Fourth Train Proposal, as outlined in Table 16-2. No Native Title claims extend over Barrow Island or the Fourth Train Proposal Area; therefore, no Native Title impacts associated with the Fourth Train Proposal are predicted.

14.3.2.2 Maritime Heritage

Seabed disturbance associated with the Fourth Train Proposal was identified as the key stressor that may affect maritime heritage. Installation of the Fourth Train Proposal Feed Gas Pipeline System and associated infrastructure has the potential to result in physical contact with an unknown shipwreck site, which may destroy the ship's remains and disturb the site context, resulting in the loss of archaeological data. The potential impacts to maritime heritage in the Commonwealth Marine Area associated with the Fourth Train Proposal are discussed in Section 13.5.8.

Archival sources suggest that several important vessels have been lost in the Onslow and Barrow Island region and that there is potential for lugger shipwreck sites to exist in the vicinity of Barrow Island (Section 6.8.3). There are several known shipwrecks north of Barrow Island, including the earliest known shipwreck of European origin (*The Trial*) in Australian waters (Figure 6-29). Records indicate that there are no known shipwreck sites along the proposed Feed Gas Pipeline System routes for the approved Foundation Project (Chevron Australia 2005). However, the Fourth Train Proposal additional to the approved Foundation Project will result in new geographic areas of seabed being disturbed, which may result in the disturbance of undiscovered shipwreck material. As required under Ministerial Conditions, the GJVs will undertake a sea floor survey of the drilling sites and Feed Gas Pipeline System to identify historic shipwreck sites.

Illustrative Measures to mitigate and manage potential impacts to Aboriginal cultural heritage and maritime heritage taken from Foundation Project EMPs are presented in Table 14-5 for assessment purposes. Section 8.3.5 explains the status of the Illustrative Measures.

Table 14-5: Illustrative Measures to Manage Impacts to Aboriginal Cultural Heritage and Maritime Heritage

Approved Foundation Project EMP/ Relevant Ministerial Condition	Illustrative Measures
Aboriginal Cultural Heritage Management Plan	If surface or buried cultural heritage material is uncovered within the Terrestrial Disturbance Footprint, these procedures will be actioned: • All construction work in the immediate vicinity of the material will cease until further notice issued by Chevron Australia and reasonable efforts to secure the material and site will be made. Construction work may continue at a reasonable distance from the area. Note: the material should not be removed or disturbed further and barriers or temporary fences may be erected to protect the material. • The Western Australian Department of Aboriginal Affairs will be contacted and advised of the situation. • The Chevron Australia representative and, where required, a qualified archaeologist will create accurate records, including map references, photographs and descriptions of the material and an in situ evaluation of the find. • Based on the recommendations of the Chevron Australia representative and/or the qualified archaeologist, decisions regarding the treatment of the material will be made in consultation with relevant Aboriginal people and the Department of Aboriginal Affairs.
Horizontal Directional Drilling Management and Monitoring Plan	• Access beyond the horizontal directional drilling site construction boundary towards the heritage site will be restricted with the use of temporary fencing, flagging, or bunting. Any horizontal directional drilling site drainage installations will be designed such that they do not impact on the natural drainage into the heritage site • All ground-breaking work will be initiated under a Ground and Vegetation Disturbance Certificate process, which will require validation that the relevant cultural surveys have been undertaken prior to work commencing • Actions required to be taken in the event of inadvertent discovery of potential cultural heritage sites are outlined in the Aboriginal Cultural Heritage Management Plan (Chevron Australia 2014b). Some key actions include: ▪ if surface or buried cultural heritage material is uncovered within the Terrestrial Disturbance Footprint, all construction work in the immediate vicinity of the material will cease until further notice ▪ where required, a Chevron Australia representative (for cultural heritage monitoring) will be in place as part of clearing procedures ▪ an archaeologist or physical anthropologist with appropriate experience will be engaged in the event of discovering human remains in the clearing or work area ▪ procedures relating to discovery of items of cultural significance, including human remains, will be developed and adhered to • The horizontal directional drilling worksite will be constructed to enable management of surface water during heavy rainfall events, including appropriate drainage controls to direct surface water away from working areas. Potentially contaminated water from bunded areas at the horizontal directional drilling site shall be collected for disposal. The system shall be designed, constructed, and maintained to allow for storm events (e.g. cyclones) without erosion or damage

Approved Foundation Project EMP/ Relevant Ministerial Condition	Illustrative Measures
Offshore Feed Gas Pipeline Installation Management Plan	• A number of seabed surveys are to be undertaken before, during, and after installation of the offshore Feed Gas Pipeline System • Should any shipwreck or relics be discovered during the course of the proposed installation activities, Department of the Environment Maritime Heritage Section will be notified, including: ▪ a detailed description of the remains of the shipwreck or the relic, which may include sonar images, electronic data, and/or digital photographs ▪ a description of the place where the shipwreck or relic is located that is sufficiently detailed to allow it to be identified and relocated, including navigation data and datum information

Given that the surveys undertaken to date have not revealed any shipwreck sites along the proposed Feed Gas Pipeline System routes for the approved Foundation Project or any Aboriginal cultural heritage sites within the approved Foundation Project Footprint or the Fourth Train Proposal Footprint on Barrow Island, the limited site disturbance associated with the Fourth Train Proposal, and the application of mitigation and management measures such as seabed surveys, the GJVs expect that the Fourth Train Proposal will not pose any substantial incremental or additional impacts to Aboriginal cultural heritage and maritime heritage. Therefore, the impact rating is assessed as 'Low'. The impacts to Aboriginal cultural heritage and/or maritime heritage from spills and leaks were not assessed by the Foundation Project.

14.3.3 Proposed Management

The GJVs consider that the potential impacts to Aboriginal cultural heritage and maritime heritage by the Fourth Train Proposal can be effectively managed under the relevant Ministerial Conditions for the Foundation Project. No measures or controls additional or different to those required for the Foundation Project have been assessed as being necessary to manage the incremental or additional potential impacts to cultural heritage from the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the various Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal. New plans covering the Fourth Train Proposal's horizontal directional drilling and offshore Feed Gas Pipeline installation activities, locations and potential impacts will also need to be prepared and approved as described in Section 16.2.3.3. However, the GJVs anticipate that the mitigation and management measures included within the existing Foundation Project Horizontal Directional Drilling Management and Monitoring Plan (Chevron Australia 2011a) and Offshore Feed Gas Pipeline Installation Management Plan (Chevron Australia 2014a) will also apply and will prevent and manage any potential impacts to the relevant social factors as a result of the Fourth Train Proposal.

The EMPs that are relevant to addressing potential impacts to Aboriginal cultural heritage and maritime heritage for the Fourth Train Proposal are:

- Horizontal Directional Drilling Management and Monitoring Plan
- Offshore Feed Gas Pipeline Installation Management Plan (or equivalent Environment Plan)
- Aboriginal Cultural Heritage Management Plan.

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

14.3.4 Predicted Social Outcome

The potential incremental impacts to Aboriginal cultural heritage and maritime heritage from vegetation clearing and earthworks, seabed disturbance, and spill and leaks are predicted to be localised during construction for the Fourth Train Proposal. Additional impacts to cultural heritage could occur from the additional construction activities and geographic areas required for the Fourth Train Proposal compared to those required for the Foundation Project. However, no different impacts to cultural heritage were identified.

Potential impacts are not predicted to result in changes to the biophysical environment that would adversely affect historical and cultural associations. Potential impacts on Aboriginal cultural heritage and maritime heritage are considered to be able to be managed to acceptable levels by implementation of the EMPs that have been approved for the Foundation Project (with minor amendments). The GJVs consider that the stressors to Aboriginal cultural heritage and maritime heritage will be adequately managed such that the potential impacts are socially acceptable and the social objective (Section 14.3.1.1) is met.

14.4 Conservation Areas

14.4.1 Assessment Framework

14.4.1.1 Social Objective

The objective established in this PER/Draft EIS for conservation areas is:

> *To protect the social values of areas identified as having significant environmental and/or heritage attributes.*

14.4.1.2 Relevant Legislation, Policies, Plans, and Guidelines

State and local government policy and framework documents relating to social values of conservation areas are listed in Table 14-6.

Table 14-6: Legislation, Policies, Plans, and Guidelines Relevant to Conservation Areas

Legislation, Policies, Plans, Guidelines	Intent
EPA Guidance Statement No. 33: Environmental Guidance for Planning and Development (EPA 2008)	Specifies that changes to the biophysical environment do not adversely affect historic and cultural associations and that such changes comply with heritage legislation.
Heritage of Western Australia Act 1990 (WA)	Provides a legal framework that conserves cultural heritage places of significance and facilitates development in harmony with cultural heritage values.
Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007–2017 (DEC 2007)	Details the ecological values and social values of the area, management objectives, strategies, and targets. The goal of the plan is to facilitate the conservation of the marine biodiversity of the area and to ensure that the existing and future pressures on the reserves are managed within an ecologically sustainable framework.
Shire of Ashburton Town Planning Scheme No 7 (Shire of Ashburton 2004)	Requires the consideration of socioeconomic impacts on the local amenity, the capacity of the site to support the development, and potential loss of benefits or services to the community.

Legislation, Policies, Plans, Guidelines	Intent
Shire of Ashburton Local Planning Policy 20: Social Impact Assessment (Shire of Ashburton 2013)	Requires the minimisation of negative and maximisation of positive impacts, and the consideration of a range of social issues including the infrastructure, resource issues, cultural, transport, economic and fiscal, and community impacts.
Shire of Ashburton Municipal Heritage Inventory (Shire of Ashburton 1999)	Aims to conserve any object or place of heritage significance.

14.4.2 Assessment and Mitigation of Potential Impacts

Barrow Island is recognised for its conservation values and has been declared as a Class A nature reserve and is zoned for 'Conservation, Recreation and Nature Land' under the Shire of Ashburton Town Planning Scheme No 7 (Shire of Ashburton 2004). Marine waters surrounding Barrow and Montebello Islands have also been protected and form part of the Montebello/Barrow Island Marine Conservation Reserve. Beyond the conservation areas of Barrow Island and its surrounding waters are the Ningaloo Marine Park, the Muiron Islands Marine Management Area and the national heritage listed Ningaloo Coast. Section 6.7 discusses these reserves and protected areas in further detail. Stressors such as physical interaction, physical presence of infrastructure, and spills and leaks could impact on the social values of conservation areas of Barrow Island and its surrounding waters.

This section assesses the potential impacts to the social values of the conservation areas of Barrow Island and its surrounding waters. The Ningaloo Coast is discussed in Section 13. The social values of the conservation areas are outlined in Section 6.7, and closely align with the ecological values of these areas. Therefore, management of potential impacts on the ecological values of conservation areas is expected to result in the protection of their social values. The potential impacts to the ecological values of Barrow Island and its surrounding waters and the relevant mitigation and management measures are considered in Sections 9.8 and 10.8. Potential impacts to the cultural heritage values of these conservation areas are addressed in Section 14.3.

Physical interaction may occur between components of the Fourth Train Proposal and visitors who may be accessing the conservation areas for their social values. The construction and operation of the Fourth Train Proposal Feed Gas Pipeline System will require the presence of additional marine vessels. However, this is not expected to result in any unacceptable incremental or additional impacts due to the presence of the petroleum safety zones, the smaller scale of the Fourth Train Proposal construction and operations phases than that of the Foundation Project, and small numbers of visitors accessing these conservation areas. Potential impacts to other sea users (e.g. commercial fishing, other third-party hydrocarbon exploration and production activities) are discussed in Section 14.5.

The physical presence of infrastructure on Barrow Island, including the Gas Treatment Plant and onshore component of the Fourth Train Proposal Feed Gas Pipeline System could potentially impact on the visual amenity and aesthetic values of Barrow Island. A visual assessment was undertaken as part of the approved Foundation Project (Chevron Australia 2005) to evaluate the degree to which the Foundation Project components (pipelines and gas processing facility) would change the visual amenity of the existing Barrow Island landscape (existing WA Oil infrastructure was not included in this assessment). Due to the remote location of Barrow Island and the consequent lack of human receptors (almost exclusively the Gorgon Gas Development and WA Oil operations workforce), it was determined that the visual impact was limited (Chevron Australia 2005). Construction equipment and laydown areas will be required on Barrow Island during construction of the Fourth Train Proposal. A visual assessment was undertaken for the approved Foundation Project to evaluate the degree to which its components would change the visual amenity of the existing environment. The assessment determined that the visual impact is limited due to the lack of human receptors and remote location of the development. The Fourth Train Proposal additional to the approved Foundation Project will increase the construction duration and therefore its visibility on Barrow Island.

Spills and leaks from the Fourth Train Proposal have the potential to affect conservation areas and their associated social values, such as tourism, fisheries, and pearling. The level of impact will depend on various factors, such as the type of release (e.g. condensate or diesel), the proximity of the source of the release to the conservation area, and how rapidly the spill or leak is managed. Potential impacts to other users of the conservation areas are considered in Section 14.5.

Illustrative Measures to mitigate and manage potential impacts to conservation areas taken from Foundation Project EMPs are presented in Table 14-7 for assessment purposes (Section 8.3.5 explains the status of the Illustrative Measures).

Table 14-7: Illustrative Measures to Manage Impacts to Conservation Areas

Approved Foundation Project EMP	Illustrative Measures
Offshore Feed Gas Pipeline Installation Management Plan	Consultation undertaken with relevant stakeholders as per Stakeholder Consultation Plan.
Post-construction Rehabilitation Plan	Monitoring of rehabilitated and related areas will: • use techniques that demonstrate the performance of rehabilitation • commence on completion of rehabilitation • continue until completion criteria are met or discontinued by agreement with the Department of Parks and Wildlife • focus on physical aspects of the rehabilitated landscape, vegetation establishment, ecosystem function, resource retention and re-establishment of fauna habitat • establish permanent photo points • provide information that will be used for rehabilitation management • report monitoring outcomes annually.

No changes to the social values of conservation areas outside those approved for the Foundation Project have been reported as a result of the Foundation Project. The incremental and additional impacts on the social values of conservation areas from physical interaction and physical presence of infrastructure are assessed to be ‘Low’. The Fourth Train Proposal is not predicted to increase the level of impact to the social values of conservation areas compared to that assessed for the approved Foundation Project. This is due to the localised nature of offshore construction activities, the broad geographic area accessible to the visitors that access these conservation areas, and the remote location of the Fourth Train Proposal.

14.4.3 Proposed Management

The GJVs consider that the potential impacts to the social values of conservation areas by the Fourth Train Proposal can be effectively managed under the relevant Ministerial Conditions for the Foundation Project. No measures or controls additional or different to those required for the Foundation Project have been assessed as being necessary to manage the incremental or additional potential impacts to the social values of conservation areas from the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the various Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal’s offshore Feed Gas Pipeline installation activities, locations and potential impacts will also need to be prepared and approved as described in Section 16.2.3.3. However, the GJVs anticipate that the mitigation and management measures included within the existing Foundation Project Offshore Feed Gas Pipeline Installation Management Plan (Chevron Australia 2014a) will also apply and will prevent and manage any potential impact to the relevant social factors as a result of the Fourth Train Proposal.

The EMPs that are relevant to addressing potential impacts to the social values of conservation areas for the Fourth Train Proposal are:

- Terrestrial and Subterranean Environment Protection Plan and associated Procedures
- Offshore Feed Gas Pipeline Installation Management Plan (or equivalent Environment Plan)
- Marine Environmental Quality Management Plan
- Post-construction Rehabilitation Plan and associated sub-Plan
- Project Site Rehabilitation Plan.

Further details of the changes needed to these EMPs to incorporate the Fourth Train Proposal are outlined in Table 16-2.

14.4.4 Predicted Social Outcome

Potential incremental impacts to the social values of conservation areas from physical interaction and the physical presence of infrastructure are predicted to be localised during construction for the Fourth Train Proposal. The potential incremental impacts from spills and leaks are examined in Section 14.5. The Fourth Train Proposal will require construction activities to be carried out over new geographic areas within which potential impacts may occur compared with the approved Foundation Project. However, no different impacts to conservation areas were identified.

Potential impacts are not predicted to affect the social values of areas identified as having significant environmental and/or heritage attributes. Potential impacts to the social values of conservation areas are considered to be able to be managed to acceptable levels by implementation of the EMPs that have been approved for the Foundation Project (with minor amendments). The GJVs consider that the stressors to the social values of conservation areas will be adequately managed such that the potential impacts are socially acceptable and the social objective (Section 14.4.1.1) is met.

14.5 Land and Sea Use

14.5.1 Assessment Framework

14.5.1.1 Social Objective

The objective established in this PER/Draft EIS for land and sea use is:

> *To avoid adversely interfering with, or compromising, other economic uses of the land or marine environment.*

14.5.1.2 Relevant Legislation, Policies, Plans, and Guidelines

Commonwealth, State, and local government policy and framework documents relating to land and sea use are listed in Table 14-8.

Table 14-8: Legislation, Policies, Plans, and Guidelines Relevant to Land and Sea Use

Legislation, Policies, Plans, Guidelines	Intent
Petroleum Safety Zone Assessments Policy (National Offshore Petroleum Safety and Environmental Management Authority 2012)	Provides a documented, systematic, and consistent approach for the conduct of assessments related to petroleum safety zones.
EPA Guidance Statement No. 33: Environmental Guidance for Planning and Development (EPA 2008)	Specifies that existing and planned recreational uses should not be compromised.
Fish Resources Management Act 1994 (WA)	Provides a legal framework to conserve, develop, and share fish resources for the benefit of current and future populations in WA.
Shire of Ashburton Town Planning Scheme No 7 (Shire of Ashburton 2004)	Requires the consideration of social issues that may affect the local amenity, the capacity of the site to support the development, and potential loss of benefits or services to the community.
Shire of Ashburton Local Planning Policy 20: Social Impact Assessment (Shire of Ashburton 2013)	Requires the minimisation of negative and maximisation of positive impacts, and the consideration of a range of social issues including community impacts.

14.5.2 Assessment and Mitigation of Potential Impacts

Potential stressors identified that may affect land and sea use due to the Fourth Train Proposal are physical interaction, physical presence of infrastructure, Marine Pests (addressed in Section 12.3), and spills and leaks. Other activities in the region encompassing the Fourth Train Proposal are described in Section 1.6

14.5.2.1 Physical Interaction

Increased traffic levels associated with the Fourth Train Proposal around mainland supply bases may cause potential land use impacts from physical interaction such as increased traffic congestion. It is anticipated that the Fourth Train Proposal will use the same mainland supply bases as the Foundation Project, although this has not been confirmed. Potential impacts created by increased traffic levels on the mainland include nuisance to local road users, longer journey times, and/or damage to road infrastructure. These impacts would be localised and greatest during construction, reducing substantially when operations commence. No other land use impacts are expected as access to Barrow Island is restricted to WA Oil personnel, Commonwealth and State government staff, and personnel associated with the approved Foundation Project.

In terms of sea use, activities associated with the Fourth Train Proposal may have an impact on the activities of other users including other oil and gas activities, commercial fishing, shipping activities, tourism. Construction of the Fourth Train Proposal will result in heightened marine vessel activity. Additional marine vessels in the vicinity of the Fourth Train Proposal Area will be required during the operations phase. Section 6.8.4.2 describes sea tenure and other sea users in the vicinity of the Fourth Train Proposal.

The Northern Pipeline Route option of the Fourth Train Proposal Feed Gas Pipeline System will require crossings with third-party pipelines, as described in Section 4.3.4.1. All third-party pipeline crossings will be designed and constructed in accordance with Australian Standards and will be managed through liaison with the third-party pipeline operator. No third-party pipeline crossings are required for the Southern Pipeline Route.

The increased offshore activity associated with the Fourth Train Proposal may potentially impact he commercial fisheries described in Section 6.8.4.2.2, and contribute to existing industry concerns about the commercial viability of fishing in the Pilbara Region. However, given the wide-ranging zones of the fisheries, none of which are confined to the Fourth Train Proposal Area, and the low level of activity for many of the relevant fisheries, a substantial impact to commercial fishing activities is not expected. Pearl farms are located in the Montebello and Lacepede Islands in the region north-east of Barrow Island. Substantial impacts to tourism and shipping operators are also not expected. No tourism activities are undertaken on Barrow Island and tourism to the Montebello/Barrow Islands Marine Conservation Reserve is currently low and limited to the charter vessel industry (DEC and Department of Fisheries 2009). Areas of greater tourism activity occur outside the Fourth Train Proposal Area at the Mackerel Islands and the Ningaloo Reef (Section 6.8.4.2.4). Shipping activities are not confined to the Fourth Train Proposal Area and are undertaken in the wider Pilbara Region. Figure 8-1 illustrates the areas of greater commercial shipping activity in relation to the Fourth Train Proposal Area.

14.5.2.2 Physical Presence of Infrastructure

During construction, petroleum safety zones may be required around the Fourth Train Proposal Feed Gas Pipeline System and subsea production wells and may be up to 500 m from the outer edges of the structures. These petroleum safety zones may remain throughout the operations phase, depending on the perceived risk from marine vessel movements to subsea infrastructure. The extent of the petroleum safety zone will depend on the consideration of a number of factors, such as the potential risk to the structure, the impact on other users, proximity to shipping lanes or commercial fisheries, water depth, activities which will or are likely to be undertaken at the structure and the outcomes of consultation undertaken. Prior to the establishment of a petroleum safety zone, in compliance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth) and the Petroleum Safety Zone Assessments Policy, consultation will be undertaken with the relevant government agencies and other users likely to be especially affected by the establishment of the petroleum safety zone (National Offshore Petroleum Safety and Environmental Management Authority 2012). The Fourth Train Proposal will also result in additional marine vessels in the vicinity of the Fourth Train Proposal Area during construction activities and additional LNG, condensate and logistic vessels during the operations phase. The presence of the petroleum safety zones and the presence of marine vessels may restrict the movements of some commercial fishing operators, commercial shipping activities, and tourism businesses. Access to and around the waters off Barrow Island may also be incrementally limited during the construction of the Fourth Train Proposal, a similar situation to the current approved Foundation Project activities.

14.5.2.3 Spills and Leaks

Hydrocarbons and other hazardous materials will be used routinely during the Fourth Train Proposal. Therefore, there is potential for an accidental spill or leak to occur to the marine environment (e.g. as a result of pipeline or equipment failure). A spill or leak may impact commercial fishing and tourism businesses. Potential harm to marine resources and/or restrictions that may apply to clean-up activities may result in an impact on incomes and business activities. The significance of such an impact would depend on the type of release (i.e. condensate or diesel), scale, duration, and location of the spill or leak.

The cumulative impact of resource sector activity on fishing resources in the Pilbara Region has been raised as a concern by key marine stakeholders; therefore the addition of the Fourth Train Proposal may be a concern of the commercial fishers (Section 15).

Oil spill modelling was completed for a range of scenarios relevant to the construction and operations phases of the Fourth Train Proposal, including an 11-week subsea blowout occurring at the Chandon well site, a Feed Gas Pipeline rupture, and several marine vessel spill scenarios. Refer to Section 5.7 for additional detail on the oil spill modelling scenarios and results. Modelling assumed that there was no intervention, i.e. no attempt to respond to or manage the spread of the spill. However, a number of mitigation measures will be implemented for the Fourth Train Proposal, to both reduce the risk of a spill or leak occurring and to respond accordingly if a spill or leak occurs, as outlined in Section 5.7.3.

A number of commercial fisheries operate within the area of possible exposure, as indicated by the trajectory of the oil spill modelling. However, most of these fisheries target species that live predominately at depth with reduced potential for exposure to hydrocarbons and have wide-ranging fishing zones, which would only be partially affected by any individual spill event and only for a relatively short time period. Possible short-term effects to commercial fisheries include the fouling of boats and/or fishing equipment, the tainting of seafood product, the displacement of fishing activities, and reduced catches due to stock mortalities.

Impact from fouling of fishing gear is unlikely given the light nature of condensate and the ability for most fisheries to remove gear in the event of a spill. A long-term adverse impact upon the commercial fisheries in the region from seafood tainting is also not expected to occur. The predominant cause of seafood tainting is the aromatic components of oil. The oil spill modelling found that elevated aromatic concentrations would be restricted to the immediate vicinity of the Chandon condensate release. Therefore, impacts to fisheries, if any, would be localised. Further, if seafood tainting were to occur, only short-term closure of fisheries is anticipated, as organisms would be expected to eliminate contaminants relatively quickly (RPS 2012). A large release of hydrocarbons (e.g. from a well blowout) also has the potential to cause stock mortalities and subsequently reduce commercial fishing catches. However, reports of fish kills from oil spills are relatively rare, especially in open waters (RPS 2012). Substantial, adverse effects to commercial fish stocks were determined to be unlikely or unexpected due to the localised and/or short-term impacts identified. Early life stages of fish may be more susceptible to hydrocarbon exposure and contact with oil droplets. However, the oil spill modelling determined that exposure to important spawning grounds or inshore nursery areas in the region, is unlikely (RPS 2012).

Modelling also indicated that under some scenarios there is the potential for a surface slick to reach pearl farms leases in the Montebello Islands. Pearl Oysters are sensitive to soluble aromatic hydrocarbons, and this could result in adverse effects to oysters and/or the fouling of pearling infrastructure. However, given the low annualised probability for shoreline exposure across the Montebello, Barrow, and Lowendal Islands, the likelihood of substantial impacts to the Montebello pearl farming industry occurring is considered low (RPS 2012). Toxicity testing on the Rock Oyster, which is considered comparable to the Pearl Oyster, was undertaken. The worst-case concentrations reaching the Montebello Islands from the oil spill modelling were well below the no effects levels for the different weathered condensates tested against the Rock Oyster (RPS 2012).

Illustrative Measures to mitigate and manage potential impacts to land and sea use taken from Foundation Project EMPs are presented in Table 14-9 for assessment purposes (Section 8.3.5 explains the status of the Illustrative Measures).

Table 14-9: Illustrative Measures to Manage Impacts to Land and Sea Use

Approved Foundation Project EMP	Illustrative Measures
Offshore Feed Gas Pipeline Installation Management Plan	• To reduce the risk of marine vessel collisions, the following measures will be implemented: ▪ Notice to Mariners lodged ▪ adherence to maritime standards and procedures, including maintaining specific lights configuration and radar/watch ▪ personnel will attend inductions and training relevant to their role ▪ equipment function tests (e.g. dynamic positioning trial) conducted to ensure that the equipment will adequately perform their functions.

Approved Foundation Project EMP	Illustrative Measures
	• To mitigate against the risk of spillage from chemical transfer, storage, and handling, these measures will be implemented: ▪ hazardous and dangerous goods will be stored and handled in accordance with relevant legal requirements and Material Safety Data Sheet (MSDS) requirements (including secondary containment, segregation with incompatible materials, level gauges, overflow protection and drainage systems) ▪ spill containment and recovery equipment will be provided where spills are possible (e.g. where fuel, oil or chemicals, and hazardous waste are used or stored) and will be maintained to ensure that it is readily available and in working condition.
Gorgon Gas Development Drilling and Completion Program	• A 500 m radius exclusion zone will be established around the rig and a Notice to Mariners will be broadcast warning of the presence of the rig • The rig and support vessels will display all required navigation lighting to minimise any navigation hazard to passing vessels • Well controls and mitigation and recovery measures will be implemented, including: ▪ blowout preventer ▪ well control systems, procedures, and training ▪ well design and planning ▪ preventive maintenance ▪ hole monitoring ▪ emergency shutdowns

Given the localised nature of construction activities and the application of mitigation and management measures, the incremental or additional impacts to land and sea use from physical interaction, physical presence of infrastructure, and spills and leaks is assessed to be 'Low'. The Fourth Train Proposal is not predicted to increase the level of impact to land and sea use compared to that assessed for the approved Foundation Project. Additional construction activities and areas will be required for the Fourth Train Proposal. No spatial overlap is expected between the Foundation Project and Fourth Train Proposal construction activities in the offshore environment. Potential impacts that may occur are expected to be localised and would not result in impacts to multiple land and sea users.

14.5.3 Proposed Management

The GJVs consider that the potential impacts to land and sea use by the Fourth Train Proposal can be effectively managed under the relevant Ministerial Conditions for the Foundation Project. No measures or controls additional or different to those required for the Foundation Project were assessed as being necessary to manage the incremental or additional potential impacts to land and sea use from the Fourth Train Proposal.

Therefore, the GJVs propose that minor changes are included in the various Foundation Project EMPs to ensure that those documents also apply to the specific construction and operations activities of the Fourth Train Proposal. A new plan covering the Fourth Train Proposal's offshore Feed Gas Pipeline activities, locations, and potential impacts will also need to be prepared and approved as described in Section 16.2.3.3. However, the GJVs anticipate that the mitigation and management measures included within the existing Foundation Project Offshore Feed Gas Pipeline Installation Management Plan (Chevron Australia 2014a) will also apply and will prevent and manage any potential impact to the relevant social factors, as a result of the Fourth Train Proposal.

The EMPs that are relevant to addressing potential impacts to land and sea use for the Fourth Train Proposal are:

- Offshore Feed Gas Pipeline Installation Management Plan (or equivalent Environment Plan; Chevron Australia 2014a).

In addition, spill response measures will be implemented, as described in Section 5.7.3. The GJVs propose that these EMPs and Subsidiary Documents (requiring regulatory approval) are updated to reflect the Fourth Train Proposal's design and activities. This approach is described further in Section 16.2.3.

Impacts to land and sea use are also managed under other legislation under which the GJVs will obtain separate government approval (Section 16.2.4.1).

14.5.4 Predicted Social Outcome

Potential incremental impacts to land and sea use from the physical presence of infrastructure, physical interaction, and spills and leaks are predicted to be localised. The Fourth Train Proposal will require additional construction activities to be carried out over new geographic areas in the offshore environment within which potential impacts may occur compared with the approved Foundation Project. However, no different impacts to land and sea use were identified.

Additional impacts to other sea users from physical presence of the Fourth Train Proposal have been assessed based on the worst-case scenario of petroleum safety zones for the operations phase of the approved Foundation Project being in place when petroleum safety zones are implemented for the Fourth Train Proposal. However, the petroleum safety zones will reduce the potential for physical interaction between fishing equipment and subsea infrastructure (via snagging). The potential for additional impacts to other users of the marine environment from physical presence of infrastructure and physical interaction is considered unlikely given the vast area available outside the petroleum safety zones, the spatial separation of the proposed petroleum safety zones, the extent of commercial fishing zones and shipping areas, and ongoing communication with stakeholder groups to ensure awareness of proposed activities that may potentially interfere with other sea uses.

The GJVs recognise that the Fourth Train Proposal additional to the approved Foundation Project will result in additional construction activities during which there is an increased risk of accidental spills and leaks occurring. Construction of the Southern Pipeline Route option for the Fourth Train Proposal will potentially expose new offshore areas to the impacts of a spill or leak. The Southern Pipeline Route option has previously been assessed and approved, with the potential impacts considered manageable through the implementation of established industry practices for mitigation. The Fourth Train Proposal additional to the approved Foundation Project will result in an increased likelihood of accidental spills and leaks during the operations phase due to the increase in marine vessel movements to and from the LNG Jetty. However, the likelihood of unplanned spills and leaks associated with the Fourth Train Proposal occurring is assessed to be 'Low', and represents no change to that assessed for the Foundation Project.

Potential impacts are not predicted to adversely interfere with, or compromise, other economic uses of the land or marine environment. Potential impacts to land and sea use are considered to be able to be managed to acceptable levels by implementation of the EMPs that have been approved for the Foundation Project (with minor amendments). The GJVs consider that the stressors to land and sea use will be adequately managed such that the potential impacts are socially acceptable and the social objective (Section 14.5.1.1) is met.

14.6 Livelihoods

14.6.1 Assessment Framework

14.6.1.1 Social Objective

The objective established in this PER/Draft EIS for livelihoods is:

> *To deliver employment and skill development opportunities that benefit the local and regional population.*

14.6.1.2 Relevant Legislation, Policies, Plans, and Guidelines

Commonwealth, State, and local government policy and framework documents relating to livelihoods are listed in Table 14-10.

Table 14-10: Legislation, Policies, Plans, and Guidelines Relevant to Livelihoods

Legislation, Policies, Plans, Guidelines	Intent
Australian Industry Participation (AIP) National Framework (Department of Industry, Innovation, Science, Research and Tertiary Education 2001)	Australian, State, and Territory Industry Ministers signed the AIP National Framework in April 2001, committing them to incorporate a number of principles aimed at maximising AIP in investment projects into their industry development policies. The objectives of the AIP National Framework are to promote, develop, and maintain sustainable and competitive Australian industry capability and to secure a greater share of the economic activity and benefits associated with investment projects within Australia (Department of Industry, Innovation, Science, Research and Tertiary Education 2001).
AIP Plans: User Guide for developing an AIP Plan and Implementation Report (Department of Industry, Innovation, Science, Research and Tertiary Education 2012)	The Australian Government may require the development of AIP Plans setting out how companies will provide full, fair, and reasonable opportunity for Australian industry to participate in the project. This document details how to prepare an AIP Plan and how to report on the outcomes in an Implementation Report.
Building Local Industry Policy (Department of Commerce 2009)	The primary objective of the Building Local Industry Policy is the creation of more, higher quality employment opportunities in Western Australia. Under the Policy, local businesses have a legitimate expectation that they will be given a full, fair, and reasonable opportunity to be considered for major work and contracts in both the public and private sector.
Western Australian Government Local Industry Participation Framework (Department of Commerce 2011)	Outlines the State Government's commitment to the principle of full, fair, and reasonable opportunity to allow competitive local suppliers to participate in Western Australia's resource projects.
Shire of Ashburton Town Planning Scheme No 7 (Shire of Ashburton 2004)	Requires the consideration of socioeconomic impacts on the local amenity, the capacity of the site to support the development, and potential loss of benefits or services to the community.
Shire of Ashburton Local Planning Policy 20: Social Impact Assessment (Shire of Ashburton 2013)	Requires the minimisation of negative and maximisation of positive impacts, and the consideration of a range of social issues including the infrastructure, resource issues, cultural, transport, economic and fiscal, and community impacts.

14.6.2 Assessment and Mitigation of Potential Impacts

The Fourth Train Proposal activities (offshore and onshore) will require an additional workforce during the construction and operation phases. The greatest number of employees will be required during construction of the Fourth Train Proposal. The economic modelling undertaken (described in Section 14.8.2) predicts that peak indirect and direct employment as a result of the Fourth Train Proposal, will also occur during construction and will reach approximately 6300 people (ACIL Tasman 2012).

Most of these workers will operate on a FIFO basis from Perth, Karratha, and other Australian states. The specific breakdown of workforce origins and ethnicity are unknown at this time; however, similar to the approved Foundation Project, the GJVs will encourage local Pilbara and Aboriginal employment and training.

The GJVs have also made specific commitments to the Western Australian Government to preference the involvement of the Pilbara, then other Western Australian, and Australian labour, services, and materials for the Fourth Train Proposal. These obligations are stipulated in Clause 15 (Use of local labour professional services and materials) of the Gorgon Gas Processing and Infrastructure Project Agreement (State Agreement).

The potential incremental and additional impacts to employment associated with the Fourth Train Proposal are 'High', but beneficial, which is the same as that assessed for the Foundation Project.

14.6.3 Proposed Management

As a major Australian project, the Fourth Train Proposal will actively support AIP as a core business policy, in line with the AIP National Framework. An AIP Plan will be developed to give effect to the Chevron Australia AIP Policy, which is expected to include the following key elements:

- Commitment to providing full, fair, and reasonable opportunity for Australian industry to supply goods and services to the Fourth Train Proposal whenever practically and economically feasible
- Consideration of, and where possible preference to, the use of Australian labour, services, and materials when price, quality, delivery, and service are equal to or better than other alternatives
- Providing preference first for the involvement of Pilbara, then other Western Australian, and then other Australian labour, services, and materials
- Promoting opportunity for Aboriginal business and employment
- Using available resources and industry capability websites such as the Industry Capability Network Western Australia (ICNWA), ProjectConnect, and Pilbara Business Capability Register (ePilbara) to fully inform and assess Australian industry.

In addition, Chevron Australia will continue to meet its obligations under the Social Impact Management Plan. The Social Impact Management Plan is reviewed every two years. The current focus areas of the Social Impact Management Plan are education, training, and employment; regional economic development; and Aboriginal-specific training and employment (Chevron Australia 2011b).

14.6.4 Predicted Social Outcome

The Fourth Train Proposal is expected to deliver employment and skill development opportunities that benefit the local and regional population. The Fourth Train Proposal will result in an extended time within which these potential beneficial impacts may take place compared with the approved Foundation Project. No different impacts to livelihoods were identified. The GJVs consider that the potential impacts are socially acceptable and the social objective (Section 14.6.1.1) is met.

14.7 Local Communities

14.7.1 Assessment Framework

14.7.1.1 Social Objective

The objective established in this PER/Draft EIS for local communities is:

> *To avoid compromising the social infrastructure, cultural, and community structures of the local host community and, where relevant, to share benefits with the community.*

14.7.1.2 Relevant Legislation, Policies, Plans, and Guidelines

Local government policy and framework documents relating to local communities are listed in Table 14-11.

Table 14-11: Legislation, Policies, Plans, and Guidelines Relevant to Local Communities

Legislation, Policies, Plans, Guidelines	Intent
Shire of Ashburton Town Planning Scheme No 7 (Shire of Ashburton 2004)	Requires the consideration of socioeconomic impacts on the local amenity, the capacity of the site to support the development, and potential loss of benefits or services to the community.
Shire of Ashburton Local Planning Policy 20: Social Impact Assessment (Shire of Ashburton 2013)	Requires the minimisation of negative and maximisation of positive impacts, and the consideration of a range of social issues including the infrastructure, resource issues, cultural, transport, economic and fiscal, and community impacts.

14.7.2 Assessment and Mitigation of Potential Impacts

The physical presence of infrastructure has been identified as the key stressor that may affect local communities.

The Barrow Island workforce (construction and operations) required for both the approved Foundation Project and the Fourth Train Proposal will be housed on Barrow Island on a FIFO basis, flying direct to Barrow Island from Perth and other regional centres, including several flights per week from Karratha. To date there has been limited pressure placed on regional airports, accommodation, and recreational/sporting facilities as a result of the approved Foundation Project. There is no anticipated increase in the use of nearby mainland regional centres as a result of the Fourth Train Proposal. Medical facilities on Barrow Island currently provide the workforce with first aid treatment and primary care. If further medical care is required, personnel are medically evacuated to the mainland for treatment.

The facilities (e.g. workforce accommodation) on Barrow Island have been designed to withstand cyclones as Barrow Island lies within a cyclone area (Sections 6.4.1 and 6.4.10.5). If a cyclone threat is identified, personnel will either remain on Barrow Island or be evacuated in a staged manner, generally to Perth airport (Chevron Australia 2012). Therefore, impact on Karratha and surrounding communities will be reduced.

Potential impacts on local communities may result from increased traffic levels to and from supply bases. It is anticipated that the Fourth Train Proposal will use existing Foundation Project supply bases. The level of impact will depend on the location of the supply bases used and the transportation routes adopted. Potential impacts to local communities are expected to be greatest during construction of the Fourth Train Proposal, reducing once the Fourth Train Proposal is operational. As discussed in Section 14.2, contractors and suppliers to Chevron Australia are required to implement a document management system that fully embraces the policies and objectives of the OEMS and to develop and implement their own activity- and/or site-specific EMPs, procedures, and work method statements.

The GJVs anticipate there will be negligible additional impacts on the coastal Pilbara communities of Karratha, Dampier, and Onslow as a result of the Fourth Train Proposal. Therefore, the interaction with, and impact on, communities as a result of the Fourth Train Proposal is assessed as 'Low'.

14.7.3 Proposed Management

No measures or controls additional or different to those required for the Foundation Project were assessed as being necessary to manage the incremental or additional potential impacts to local communities from the Fourth Train Proposal. The OEMS and Policy 530 apply to all Chevron Australia capital projects and operational activities and the GJVs propose that these will be extended and/or revised to reflect the Fourth Train Proposal. In addition, Chevron Australia will continue to meet its obligations under the Social Impact Management Plan (Chevron Australia 2011b).

14.7.4 Predicted Social Outcome

Potential incremental impacts to local communities from the physical presence of infrastructure are predicted to be localised. The Fourth Train Proposal will result in an extended time within which potential impacts may take place compared with the approved Foundation Project. However, no different impacts to local communities were identified.

Potential impacts are not predicted to compromise the social infrastructure or the cultural and community structures of the local community, but will result, where relevant, in benefits being shared with the community. Potential impacts to local communities are considered to be managed to acceptable levels by implementation of the OEMS and Chevron Australasia Business Unit Policy 530 – Operational Excellence. The GJVs consider that the stressors to local communities will be adequately managed such that the potential impacts are socially acceptable and the social objective (Section 14.7.1.1) is met.

14.8 Commonwealth, State, and Regional Economy

14.8.1 Assessment Framework

14.8.1.1 Social Objective

The objective established in this PER/Draft EIS for Commonwealth, State, and regional economy is:

> *To contribute to the achievement of national, State, and regional development policies and plans with respect to socio-economy so that benefits are brought to the national, State and regional economy and that negative impacts on the economy are avoided or managed.*

14.8.1.2 Relevant Legislation, Policies, Plans, and Guidelines

Commonwealth, State, and local government policy and framework documents relating to the national, State, and regional economy are listed in Table 14-12.

Table 14-12: Legislation, Policies, Plans, and Guidelines Relevant to the National, State, and Regional Economy

Framework Documents	Intent
Stronger Regions, A Stronger Australia (Department of Transport and Regional Services 2001)	Assesses regional development issues, according to the broad subject areas of business, government, people, and infrastructure.

Framework Documents	Intent
WA State Sustainability Strategy (Government of Western Australia 2003)	Seeks to give sustainability meaning for WA, its regions, its issues, its projects, and its communities. This strategy accepts that there are tensions between economic, environmental, and social goals and seeks to resolve them through finding mutual benefit.
WA State Planning Strategy (Western Australian Planning Commission 1997)	Provides a strategic guide for land use planning through to 2029; aimed at developing a land use planning system. The strategy is very broad and identifies a number of regional actions for the Pilbara.
WA State Regional Development Policy – Regional Western Australia – a Better Place to Live (Department of Local Government and Regional Development 2003)	Provides a framework for the development of the State's non-metropolitan regions to achieve 'social, economic, and environmental progress in a sustainable way'. Every major aspect of regional activity is covered; as a result, the policy sets out a clear direction for Government and establishes a set of priorities for regional development.
State Agreement	Requires the use of local labour, professional services, and materials.
AIP Policy (Chevron Australia 2009)	Develops and envisages positive discrimination in favour of Australian industry. Chevron Australia agreed that the approved Foundation Project will actively support AIP as a core business policy, in line with the AIP National Framework and Australian Petroleum Production and Exploration Association (APPEA)/Australian Competitive Energy policy.
Pilbara Planning and Infrastructure Framework (Pilbara Regional Planning Committee and Western Australian Planning Commission 2012)	Provides a response to many of the opportunities and challenges facing the region. This framework sets a basis for further, detailed planning at the local level, and also establishes unified action between State and local governments in the adoption and ongoing review of the framework.
Shire of Ashburton Town Planning Scheme No 7 (Shire of Ashburton 2004)	Requires the consideration of socioeconomic impacts on the local amenity, the capacity of the site to support the development, and potential loss of benefits to the community.
Shire of Ashburton Local Planning Policy 20: Social Impact Assessment (Shire of Ashburton 2013)	Requires the consideration of a range of social issues including economic and fiscal impacts and community impacts.

14.8.2 Assessment and Mitigation of Potential Impacts

The Fourth Train Proposal will involve considerable capital and operating expenditure in terms of employment, contribution to Gross Domestic and State Products, and government revenues. The GJVs consider that the proposed activities of the Fourth Train Proposal will have a positive effect on the national, State, and regional economies, and will support government policy and plans.

Government economic policy and planning impacts that the GJVs identified and considered were:

- the continued use of a FIFO workforce
- protection of sensitive environmental and heritage areas
- local participation opportunities, including Aboriginal participation.

These impacts were also considered as part of the approved Foundation Project and mitigation and management measures are in place, as discussed in Sections 14.2, 14.3, 14.4, and 14.6.

The positive economic effects are considered to be of major importance to the national, State, and regional economies. The incremental economic impact of the Fourth Train Proposal was assessed by ACIL Tasman (2012) using the independent macroeconomic model – Monash Multi-Regional Forecasting. This economic model reflects a number of assumptions made at the time of modelling. The model assumed the effective life of the project is 2012–2040, therefore discussions about the life of the project in this Section relate to this time period. The modelling also assumed that if the Fourth Train Proposal is approved, the indicative start date for construction of the Fourth Train Proposal is 2014. However, work has commenced on the project (i.e. project approvals, design, contracts) prior to construction commencing, and this early expenditure has not been accounted for in the modelling.

The model estimates that considerable capital and operating expenditure is anticipated as a result of the Fourth Train Proposal. The estimated impacts and expenditures (all figures in 2010 Australian dollars) of the Fourth Train Proposal, by ACIL Tasman (2012), at the time of modelling include:

- an increase in total construction expenditure over the three-train base case of approximately AU$16 billion (equivalent to a net present cost [NPC] of AU$12 billion) over the effective life of the project. This expenditure covers the construction of offshore infrastructure, pipelines, and onshore processing facilities on Barrow Island[20]. Total operating expenditure in the first 20 years of operation is approximately AU$3 billion (for an NPC of approximately AU$1.5 billion)
- total revenues over the effective life of the project would be approximately AU$97 billion (for a Net Present Value [NPV] of approximately AU$46 billion)[21]
- employment will peak at approximately 6300 people directly and indirectly employed as a result of the Fourth Train Proposal
- total direct and indirect payments to governments in Australia during the effective life of the project of approximately AU$24.6 billion (not including any costs incurred under the *Clean Energy Act 2012* [Cth])
- total payments to the Commonwealth Government of Australia of approximately AU$24 billion over the effective life of the project (not including any costs incurred under the *Clean Energy Act 2012* [Cth])
- total payments to State and local governments in Australia of approximately AU$0.6 billion over the effective life of the project (not including any costs incurred under the *Clean Energy Act 2012* [Cth]).

Other positive economic impacts of the Fourth Train Proposal (e.g. direct government economic benefits) are discussed in the following subsections.

14.8.2.1 National Benefits

National benefits are likely to be accrued through:

- increases to Australia's Gross Domestic Product (GDP)
- increases in national private consumption of goods and services
- payments through the Petroleum Resource Rent Tax (PRRT), company tax, personal tax, and the Goods and Services Tax (GST)
- carbon emissions liability payments
- net exports.

According to the economic modelling, the Fourth Train Proposal is likely to increase Australia's GDP by an approximate 0.23% in its first full year of operation, with this contribution declining as the economy grows (ACIL Tasman 2012). Overall, the Fourth Train Proposal alone would

[20] Real discount rate of 4%

[21] Includes LNG and condensate sales

increase Australia's GDP by approximately AU$83.1 billion (in 2010 dollars) (ACIL Tasman 2012).

The economic modelling expects national private consumption (a measure of the value of consumption goods and services acquired by households at a national level) as a result of the Fourth Train Proposal to increase by approximately AU$29.7 billion (in 2010 dollars). At a 4% real discount rate, this represents an NPV of approximately AU$14 billion in 2010 dollars (ACIL Tasman 2012). In effect, this measure reflects the increased spending by households as a result of direct income from the project, increased real wages throughout the national economy, and increased income to households as a result of additional transfers by governments from their receipts from the project (ACIL Tasman 2012).

Furthermore, the Commonwealth Government will receive payments directly or indirectly through the PRRT, company tax, personal tax, and the GST. Economic modelling indicates that Commonwealth tax revenue will increase by a total of approximately AU$24 billion in 2010 dollars over the effective life of the project (or approximately AU$11 billion NPV). Annual contributions to the Commonwealth Government will increase substantially once the PRRT payments commence around 2022[22] (ACIL Tasman 2012).

The Fourth Train Proposal will substantially increase the export capacity of the approved Foundation Project, which will have a positive impact on the level of Australia's net exports after the first year of operation of the Fourth Train Proposal. The overall stimulus to Australia's net exports over the life of the project is estimated at AU$16 billion in NPV terms.

14.8.2.2 State and Regional Benefits

Similar to national benefits, a number of State benefits are likely to be accrued through:

- increases to the State's Gross State Product (GSP)
- increases in real private consumption
- State payments through payroll tax receipts
- employment
- net exports.

Economic modelling forecast the GSP to increase by approximately AU$89.5 billion in 2010 dollars (or approximately AU$44 billion in NPV terms over the life of the project) (ACIL Tasman 2012). This figure exceeds the NPV of national GDP growth by approximately AU$4 billion, indicating that economic growth in the remainder of Australia is slightly reduced as a result of the project, mainly as a result of two factors:

- competition for labour leads to a reduction in the available labour supply outside WA
- the additional LNG production from WA leads to an increase in the foreign exchange rate, which results in a reduction in exports from other Australian exporting industries. Existing WA exporters may also reduce exports as a result of the currency appreciation.

Real private consumption in WA will increase as a result of the construction and operation of the Fourth Train Proposal and its impact on local employment, real wages, and government transfers to households. This impact has been estimated at approximately AU$7 billion in 2010 dollars, or approximately AU$3 billion in NPV terms, over the effective life of the project (ACIL Tasman 2012).

The current level of real private consumption in WA is estimated by the Australian Bureau of Statistics (ABS) to be AU$71.3 billion (ABS 2010). The Fourth Train Proposal is estimated to contribute AU$300 million to AU$400 million per year towards real private consumption in WA. This will result in an increase of around 0.5% in current private consumption.

[22] This PRRT commencement date is based on the Fourth Train Proposal as a standalone project. Ultimately, the actual PRRT commencement date will depend on each GJVs' individual tax position.

Due to direct and indirect employment associated with the Fourth Train Proposal, payroll tax receipts by the State Government will increase. Over the life of the project, the economic modelling predicts payroll tax receipts will increase by approximately AU$582 million in 2010 dollars (or approximately AU$386 million in NPV terms) (ACIL Tasman 2012).

The large import component required for construction of the Fourth Train Proposal reduces WA's net exports. However, this is a short-term reduction and net exports are predicted to increase during operations. The overall stimulus to WA's net exports over the life of the project is approximately AU$34.6 billion in NPV terms (ACIL Tasman 2012).

The Fourth Train Proposal will bring considerable economic benefits to the national, State, and regional economy. The GJVs consider that the Fourth Train Proposal will not pose any unacceptable incremental or additional impacts to the national, State, or regional economy. When added to the impacts of the approved Foundation Project, the Fourth Train Proposal will offer Western Australians the opportunity for employment, training, and economic development.

14.8.3 Predicted Socioeconomic Outcome

The GJVs predict that the Fourth Train Proposal will bring economic benefits to the economies of Western Australia and Australia. The Fourth Train Proposal will contribute to the achievement of national, State, and regional development policies and plans with respect to the socio-economy so that benefits are brought to the national, State, and regional economy and that negative impacts on the economy are avoided or managed. The GJVs consider that there will be no unacceptable incremental or additional impacts to the national, State, or regional economy and social objective (Section 14.8.1.1) is met.

14.9 Decommissioning Activities

The future decommissioning of the Fourth Train Proposal has the potential to result in impacts, including from vegetation clearing and earthworks, physical interaction, and spills and leaks. Section 4.8 outlines current industry practice in decommissioning strategies, noting there will be advances in decommissioning technology and information and potential changes to decommissioning procedures and regulatory requirements in the interim.

Assuming current practices and technologies, decommissioning is predicted to result in impacts similar to those from construction activities of the Fourth Train Proposal:

- physical interaction with the public and other land and sea users is predicted to result in potential impacts similar to, or less than, those associated with the construction activities of the Fourth Train Proposal
- increased employment opportunities during the decommissioning period that would benefit the local and regional population.

The following Foundation Project EMPs are relevant to addressing potential impacts from decommissioning of the Fourth Train Proposal:

- Project Site Rehabilitation Plan
- Decommissioning and Closure Plan.

Depending on the timing of the development and submission of these EMPs, they may be submitted for approval for the Combined Gorgon Gas Development. If these EMPs have already been approved for Foundation Project, they will be revised to incorporate the Fourth Train Proposal.

Potential impacts as a result of decommissioning activities are predicted to meet the social objectives for each factor (Section 14.2.1.1 to 14.8.1.1), resulting in the development areas being returned to Commonwealth or State agencies in an appropriate condition following decommissioning activities.

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15. Cumulative Impacts

15.1 Introduction

Assessment of cumulative impacts is required by the Commonwealth DotE, as specified in the Tailored Guidelines for the preparation of a Draft EIS for the Gorgon Fourth Train Proposal (SEWPaC 2011, hereafter referred to as SEWPaC's Tailored Guidelines). The Western Australian EPA also requires that the environmental impacts resulting from the Fourth Train Proposal, including cumulative impacts, can be acceptably managed (EPA 2010).

For the purposes of this assessment, cumulative impacts are defined as the potential incremental impacts of the Fourth Train Proposal when combined with the approved Foundation Project and other present and reasonably foreseeable future actions in the vicinity of the Fourth Train Proposal Area (Figure 15-2). Present and reasonably foreseeable future actions that have the potential to impact the environment in a similar manner to the Fourth Train Proposal are defined as 'considered actions' (outlined in Section 15.3). Reasonably foreseeable future actions (referred to hereafter as future actions) are projects that are referred proposals currently in the Commonwealth or Western Australian Governments' approvals system.

The potential incremental impacts of the Fourth Train Proposal and the additional impacts of the Fourth Train Proposal in combination with the approved Foundation Project are discussed in the relevant sections for each environmental factor (Section 5 and Sections 9 to 14). The relationship between incremental, additional, and cumulative impacts is illustrated in Figure 15-1.

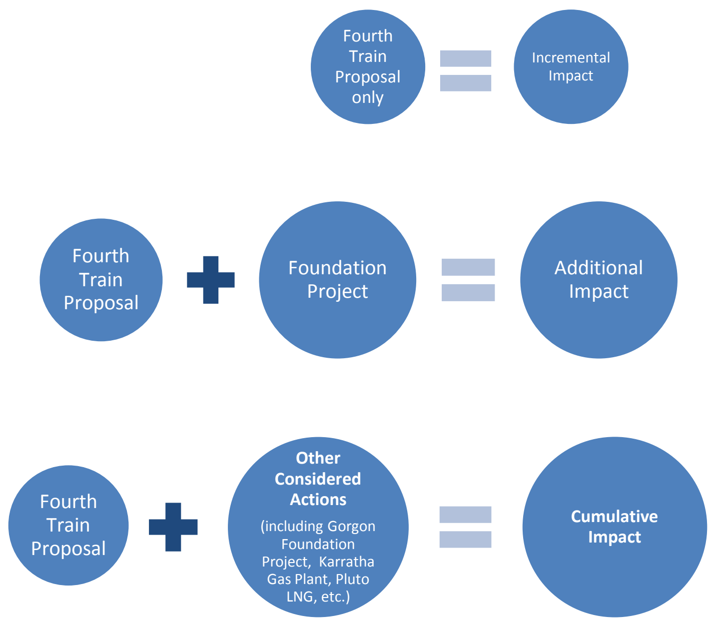

Figure 15-1: Cumulative Impacts Diagram

The Fourth Train Proposal Area, including terrestrial, coastal, and nearshore components, and the Commonwealth Marine Area associated with the Fourth Train Proposal (Figure 13-1), was used as the boundary for the cumulative impact assessment for most factors, except when assessing the potential impact from atmospheric emissions (Figure 15-2). The Fourth Train Proposal Area was determined as the area where impacts from considered actions are most likely to interact, and act cumulatively, for most stressors. The area taken into account when assessing the cumulative impacts of atmospheric emissions from operations includes the whole Pilbara Region—a substantially larger area than for other stressors, including extra considered actions. Section 15.3 discusses the considered actions taken into account for the cumulative impact assessment.

Potential impacts associated with the operation of oil and gas fields, pipelines, processing plants, and commercial fishing and shipping, including present and future impacts, were considered within the constraints of publicly available information.

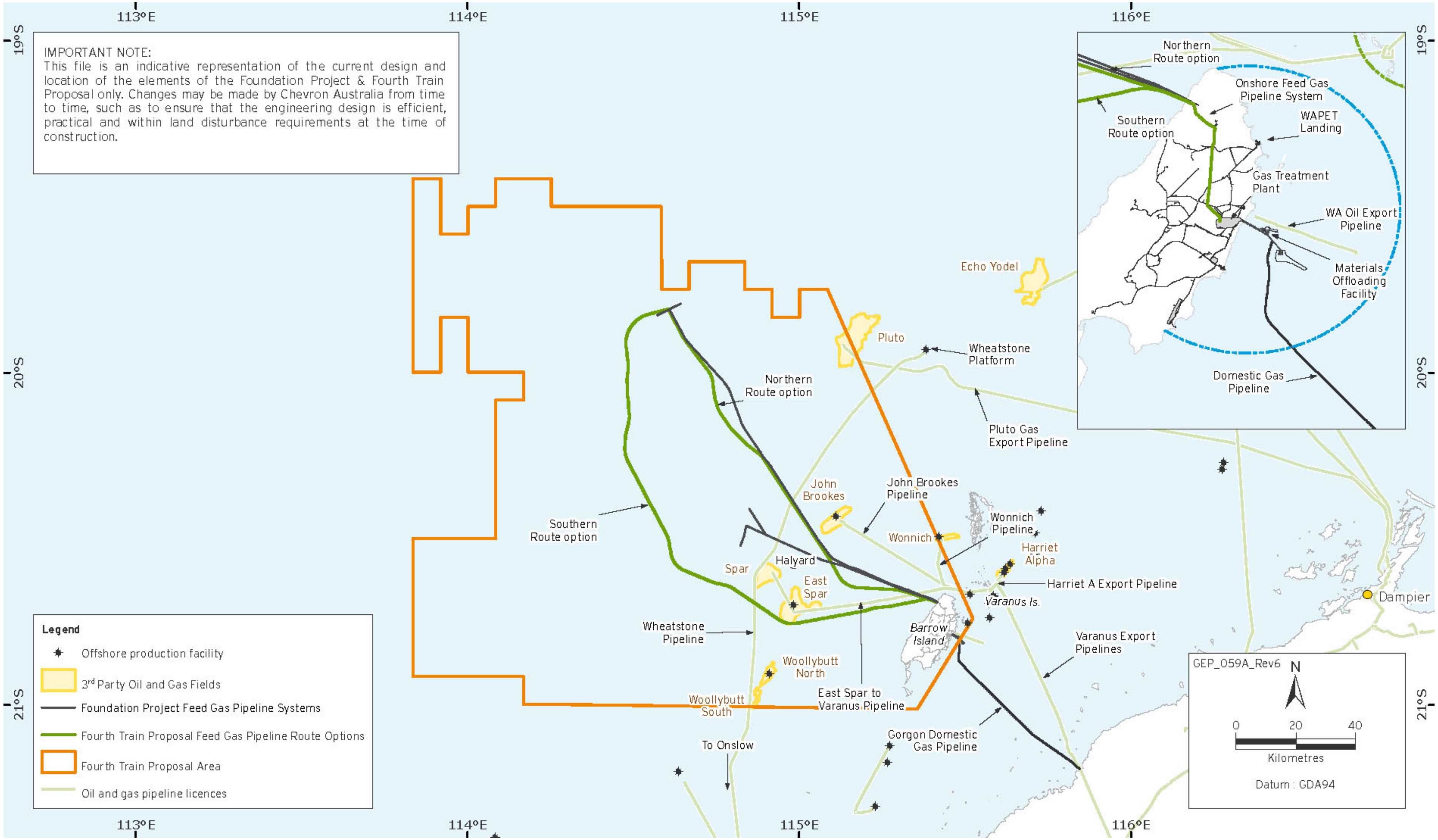

Figure 15-2: Fourth Train Proposal Area and Considered Actions

15.2 Cumulative Impacts Assessment Methodology

This cumulative impact assessment was carried out by:

- identifying 'considered actions' in the Fourth Train Proposal Area (Section 15.3)
- identifying the stressors from the Fourth Train Proposal assessment that may have potential cumulative impacts (Section 15.4)
- assessing cumulative impacts and mitigation and management measures (Section 15.5).

15.2.1 Identifying Considered Actions

The criteria used to identify considered actions for inclusion in the cumulative impact assessment were:

- activities and projects under construction, operating, or future actions within the Fourth Train Proposal Area (or the Pilbara Region for the cumulative impacts of atmospheric emissions)
- considered actions likely to have aspects that may cause impacts on the same factor as the Fourth Train Proposal in combination with the approved Foundation Project
- considered actions where sufficient information is available to undertake a qualitative impact assessment.

Existing and proposed considered actions in the Fourth Train Proposal Area were evaluated for their potential to have cumulative impacts with those of the Fourth Train Proposal. The cumulative atmospheric emissions assessment also included predictions related to the expansion of existing sources of atmospheric emissions, including the growth of Pilbara towns and mainland port operations.

15.2.2 Identifying Stressors and Factors

Each stressor and factor relevant to the Fourth Train Proposal was considered in this cumulative impact assessment. Stressors and factors with the potential for cumulative impacts are further assessed in Section 15.5. Stressors and factors with no potential cumulative impact or a trivial impact (Section 8.2) were excluded from this assessment. Four matters of national environmental significance (matters of NES) were identified by SEWPaC (now DotE) as controlling provisions for the Fourth Train Proposal. Table 15-1 considers these controlling provisions in relation to the identified stressors from Section 13.

Table 15-1: Controlling Provisions for the Fourth Train Proposal

Controlling Provisions	Relevant Assessment Section (Cumulative Impacts)
National Heritage Places (Sections 15B and 15C of the EPBC Act)	Atmospheric emissions were identified as having the potential to impact cumulatively upon the Ningaloo Coast National Heritage Place. This stressor is assessed in: • Sections 15.3.1 Considered Actions Related to Atmospheric Emissions and 13.2.2.1 Atmospheric Emissions (except dust) • Section 15.4 Stressors and Factors Considered in the Cumulative Impact Assessment.
Listed threatened species and communities (Sections 18 and 18A of the EPBC Act)	• Section 15.5.1.2 Terrestrial Fauna • Section 15.5.1.3 Subterranean Fauna • Section 15.5.2.3 Marine Fauna

Controlling Provisions	Relevant Assessment Section (Cumulative Impacts)
Listed migratory species (Sections 20 and 20A of the EPBC Act)	• Section 15.5.1.2 Terrestrial Fauna • Section 15.5.2.3 Marine Fauna
Commonwealth Marine Environment (Sections 23 and 24A of the EPBC Act).	• Section 15.5.2 Coastal and Nearshore Environment • Section 15.5.2.4 Benthic Primary Producer Habitat • Section 15.5.3 Social, Cultural, and Economic Environment

15.2.3 Assessing Cumulative Impacts and Identifying Mitigation and Management Measures

This cumulative impact assessment was based on a high-level analysis of potential impacts using the professional judgement of subject matter experts, supported by baseline studies and a range of quantitative assessments related to individual factors associated with the Fourth Train Proposal, as presented in Section 5 and Sections 9 to 14.

The assessment was largely qualitative due to the lack of publicly available information on considered actions that would enable the potential impacts to be quantitatively assessed. However, cumulative atmospheric emissions have been quantified for the Pilbara Region (Section 5.2).

15.3 Considered Actions in the Cumulative Impact Assessment

15.3.1 Considered Actions Related to Atmospheric Emissions

Atmospheric dispersion modelling conducted for the Fourth Train Proposal modelled the cumulative impacts on ambient air quality in the Pilbara Region, including the Ningaloo Coast National Heritage Place. The results are described in Section 5.2.3.4. Modelling included nitrogen dioxide (NO_2) emissions (a representative pollutant for oxides of nitrogen [NO_x]) and ozone (O_3) creation from existing, approved, and future actions likely to occur in the Pilbara Region. The potential for bushfires, which could affect the air quality in the Pilbara Region, was also included. The considered actions in the cumulative atmospheric emissions impact assessment (regional scale modelling) are listed in Table 15-2.

Table 15-2: Considered Actions in the Cumulative Atmospheric Emissions Impact Assessment

Present Sources	Future Sources
• Approved Gorgon Foundation Project • Cape Lambert Power Station • Citic Pacific Power Station, pellet plants, and mine vehicles • Dampier Power Station • Devils Creek Gas Project • Karratha Gas Plant • Other over water (including floating production, storage, and offloading vessels [FPSOs] and oil and gas rigs) and overland sources • Pilbara towns • Pluto LNG • Shipping – ports and channels • Varanus Production Area	• Anketell Point Power Station • Anketell Port vehicles • Balmoral South Power Station, pellet plants, and mine vehicles • Burrup Nitrates • Macedon Domestic Gas

Present Sources	Future Sources
• WA Oil • West Pilbara Power Station – Karratha • Wheatstone Project • Yara Pilbara Fertilisers • Yurralyi Maya Power Station	

The atmospheric modelling studies indicate that the expected ambient air quality resulting from the cumulative emissions from the Fourth Train Proposal as well as the considered actions listed in Table 15-2 is within the relevant criteria (Table 5-8), both within the Fourth Train Proposal Area and at the Ningaloo Coast.

15.3.2 Considered Actions for Other Stressors

The considered actions for the assessment of cumulative impacts for stressors other than atmospheric emissions for the Fourth Train Proposal are:

- the approved Foundation Project
- existing operations of the WA Oil facility on Barrow Island
- existing subsea infrastructure and pipelines associated with the Varanus Island Production Area
- offshore platform and pipelines associated with the Wheatstone LNG Project (the LNG Plant at Ashburton North Strategic Industrial Area is located outside the Fourth Train Proposal Area)
- Pluto LNG offshore platform
- Woollybutt FPSO vessel
- commercial fishing
- commercial shipping
- future gas fields that are currently planned to be developed as part of the Gorgon Project but are not included in the Fourth Train Proposal assessment as they are subject to further technical evaluation.

Each of these considered actions (or a component of them) is within the Fourth Train Proposal Area and has the potential to impact the environment in a similar manner to the Fourth Train Proposal. Table 15-3 outlines the stressors associated with the considered actions that were included in the cumulative impact assessment, and defines the cumulative impact as affecting the marine environment (M), the terrestrial environment (T), or both (T+M).

As a result of Barrow Island's geographic isolation (Figure 15-2), the Fourth Train Proposal, the approved Foundation Project, and WA Oil are the only projects identified as potentially acting cumulatively on Barrow Island's terrestrial environment (except in the case of atmospheric emissions modelling).

Table 15-3: Stressors Associated with the Considered Actions included in the Cumulative Impact Assessment

Stressor	Considered Action (except for those used in atmospheric emissions modelling)								
	Gorgon Foundation Project	WA Oil	Varanus Production Area	Wheatstone Project	Pluto LNG Platform	Woollybutt	Commercial Fisheries	Commercial Shipping	Future gas fields (Gorgon Project)
Artificial light	M	M	M	M	M	M	M	M	M
Discharges to sea	M	M	M	M	M	M	M	M	M
Noise and vibration	T+M	T+M	M	M	M	M	M	M	M
Fire	T	T							
Seabed disturbance	M	M		M			M		M
Vegetation clearing and earthworks	T	T							
Physical interaction	T+M	T+M	M	M	M	M	M	M	M
Physical presence of infrastructure	T+M	T+M	M	M	M	M			M
Spills and leaks	T*	T	*	*	*	*	*	*	*

T *The considered action together with the Fourth Train Proposal may have cumulative impacts within the terrestrial environment.*

M *The considered action together with the Fourth Train Proposal may have cumulative impacts within the marine environment.*

T+M *The considered action together with the Fourth Train Proposal may have cumulative impacts within the terrestrial and marine environments.*

* *Spills and leaks in the marine environment have not been discussed for the reasons outlined in Section 15.4*

The following subsections summarise the existing sources of considered actions that were assessed as part of the cumulative impact assessment for the Fourth Train Proposal.

15.3.2.1 Gorgon Foundation Project

The Gorgon Foundation Project includes offshore and onshore components to develop the gas reserves of the Gorgon and Jansz–lo fields, which are located off the Barrow Island coast. The Foundation Project commenced construction in late 2009; significant progress has been made to date in developing both the offshore and onshore (Barrow Island) components. The Foundation Project will be constructed, commissioned, and operated in a staged manner, with sequential completion of three LNG trains. The Gas Treatment Plant start-up is planned for late 2014, leading to the first LNG cargo in the first quarter of 2015.

15.3.2.2 WA Oil

WA Oil, located predominantly in the southern central portion of Barrow Island, has explored for and produced oil since 1967; it is currently operated by Chevron Australia. Oil from approximately 468 production wells on Barrow Island is piped to separation facilities located in the oilfield, for treatment. Processed oil is then transferred via pipelines for storage at the Terminal Tanks Facility, located north of the approved Foundation Project Gas Treatment Plant, prior to transfer to oil tankers by a 10 km subsea pipeline and tanker mooring facility (Chevron Australia 2012). The location of the WA Oil facilities is shown in Figure 15-2.

Produced formation water is disposed into the Flacourt Formation by deep well injection. It is treated by oily water separation prior to injection. Gases are flared or compressed and used to fuel the central power station (Chevron Australia 2012). Staff and contractors working for WA Oil reside at the Chevron Australia Camp.

15.3.2.3 Varanus Production Area

Two onshore oil and gas processing plants, operated by Apache Energy, are located on Varanus Island approximately 20 km north-east of Barrow Island (Apache 2012). Oil and gas is transported from the Spar, East Spar, Wonnich, Halyard, and John Brookes Gas Fields to Varanus Island by subsea pipelines located west of Barrow Island in the Fourth Train Proposal Area (Figure 15-2).

The subsea pipeline that connects the East Spar subsea manifold to the Varanus Island gas processing plant intersects with the approved Foundation Project Feed Gas Pipeline System and the Northern Pipeline Route option of the Fourth Train Proposal Feed Gas Pipeline System (the Southern Pipeline Route option does not cross any third-party pipelines). The Northern Pipeline Route option for the Fourth Train Proposal Feed Gas Pipeline System would also intersect with the control umbilical for the Halyard Gas Field. Following processing on Varanus Island, liquids are stored in above-ground tanks prior to transport to tankers by subsea pipeline and a tanker mooring facility (Apache 2012).

Natural gas from Varanus Island is delivered to the mainland gas network by two subsea pipelines. Natural gas is also used to fuel the plant operations; flaring of gas is carried out for pressure control and emergency shutdown pressure relief. Produced water is treated to remove hydrocarbons prior to disposal by deep well injection (Apache 2012).

15.3.2.4 Wheatstone Project

The Wheatstone Project, operated by Chevron Australia, is currently in the construction phase, and comprises a multi-train LNG Plant at Ashburton North Strategic Industrial Area, on the Western Australian mainland south of Barrow Island. It includes a 225 km subsea pipeline that will link the LNG Plant to the Wheatstone Platform, which will be approximately 100 km north of Barrow Island. The subsea pipeline will intersect with the Fourth Train Proposal and approved Foundation Project Feed Gas Pipeline Systems. Only the atmospheric emissions and the subsea pipeline were included in this cumulative impact assessment because the Wheatstone Platform and the LNG Plant are located outside the Fourth Train Proposal Area.

15.3.2.5 Pluto LNG

Pluto LNG, operated by Woodside, has a subsea gas gathering system that ties back to an approved offshore riser platform located north-east of the Jansz Feed Gas Pipeline, within the Fourth Train Proposal Area (Figure 15-2). The Karratha Processing Plant on the mainland, which is included in this cumulative impact assessment for atmospheric emissions only, processes the LNG.

15.3.2.6 Woollybutt

Woollybutt is a FPSO operated by Eni (Petroleum Exploration Society of Australia [PESA] 2003; Premuda 2005). Woollybutt is more than 50 km south-east of Barrow Island (Figure 15-2). This FPSO is fitted with a detachable single-point mooring system. Produced crude oil is stored in the FPSO’s hull and offloaded via pumps to a trading tanker (Premuda 2005). Stressors with the potential for cumulative impact with the Fourth Train Proposal associated with the Woollybutt FPSO are associated with the marine environment, and are outlined in Table 15-3. Atmospheric emissions from FPSOs are included in the atmospheric emissions assessment.

15.3.2.7 Commercial Fisheries

Commercial fishing (including prawning) in the Fourth Train Proposal Area is managed by both Commonwealth and Western Australian fisheries agencies (Section 6.8.4.2.2). Stressors with the potential for cumulative impact with the Fourth Train Proposal associated with commercial fisheries are associated with the marine environment, and are outlined in Table 15-3.

15.3.2.8 Commercial Shipping

Commercial shipping operations that are not directly associated with any industrial projects in the Fourth Train Proposal Area may have vessels traversing the area, and consequently, these operations have the potential to contribute to cumulative impacts. Shipping operations may exert stress on the marine environment through artificial light, noise and vibration emissions, discharges to sea, physical interaction with marine fauna, and spills and leaks. Shipping activities in ports and channels are considered in the cumulative atmospheric emissions assessment.

15.3.2.9 Future Gas Fields Developed as Part of the Gorgon Project

The Fourth Train Proposal is part of a staged development of the gas fields within the Greater Gorgon Area and Title Areas, as defined in the State Agreement. The GJVs plan to develop additional gas fields as part of the Gorgon Project that do not form part of the approved Foundation Project, and are not part of the approval being sought for the Fourth Train Proposal (Section 4.3.1). These future gas fields are a considered action; therefore, the cumulative impacts of developing these gas fields are included in this cumulative impact assessment.

Additional production wells, subsea infrastructure, and intrafield flowlines are expected to be required to develop these future gas fields. However, no additional Feed Gas Pipeline System is planned, as the hydrocarbons can potentially be evacuated by the approved Foundation Project or Fourth Train Proposal Feed Gas Pipeline Systems. It is anticipated that the hydrocarbons from the future gas fields (Section 4.3.1), would be accommodated within the scope of the currently approved Foundation Project's Carbon Dioxide Injection System as authorised under Section 13 of the *Barrow Island Act 2003* (WA).

15.3.3 Discounted Actions

The following actions were not included in the cumulative impact assessment for the reasons set out below. Areas such as the Kimberley Region of Western Australia were also discounted as they were considered too far away to influence cumulative impacts in the Fourth Train Proposal Area or ambient air quality in the Pilbara Region.

15.3.3.1 Airlie Island

The Airlie Island operation, located south-west of Barrow Island, is licensed to Apache Energy (Apache 2012a) and is understood to no longer be in operation (Department of Industry and Resources [DoIR] 2008; DMP 2011). Pan Pacific Petroleum, an Apache Joint Venture partner, reported that Apache Energy is continuing to review the potential within the production licence (Pan Pacific Petroleum 2011). The current intentions for this project are unknown; therefore, this action was not considered in the cumulative impact assessment.

15.3.3.2 Existing and Future Offshore Discoveries

Gas fields intended to be developed as part of the Gorgon Project that do not form part of the approved Foundation Project and are not part of the approval being sought for the Fourth Train Proposal are included as considered actions in this cumulative impact assessment (Section 15.3.2.9). Other than these gas fields, there are no current proposals to develop existing known but undeveloped resources within the Fourth Train Proposal Area. Surveying is still being carried out and discovery of further resources, in addition to those already discovered in the Fourth Train Proposal Area, is possible. Predictions of likely future activity in the area would be speculative and beyond the scope of this evaluation; therefore, unknown future developments are not included in the cumulative impact assessment.

15.4 Stressors and Factors Considered in the Cumulative Impact Assessment

The identified stressors relevant to the Fourth Train Proposal were the same as those identified for the approved Foundation Project (Section 8.2.2). These identified stressors for the Fourth Train Proposal were considered in terms of their potential to have cumulative impacts in combination with other considered actions. Factors identified and discussed in other assessment sections of this PER/Draft EIS (Sections 9, 10, and 12 to14) were carried forward for assessment within this Section if it was considered that stressors related to the Fourth Train Proposal and relevant considered actions may manifest in cumulative impacts to that factor. Figure 15-3 provides an overview of factors and relevant stressors considered in this cumulative impact assessment.

This cumulative impact assessment does not include spills and leaks in the marine environment. This is because of:

- the low probability of spills and leaks occurring from the Fourth Train Proposal, as discussed in Section 5.7.2.1.3
- the rapid dispersion, dilution, and degradation of any spilled hydrocarbon in the marine environment
- the even lower likelihood of more than one spill occurring sufficiently close to another to have a cumulative impact on the same area of the marine environment at the same time.

Conversely, spills occurring in the terrestrial environment tend to be more persistent over time and therefore are considered in this cumulative impact assessment.

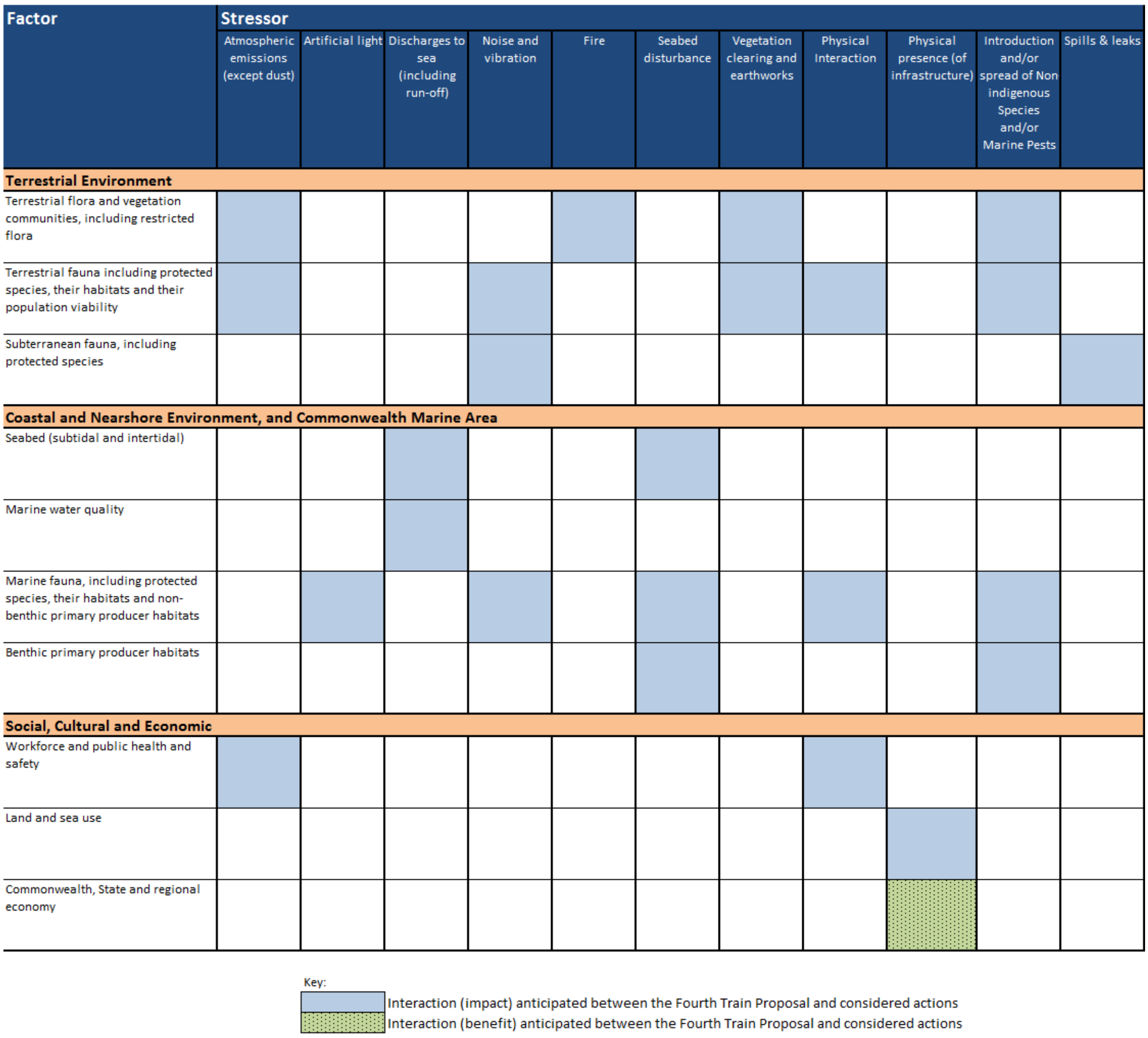

Figure 15-3: Factors and Stressors Relevant to the Cumulative Impacts within the Fourth Train Proposal Area

15.5 Cumulative Impact Assessment and Mitigation and Management

The cumulative impacts of the Fourth Train Proposal incremental impacts combined with the approved Foundation Project and other considered actions in the Fourth Train Proposal Area (or Pilbara Region for cumulative atmospheric emission impacts) on the environmental and social factors identified in Figure 15-3, were considered and are assessed below.

15.5.1 Terrestrial Environment

Except for impacts from atmospheric emissions, which are generated from industry and natural processes throughout the Pilbara Region and which may have impacts on a regional scale, WA Oil and the approved Foundation Project are the only considered actions that could have potential terrestrial cumulative impacts with the Fourth Train Proposal.

15.5.1.1 Flora and Vegetation

Potential cumulative impacts to flora and vegetation may result when stressors from the Fourth Train Proposal (as assessed in Section 9.5) are combined with the Foundation Project and other considered actions. These stressors may include atmospheric emissions, fire, vegetation clearing, and earthworks.

15.5.1.1.1 Atmospheric Emissions

In the absence of Australian ecosystem-specific criteria, potential cumulative impacts to vegetation and flora from atmospheric emissions were assessed based on the World Health Organization (WHO) standards for acid deposition (sulfur and nitrogen) and ozone (WHO 2000). The modelled acid deposition and ozone loads for Barrow Island and the Pilbara Region are within the specified WHO 2000 criteria (Section 5.2). Consequently, no detrimental cumulative impacts to flora and vegetation are anticipated to be attributable to atmospheric emissions.

15.5.1.1.2 Clearing and Earthworks

Clearing and earthworks for the Fourth Train Proposal will be within the allocated uncleared land available for tenure on Barrow Island under the *Barrow Island Act 2003* (WA). This land allocation is already substantially cleared for the approved Foundation Project. The positioning of the uncleared land tenure took into account conservation-significant vegetation and flora on Barrow Island.

Clearing and earthwork activities associated with WA Oil operations include those required to maintain WA Oil infrastructure and the ongoing operation of the Barrow Island Oilfields. Clearing associated with these activities is reduced as much as practicable, and the conservation significance of Barrow Island's flora is taken into account to reduce the impact to areas of particular conservation value.

15.5.1.1.3 Fire

Unplanned fires as a result of the Fourth Train Proposal are expected to be prevented or rapidly extinguished and contained within the Fourth Train Proposal Footprint or its immediate vicinity (Section 9.5.2.4). Foundation Project experience to date is in line with this expectation; recorded fires were almost entirely restricted to the vicinity of Foundation Project equipment or facilities (with only one fire occurring outside the Foundation Project tenure boundary), and were rapidly extinguished. The cumulative risk of occurrence of unplanned fire will be slightly increased as a result of additional higher-risk construction activities associated with the Fourth Train Proposal. However, the cumulative risk is not considered to be substantially above that from the WA Oil operations and the approved Foundation Project activities on Barrow Island owing to the low likelihood of multiple fires from different sources occurring simultaneously, and the effectiveness of existing measures for rapidly controlling and extinguishing fires.

15.5.1.1.4 Predicted Environmental Outcome

Substantial cumulative impacts to flora and vegetation are not expected from the Fourth Train Proposal incremental impacts when combined with the approved Foundation Project and WA Oil operations. This is largely due to the short-term, non-persistent nature of many of the potential impacts following the application of appropriate mitigation and management measures by the Fourth Train Proposal and approved Foundation Project, as described in Section 9.5.4.

The GJVs predict that, with appropriate controls in place on all relevant actions, the potential cumulative impacts to flora and vegetation can be acceptably managed to meet the objectives established for the Fourth Train Proposal and are not expected to compromise Commonwealth and/or State objectives for flora and vegetation as stated within relevant policies, plans, and guidelines (Section 9.5.1.2).

15.5.1.2 Terrestrial Fauna

Potential cumulative impacts to terrestrial fauna, including species listed under Commonwealth and State legislation and their habitats, may result when stressors from the Fourth Train Proposal (assessed in Sections 9.6 and 13.3) are combined with the Foundation

Project and other considered actions. These stressors may include atmospheric emissions, noise and vibration, vegetation clearing and earthworks, and physical interaction.

15.5.1.2.1 Atmospheric Emissions

Cumulative atmospheric emissions modelling for NO_x and O_3 for the Fourth Train Proposal in combination with current industry, future industry, and natural processes in the Pilbara Region did not exceed National Environmental Protection Measure (Ambient Air NEPM; NEPC 2003) values at sensitive ground-level receptors (Table 5-9). Impacts of atmospheric pollutants and air toxics on the terrestrial fauna of Barrow Island are assessed with reference to criteria established in the NEPM, the National Exposure Standards (National Occupational Health and Safety Commission [NOHSC]:1003–1995; as amended – Safe Work Australia [SWA] 1995), and WHO Air Quality Guidelines for Europe (WHO 2000). Air quality concentrations were modelled to be considerably below the relevant critical levels determined to be potentially harmful to terrestrial fauna through inhalation or ingestion. Therefore, cumulative impacts to terrestrial fauna from atmospheric emissions from the Fourth Train Proposal and considered actions are not predicted.

15.5.1.2.2 Noise and Vibration

Onshore anthropogenic noise emissions from the Fourth Train Proposal combined with the approved Foundation Project and WA Oil operations have the potential to change the behaviour, distribution, and communication of terrestrial fauna, including some species protected under Commonwealth and State legislation. Sources of terrestrial noise during construction of the Fourth Train Proposal include blasting, grading, excavating, trenching, levelling, materials offloading, grinding, and erecting (Section 5.4.3.1.2). The primary source of anthropogenic noise during the operations phase of the Fourth Train Proposal (and approved Foundation Project) will be the Gas Treatment Plant (Section 5.4.2.2). Due to the small scale of the WA Oil operations and the isolated location of the WA Oil operations base in the southern central section of Barrow Island, it is assumed that its noise emissions would be substantially less than those generated by the Fourth Train Proposal and approved Foundation Project. Therefore, the combined noise emissions from the Fourth Train Proposal, approved Foundation Project, and WA Oil operations are not anticipated to result in cumulative impacts to terrestrial fauna.

15.5.1.2.3 Vegetation Clearing and Earthworks

Clearing for the Fourth Train Proposal will be within the uncleared land available on Barrow Island for tenure under the *Barrow Island Act 2003* (WA). Where practicable, the Fourth Train Proposal will use land previously cleared as a result of the approved Foundation Project and WA Oil operations (i.e. roads and laydown areas). The small size of the area to be cleared for the Fourth Train Proposal will not make a substantial contribution to cumulative impacts on habitat availability, including habitat for EPBC Act-listed and State-listed species. The Fourth Train Proposal will not contribute substantially to the overall cumulative impact, which will not compromise the population viability of species on Barrow Island (Section 9.6.2.1).

15.5.1.2.4 Physical Interactions

Physical interactions from activities such as vehicle movements or increased risk of entrapment associated with the Fourth Train Proposal may have potential cumulative impacts on terrestrial fauna when combined with the approved Foundation Project and WA Oil operations. However, there are substantially fewer vehicle movements and open excavations associated with WA Oil activities than the approved Foundation Project and Fourth Train Proposal. Therefore, cumulative impacts including WA Oil would not be substantially higher than the additional impacts described in Section 9.6.2.5.

The increased frequency of terrestrial fauna/vehicle interactions and the increased risk of entrapment as a result of the Fourth Train Proposal will be managed by the implementation of the mitigation and management measures outlined in Section 9.6.3. Interactions with fauna are anticipated to be at an individual level and, with appropriate controls in place, cumulative impacts are not expected to affect the population viability of species on Barrow Island.

15.5.1.2.5 Predicted Environmental Outcome

Substantial cumulative impacts to terrestrial fauna, including species and their habitat protected under Commonwealth and/or State legislation, are not expected from the Fourth Train Proposal when combined with the approved Foundation Project and WA Oil operations. This is largely a result of the short-term, non-persistent nature of many of the potential impacts following the application of appropriate mitigation and management measures by the Fourth Train Proposal, as described in Sections 9.6.3 and 13.6.

The GJVs predict that, with appropriate controls in place on all relevant actions, the potential cumulative impacts to terrestrial fauna can be acceptably managed to meet the objectives established for the Fourth Train Proposal and are not expected to compromise Commonwealth and/or State objectives for terrestrial fauna as stated within relevant policies, plans, and guidelines (Section 9.6.1.2).

15.5.1.3 Subterranean Fauna

Potential cumulative impacts to subterranean fauna, including species listed under Commonwealth and State legislation (Appendix E2 [Conservation Significant Species Considered for Assessment in this PER/Draft EIS]), may result when stressors from the Fourth Train Proposal (as assessed in Sections 9.7 and 13.3.2.3) are combined with the Foundation Project and WA Oil operations. These stressors include vibrations and spills and leaks.

Subterranean fauna are more vulnerable to population viability impacts where populations are isolated and occur in non-contiguous distributions. However, there is no evidence of large caves or other large-scale geomorphological features that might create barriers to gene flow between subterranean fauna in the Fourth Train Proposal Footprint and adjacent habitats on Barrow Island.

15.5.1.3.1 Noise and Vibration

Vibrations from the Fourth Train Proposal with the potential to affect subterranean fauna are discussed in Section 9.7.2.4. No substantial disturbance of subterranean fauna habitat is expected as a result of vibrations from the approved Foundation Project construction or operations activities, or with the addition of vibrations from the Fourth Train Proposal. WA Oil operations activities are substantially different to those of the Fourth Train Proposal and approved Foundation Project, comprising occasional drilling with no major construction works planned. The WA Oil activities are also distant from each other. Therefore, vibration emissions from the Fourth Train Proposal are not expected to interact cumulatively (when combined with those from the approved Foundation Project and WA Oil operations) to produce substantial impacts to subterranean fauna or their habitats.

15.5.1.3.2 Spills and Leaks

Large or chronic spills and leaks have the potential to result in contamination of groundwater and soil, which provide important habitat for subterranean fauna. Local contamination of subterranean fauna habitat can potentially result in the reduced health or loss of troglofauna or stygofauna individuals (Section 9.7.2.3).

Generally, impacts from spills and leaks are localised, and the application of mitigation and management measures (Section 9.7.3) are expected to reduce their occurrence during the construction and operation of the Fourth Train Proposal. Any leaks or spills are expected to be contained through design controls (e.g. bunding) and/or timely spill response and clean-up actions. As such, the risk of cumulative impacts from the Fourth Train Proposal in combination with the approved Foundation Project and WA Oil operations is considered to be managed and is unlikely to impact substantial portions of subterranean habitat or to compromise the population viability of subterranean species on Barrow Island.

15.5.1.3.3 Predicted Environmental Outcome

The GJVs predict that, with appropriate controls in place, the potential cumulative impacts to subterranean fauna can be managed to an acceptable level and are not expected to compromise Commonwealth and/or State objectives for the conservation of a protected species, as stated in the relevant policies, plans, and guidelines (Section 9.7.1.2).

15.5.2 Coastal and Nearshore Environment, and Commonwealth Marine Environment

15.5.2.1 Seabed

Potential cumulative impacts to the seabed may result when stressors from the Fourth Train Proposal (as assessed in Sections 10.4and 13.5.7) are combined with the Foundation Project and other considered actions. The primary stressor that may act cumulatively on the seabed is seabed disturbance.

15.5.2.1.1 Seabed Disturbance

Activities with the potential for seabed disturbance include the laying of the Fourth Train Proposal Feed Gas Pipeline System, anchoring marine vessels in the nearshore and offshore environments (State Waters), and discharging drilling fluids and cuttings within the Commonwealth Marine Area. These activities may result in physical and/or chemical modification of the seabed and disturbance to the benthic communities that use the seabed.

Continental slope demersal fish communities and the Exmouth Plateau overlap the Fourth Train Proposal Area; a summary of the values of these features is provided in Table 13-21. However, disturbance and modifications to seabed substrate resulting from pipe-lay or umbilical installation activities associated with the Fourth Train Proposal and considered actions (such as the Foundation Project and Wheatstone) are expected to impact only a small proportion of the available seabed within the Fourth Train Proposal Area. No areas of important benthic primary producer habitat are expected to be modified by the Fourth Train Proposal (Sections 10.4.2 and 15.5.2.4).

The Montebello Commonwealth Marine Reserve is designated as a Multiple Use Area. This Reserve overlaps the ancient coastline at the 125 m depth contour, which is considered a key ecological feature associated with the Commonwealth Marine Area. The Fourth Train Proposal Feed Gas Pipeline System traverses approximately 12 km of this Reserve, which is less than 0.01% of the 3413 km^2 Reserve area (DotE 2013). Activities related to the considered actions (e.g. commercial fishing, petroleum exploration and production) may also cumulatively impact upon this Multiple Use Area (Table 13-20).

If impacts were to occur, they would be minor, occur within a dispersive environment, and only affect a small area in relation to the available area and habitat within the Reserve. Fauna and habitats identified in other areas of the Commonwealth Marine Area associated with the Fourth Train Proposal are not considered unique in the context of the wider North West Shelf. Consequently, the Fourth Train Proposal together with the considered actions is not expected to result in any unacceptable cumulative impacts within the Commonwealth Marine Area (Section 13.5.7.4).

15.5.2.1.2 Predicted Environmental Outcome

The GJVs predict that, with appropriate controls in place on all relevant actions, the potential cumulative impacts to seabed in State Waters and within the Commonwealth Marine Area can be acceptably managed to meet the objectives established for the Fourth Train Proposal and are not expected to compromise Commonwealth and/or State objectives for the seabed as stated within relevant policies, plans, and guidelines (Section 10.4.1.2).

15.5.2.2 Marine Water Quality

Potential cumulative impacts to the marine water quality may result when stressors (including discharges to sea) from the Fourth Train Proposal (as assessed in Sections 10.5 and 13.5) are combined with the Foundation Project and other considered actions. The primary stressor that may act cumulatively on the seabed is discharges to sea.

15.5.2.2.1 Discharges to Sea

Discharges from vessels and drilling rigs operating in Australian waters are governed by MARPOL 73/78 (International Maritime Organization [IMO] 1997) as amended, and the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* (Cth) (Sections 10.5.2.1 and 13.5.5). Discharges typically include domestic marine vessel waste, including deck drainage, sewage and putrescibles, cooling water, reject brine from vessel reverse osmosis units, ballast water, and bilge water.

In the waters surrounding Barrow Island, discharges to the sea from the Fourth Train Proposal when combined with discharges from the approved Foundation Project and WA Oil operations have the potential to result in cumulative impacts. However, discharges to sea resulting from the Fourth Train Proposal are expected to be localised, small in volume relative to the capacity of the receiving environment, and are expected to disperse quickly such that concentrations of contaminants are not expected to affect water quality except close to the discharge location.

Drilling activities from the Fourth Train Proposal within the Commonwealth Marine Area will result in the discharge of drilling cuttings and associated drilling fluids. These discharges will occur in an environment with a high dispersive capacity and therefore any reduction in water quality is not expected to be persistent or widespread. Discharges from drilling activities associated with the Fourth Train Proposal are also expected to be temporally and/or spatially distant from offshore activities related to the considered actions, and would not be expected to interact to produce substantial cumulative impact (Section 13.5.5). Thus, discharges related to drilling activities and/or marine vessels are not expected to result in substantial cumulative impacts on marine water quality.

The Fourth Train Proposal and approved Foundation Project will both discharge reject brine from the Foundation Project reverse osmosis facilities. As illustrated in Figure 4-11, the outfall for these facilities is adjacent to the Materials Offloading Facility. WA Oil discharges its effluents into the sea off the east coast of Barrow Island, including:

- treated sanitary effluent from the wastewater treatment plant, which is discharged via a submarine ocean outfall pipeline located approximately 300 m offshore
- reject brine from the Chevron Australia Camp reverse osmosis facilities, which is discharged via an outfall pipeline approximately 160 m from the Camp into the coastal zone.

Water quality in the vicinity of the Materials Offloading Facility is described in Section 6.4.4.

To assess the potential impact on water quality parameters, interaction between the plumes from the Gorgon Foundation Project temporary and permanent reverse osmosis brine outfalls was modelled with the plume from a potential Foundation Project accommodation vessel located in the tug pen (Section 10.5.2.1.3). The spatial separation of the three facilities' discharge points will result in plumes that are highly localised and do not overlap. As there is approximately 3 km between WA Oil's marine discharge points and those used by the Fourth Train Proposal and the approved Foundation Project, these discharges should not interact to create a cumulative impact.

15.5.2.2.2 Predicted Environmental Outcome

Substantial cumulative impacts to marine water quality are not expected from the Fourth Train Proposal when combined with the approved Foundation Project and other considered actions. This is largely a result of the highly localised nature of impacts, the geographic isolation of some of the discharges (particularly within the Commonwealth Marine Area), the dispersive nature of the marine environment, and the application of appropriate mitigation and management measures by the Fourth Train Proposal, as described in Sections 10.5 and 13.5.5.4.

The GJVs predict that, with appropriate controls in place on all relevant actions, the potential cumulative impacts to marine water quality in State Waters and within the Commonwealth Marine Area can be acceptably managed to meet the objectives established for the Fourth Train Proposal and are not expected to compromise Commonwealth and/or State objectives for marine water quality as stated within relevant policies, plans, and guidelines (Section 10.5.1.2).

15.5.2.3 Marine Fauna

Potential cumulative impacts to marine fauna, including species and their habitats protected under Commonwealth and/or State legislation may result when stressors from the Fourth Train Proposal (as assessed in Sections 10.6 and 13.4) are combined with the Foundation Project and other considered actions. These stressors may include artificial light, noise and vibration, seabed disturbance, and physical interaction.

15.5.2.3.1 Artificial Light

Artificial light emissions in the Fourth Train Proposal Area have the potential to impact certain marine fauna that use light for visual cues to elicit biological responses. The degree of disruption to marine fauna will depend on multiple factors including the number of light sources, the emitting wavelength and intensity of the lights, their location (line of sight), and the operation/use of lighting (Sections 10.6.2.2 and 13.5.4). Marine turtles and migratory birds are considered particularly sensitive to artificial light emissions.

Barrow Island light sources that have the potential to interact cumulatively with the Fourth Train Proposal are those from the approved Foundation Project and WA Oil operations. Other considered actions in the Fourth Train Proposal Area that generate long-term light emissions with the potential to act cumulatively include the operation of the Pluto LNG and John Brookes platforms, the Woollybutt FPSO, and the Varanus Production Area. Transient lighting in the Fourth Train Proposal Area will be generated from marine vessel activities associated with these actions, and from commercial shipping and fishing vessel traffic transiting the area. The contribution of the Fourth Train Proposal to cumulative impacts from vessel lighting in the area will be an additional 60 to 80 vessels each year; these vessels will anchor in the approved designated Barrow Island Anchorage Area (approximately 10 nm east of the LNG Jetty) until they are required at the LNG Jetty. The light emissions from each of these activities are geographically dispersed and/or temporally separated, and are not expected to interact to cause unacceptable cumulative impacts to marine fauna populations.

Light spill generated by WA Oil operations on Barrow Island was taken into account in pre-Foundation Project monitoring of marine turtle activities on the beaches and surrounding waters of Barrow Island and therefore has been incorporated into the baseline used for the assessment of additional impacts (Section 10.6.2.2). Accordingly, the cumulative impacts of the Fourth Train Proposal in combination with the approved Foundation Project and WA Oil light spill are expected to be no greater than the additional impacts assessed in Section 10.6.2.2. This light spill is not anticipated to result in any substantial cumulative impact and is not anticipated to result in unacceptable impacts on marine fauna populations, including species protected under Commonwealth and/or State legislation (Sections 10.6.2.2 and 13.5.4).

The Long-term Marine Turtle Management Plan (Chevron Australia 2014) directs the management of artificial light for the approved Foundation Project, including an adaptive management framework, elements of which will be extended to include the management of artificial light from the Fourth Train Proposal. For additional detail on the Long-term Marine Turtle Management Plan's adaptive management framework, refer to Section 10.6.2.2.4.

15.5.2.3.2 Anthropogenic Marine Noise

Anthropogenic marine noise emissions have the potential to disrupt the behaviour of marine fauna by affecting their acoustic cues related to communication, feeding, orientation, and navigation. The spatial extent of potential impacts depends on a range of factors, including the dominant frequency and intensity of the noise produced, together with environmental factors such as water depth, salinity, and seabed characteristics (Sections 10.6.2.4 and 13.5.6).

Fourth Train Proposal activities that are expected to result in short-term anthropogenic marine noise at levels that have the potential to cause disturbance to marine fauna include offshore drilling (e.g. Vertical Seismic Profiling [VSP]) and construction of the Feed Gas Pipeline System, including construction of the shore crossing. Other considered actions may also emit short-term anthropogenic marine noise in the Fourth Train Proposal Area through similar activities (e.g. drilling or pipeline installation). Marine vessels associated with the Fourth Train Proposal, the approved Foundation Project, and other considered actions may also result in background noise, although these noise emissions will be transitory.

Gas flow in the approved Foundation Project domestic gas pipeline and Feed Gas Pipeline System will be a long-term source of noise in the Fourth Train Proposal Area. Long-term sources of marine anthropogenic noise from other considered actions that may overlap with those of the Fourth Train Proposal include noise generated on existing offshore petroleum infrastructure such as surface platforms, FPSOs, and subsea infrastructure. The Fourth Train Proposal will only produce a small amount of long-term noise, which in combination with the spatially dispersed nature of other considered actions, is not expected to produce a substantial cumulative impact in the Fourth Train Proposal Area.

Certain marine fauna (such as cetaceans) are known to be particularly sensitive to anthropogenic marine noise; however, the expected response to this stressor by these marine fauna is local avoidance. The noise generated by the Fourth Train Proposal when combined with the approved Foundation Project and other considered actions is not expected to result in long-term behavioural changes or direct adverse health effects that could affect the population viability of marine fauna.

15.5.2.3.3 Physical Presence of Infrastructure

Activities that may affect benthic habitats associated with the Fourth Train Proposal, Foundation Project, and other considered actions include the placement of infrastructure such as pipelines, wellheads, and subsea infrastructure on the seabed, the settlement of discharged drilling cuttings and associated fluids onto the seabed, and vessel anchoring (Sections 10.7.2.3 and 13.5.8).

Based on the evidence available, the nearshore benthic habitat off the west coast of Barrow Island is predominantly macroalgal assemblages and infaunal/epifaunal communities on unconsolidated calcarenite sediments. The offshore Commonwealth Marine Area associated with the Fourth Train Proposal Area is generally characterised by relatively low species-richness and abundance. Seabed disturbance associated with the Fourth Train Proposal, the Foundation Project, and other considered actions will occur at different times, allowing time for benthic habitat recovery, other than where permanent structures are placed or where trenching through consolidated or hard substrate is undertaken. Most seabed disturbance impacts will be localised and short term. Consequently, the cumulative impact on marine fauna as a result of seabed disturbance is considered unlikely.

Indirect impacts to marine fauna through changes in habitat are unlikely in both the nearshore and offshore marine environments in the Fourth Train Proposal Area. No important habitats for marine fauna have been identified solely within the Fourth Train Proposal Area.

15.5.2.3.4 Physical Interaction

An increase in marine vessel movements in the Fourth Train Proposal Area may result in an increase in the likelihood of physical interaction, particularly vessel strike, with marine fauna. Marine megafauna of particular concern recorded in the Fourth Train Proposal Area include a number of whale and dolphin species, Dugongs, Whale Sharks, and marine turtles (Sections 10.6.2.6 and 13.5.8). Vessel speed is a key risk factor in marine fauna collisions—the higher the speed, the greater the risk.

Humpback Whales are known to migrate through the Fourth Train Proposal Area between June and October. Similarly, Whale Sharks are known to travel north-east from Ningaloo Reef along the continental shelf and therefore through the Fourth Train Proposal Area between May and June. Thus, an increase in the number of marine vessel movements generated by the Fourth Train Proposal, Foundation Project, and other considered actions during these migration events increases the possibility of physical interaction with Humpback Whales and Whale Sharks. To date, no strikes on marine mammals or sharks have been reported by marine vessels associated with the Foundation Project. If strikes were to occur, they are likely to affect individuals and would not be expected to result in wider population viability impacts.

Dugongs are unlikely to be involved in physical interaction impacts; to date, no vessel strikes on Dugongs have occurred off either the east or west coasts of Barrow Island during the construction of the Foundation Project. If strikes were to occur, they are likely to affect individuals and would not be expected to result in wider population viability effects. Dolphins using shallow waters may be observed during construction of the approved Foundation Project, but vessel strike incidents are not expected as dolphins can change course rapidly.

Green Turtles and Flatback Turtles are known to use Barrow Island for feeding, mating, and nesting. The increase in vessel movements in the Fourth Train Proposal Area as a result of the Fourth Train Proposal, combined with the Foundation Project and other considered actions, may increase the possibility of physical interaction with turtles. Vessel strikes are known to occur occasionally; however, any increase would affect individuals and would not be expected to result in wider population viability impacts.

The application of mitigation and management measures by the Fourth Train Proposal will aim to reduce the potential occurrence of marine fauna strikes. In particular, Marine Fauna Observers will be present on vessels, where required, and vessels will be managed in accordance with port requirements, which include speed management to reduce the risk of vessel interactions with marine fauna.

Marine vessel strike is only expected to occur at the individual level and no substantial cumulative impact on the regional populations of marine fauna is anticipated. The contribution of the Fourth Train Proposal to marine vessel traffic in the Fourth Train Proposal Area during construction will be short term.

15.5.2.3.5 Predicted Environmental Outcome

No substantial cumulative impacts to marine fauna are expected from the Fourth Train Proposal when combined with the approved Foundation Project and other considered actions. This is largely because of the spatial and temporal separation of the considered actions and because any potential impacts are likely to affect individuals rather than have impacts on population viability. The habitat in the Commonwealth Marine Area is expected to be contiguous over the Fourth Train Proposal Area with no unique habitats or species. The considered actions are not expected to create any significant barriers to the movements of mobile marine fauna. In addition, the Fourth Train Proposal will apply mitigation and management measures to reduce its contribution to potential cumulative impacts.

The GJVs predict that, with appropriate controls in place on all relevant actions, the potential cumulative impacts to marine fauna in State Waters and within the Commonwealth Marine Area can be acceptably managed to meet the objectives established for the Fourth Train

Proposal and are not expected to compromise Commonwealth and/or State objectives for marine fauna as stated in relevant policies, plans, and guidelines (Section 10.6.1.2).

15.5.2.4 Benthic Primary Producer Habitat

Potential cumulative impacts to benthic primary producer habitat (BPPH) may result when stressors from the Fourth Train Proposal (as assessed in Section 10.7) are combined with those of the Foundation Project and other considered actions. These stressors may include discharges to sea, seabed disturbance, and physical presence of infrastructure.

BPPH generally only occurs in intertidal and subtidal areas within the photic zone, which roughly corresponds to water depths less than 40 m. In the Fourth Train Proposal Area, this depth is likely to be close to islands (including Barrow Island).

15.5.2.4.1 Seabed Disturbance and Physical Presence of Infrastructure

Seabed disturbance and physical presence of infrastructure from the Fourth Train Proposal are not expected to have any substantial incremental impact on BPPH in the waters surrounding Barrow Island, and these potential incremental impacts are expected to be managed by the measures described in Section 10.7.3. Direct impacts to BPPH from WA Oil are limited to the presence of a 10 km pipeline off the coast of Barrow Island. The use of horizontal directional drilling by the approved Foundation Project reduced potential construction impact to BPPH on the west coast of Barrow Island; the east coast construction impact will be limited to the marine disturbance footprint approved for the Foundation Project. Direct impacts to areas of BPPH by other considered actions in the Fourth Train Proposal Area are also likely to be the result of marine construction (seabed disturbance or physical presence of infrastructure). These disturbances are likely to be highly localised, distant from each other, and represent only a small proportion of the BPPH available in the Fourth Train Proposal Area.

15.5.2.4.2 Discharges to Sea

Discharges to sea from activities other than the Fourth Train Proposal, but occurring in the Fourth Train Proposal Area are likely to be spatially separated and rapidly dispersed into the receiving environment. Therefore these discharges are not likely to act cumulatively with discharges to sea from the Fourth Train Proposal.

15.5.2.4.3 Predicted Environmental Outcome

Substantial cumulative impacts to BPPH are not expected from the Fourth Train Proposal when combined with the approved Foundation Project and other considered actions. Impacts to BPPH from seabed disturbance, physical presence of infrastructure, and discharges to sea are expected to be distant from each other, highly localised, and/or rapidly dispersed.

The GJVs predict that, with appropriate controls in place on all relevant actions, the potential cumulative impacts to BPPH in State Waters and within the Commonwealth Marine Area can be acceptably managed to meet the objectives established for the Fourth Train Proposal and are not expected to compromise Commonwealth and/or State objectives for BPPH as stated within relevant policies, plans, and guidelines (Section 10.7.1.2).

15.5.3 Social, Cultural, and Economic Environment

15.5.3.1 Land and Sea Use

Potential cumulative impacts to land and sea use may result when stressors from the Fourth Train Proposal (as assessed in Sections 13.5.8 and 14.5) are combined with the Foundation Project and other considered actions. The primary stressor that may act cumulatively on the seabed is the physical presence of infrastructure.

15.5.3.1.1 Physical Presence of Infrastructure

Cumulative social impacts from the physical presence of infrastructure associated with land use are not anticipated because of the existing land use restrictions on Barrow Island.

Recreational marine activities and commercial and recreational fishing may be subject to cumulative impacts from the Fourth Train Proposal combined with the Foundation Project and other considered actions in the Fourth Train Proposal Area.

In the marine environment, potential cumulative impacts may arise from the presence of subsea infrastructure, as well as marine vessels and their associated anchors within the nearshore environment and Commonwealth Marine Area associated with the Fourth Train Proposal Area. Stabilisation and/or covering of subsea sections of the Fourth Train Proposal Feed Gas Pipeline System with rock will reduce the potential for interaction (e.g. with demersal fishing activities). Furthermore, during construction of subsea infrastructure for the Fourth Train Proposal, petroleum safety zones (approximately 500 m radius) will be used; although these may restrict fishing and shipping activities, such zones help reduce the potential impacts associated with physical interaction between the Fourth Train Proposal activities and other sea users.

Petroleum safety zones may remain throughout the operations phase of the Fourth Train Proposal, depending on the perceived risk from marine vessel movements to subsea infrastructure. It is unlikely that petroleum safety zones will lead to cumulative impacts on recreational and commercial fishing, marine tourism, and shipping as they are small in scale and number, and spatially separated. Commercial and recreational fishing and marine tourism activities in the Montebello/Barrow Islands Marine Conservation Reserves are limited (Department of Conservation and Environment [DEC] 2007). Given the wide-ranging zones of the fisheries, none of which are confined to the Fourth Train Proposal Area, and the low level of activity for many of the relevant fisheries, a substantial impact to commercial fishing activities is not expected.

15.5.3.1.2 Predicted Environmental Outcome

Substantial cumulative impacts to land and sea use are not expected from the Fourth Train Proposal combined with the approved Foundation Project and other considered actions. This is largely as result of the small scale of the petroleum safety zones and limited activities associated with considered actions in the Fourth Train Proposal Area. In addition, the Fourth Train Proposal will apply appropriate mitigation and management measures to reduce its contribution to potential cumulative impacts.

The GJVs predict that, with appropriate controls in place on all relevant actions, the potential cumulative impacts to land and sea use can be acceptably managed to meet the objectives established for the Fourth Train Proposal and are not expected to compromise Commonwealth and/or State objectives for land and sea use as stated within relevant policies, plans, and guidelines (Section 14.5.1.2).

15.5.3.2 National, State, and Regional Economy

Cumulative impacts from the Fourth Train Proposal combined with the approved Foundation Project and other considered actions to the national, State, and regional economy are anticipated to be positive, with the considered actions in the Fourth Train Proposal Area expected to bring benefits such as increased revenue, employment, training, business development opportunities, and community investment benefits to national, State, and regional communities.

15.6 Conclusion

This assessment evaluates the potential cumulative impacts to which the Fourth Train Proposal may contribute when combined with the approved Foundation Project and other considered actions.

Except for impacts from atmospheric emissions, WA Oil and the approved Foundation Project are the only considered actions that could have potential terrestrial cumulative impacts with the Fourth Train Proposal. Atmospheric emissions are not predicted to have any detrimental cumulative impacts on the Barrow Island or mainland terrestrial environments, as they fall below the relevant criteria. The Fourth Train Proposal combined with the approved Foundation Project and WA Oil operations are not expected to create any substantial cumulative impacts to terrestrial flora, vegetation, terrestrial and subterranean fauna, and habitats on Barrow Island, due to both the nature of the stressors present and the application of appropriate mitigation and management measures by the Fourth Train Proposal. Minimisation of clearing and earthworks will help preserve flora, vegetation, and fauna habitat. The residual impacts contributing to cumulative impact to the terrestrial environment are predicted to be short term and non-persistent.

The coastal and marine environments in the Fourth Train Proposal Area may be subject to potential cumulative impacts from the Fourth Train Proposal combined with the approved Foundation Project and other considered actions (Section 15.3.2). These actions are unlikely to result in substantial cumulative impacts to the intertidal and subtidal area as they are likely to be spatially dispersed and impact only a small area of the available seabed in the Fourth Train Proposal Area. Substantial cumulative impacts to marine water quality are not expected to occur as relevant impacts are highly localised, geographically isolated, and occur within a highly dispersive environment. No substantial cumulative impacts to marine fauna are expected as a result of the spatial and temporal separation of considered actions, the contiguous nature of the habitats in the Fourth Train Proposal Area, and the implementation of mitigation and management measures for the Fourth Train Proposal. Any potential impacts are likely to affect individuals rather than have impacts on population viability. No cumulative impacts to BPPH are expected.

With appropriate controls in place on all relevant actions, potential cumulative impacts to workforce and public health and safety are not expected to compromise Commonwealth or State objectives. Substantial cumulative impacts are not expected on land and sea use owing to the small scale of petroleum safety zones and the limited activities associated with considered actions in the Fourth Train Proposal Area. The cumulative impacts to the national, State, and regional economies are expected to be positive and beneficial.

The contribution of the Fourth Train Proposal to potential cumulative impacts to the marine, terrestrial, and social environments is considered to be managed through the application of appropriate mitigation and management measures.

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Section 16: Table of Contents

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16. Environmental Management Framework

16.1 Introduction

Consistent with their undertaking for the approved Foundation Project, the GJVs are committed to developing the Fourth Train Proposal in an environmentally responsible manner that contributes to the local community's aspiration for sustainable development. This includes continuing to protect the conservation values of Barrow Island; managing all environmental, health, and safety requirements responsibly; and implementing responsible practices throughout all phases of the Fourth Train Proposal.

This section describes the environmental management framework that Chevron Australia, as operator of the Fourth Train Proposal on behalf of the GJVs, intends to implement to address the potential Fourth Train Proposal attributable impacts that have been identified during the impact assessment process in this PER/Draft EIS.

16.2 Environmental Management Framework for the Fourth Train Proposal

Chevron Australia intends to manage the potential impacts predicted in this PER/Draft EIS using the same environmental management framework as that adopted for the approved Foundation Project. Based on experience in implementing the approved Foundation Project to date (Section 16.2.1), the GJVs are confident that this framework has provided, and will continue to provide, an effective method for protecting the environmental and conservation values of Barrow Island and its surrounding waters. Based on the conclusions of the environmental impact assessment presented in Section 5 and Sections 9 to 15, the GJVs essentially propose only minor changes which do not affect the objectives or legal requirements of the Environmental Management Plans (EMPs, collectively defined as statutory Environmental Management and Monitoring Plans, Programs, Systems, Procedures and Reports) prescribed under the Ministerial Conditions. In particular, the changes will not affect the management measures, monitoring programs, performance standards or management triggers in the EMPs. Rather, the changes will simply be to increase the scope of the EMPs' coverage so that they clearly regulate the potential impacts of the Fourth Train Proposal. If the Fourth Train Proposal is approved, the GJVs propose that minor changes are incorporated into the relevant approved Foundation Project EMPs to ensure that these documents also appropriately address the impacts of the Fourth Train Proposal (i.e. revisions to the plans will be made to ensure that incremental and additional impacts from the Fourth Train Proposal are adequately considered). These changes are detailed in Section 16.2.3 and in Table 16-2. It is understood that the Minister will delegate the consultation and review of the proposed revisions to the EMPs to the post-approval branch (Compliance and Enforcement).

The existing environmental management framework developed for and being implemented by the approved Foundation Project is described in Section 3.4, and is illustrated in Figure 16-1. The overarching component of this framework is Chevron Corporation's OEMS. Underneath this sits the Environmental Management and Assessment Program, which incorporates this statutory impact assessment and resultant Ministerial Conditions, and EMPs.

The final tier comprises of a set of Subsidiary Documents, which are either approval documents created to fulfil legal obligations other than the approvals of this PER/Draft EIS, or are internal documents that are not legally binding.

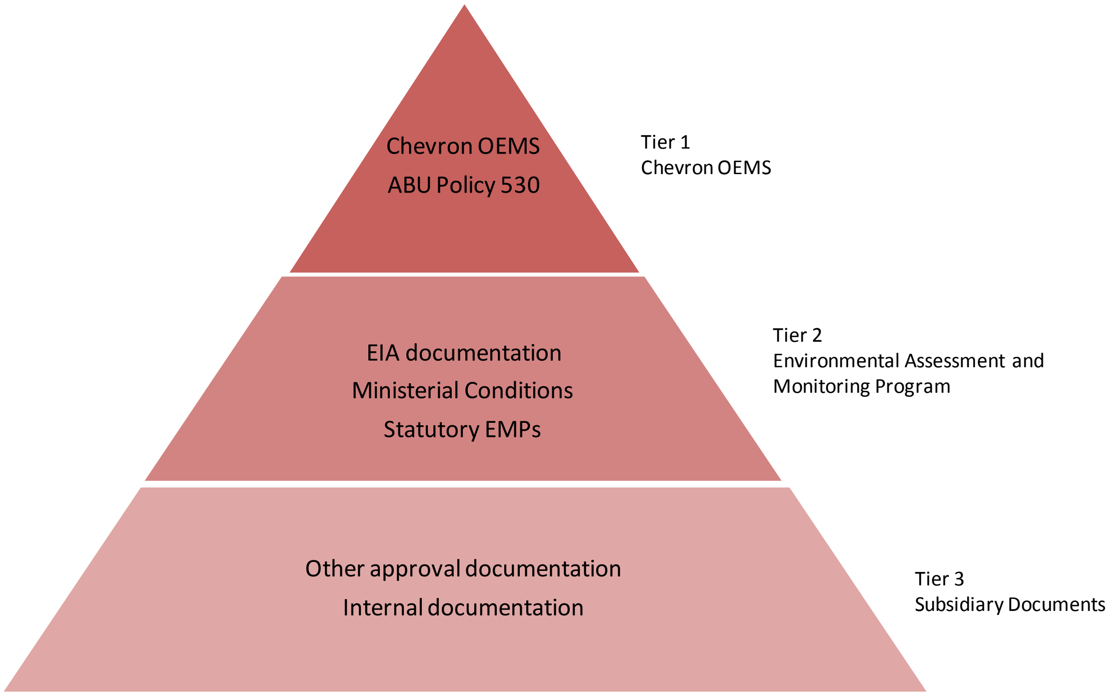

Figure 16-1: Environmental Management Framework

16.2.1 Experience Gained

Adaptive management processes are built in to many of the approved Foundation Project EMPs, as outlined in Section 3.4.2.3.1. The same mechanisms of adaptive management are planned to be used by the EMPs and subsidiary documents when applied to the Fourth Train Proposal. The processes that facilitate adaptive management include experience gained from auditing, inspections and monitoring; improved understanding from implementation of the EMPs; as a result of audit findings or on the basis of recommendations from the Expert Panels.

In many cases, the approved Foundation Project EMPs are designed within an adaptive management framework, with required changes being identified through the ecological monitoring management trigger process, or the incident response process. EMPs (and their Subsidiary Documents) are also updated from time to time to as part of regular ongoing reviews and updates where required by Ministerial Conditions.

When the Foundation Project EMPs are updated to incorporate the Fourth Train Proposal, any adaptive management measures approved up to that time will therefore also apply to the Fourth Train Proposal.

Table 16-1 details Foundation Project experience gained, lessons learnt and adaptive management from activities undertaken to date and results from monitoring data that are relevant to the Fourth Train Proposal. Section 3.5 provides further information about the monitoring programs implemented for the Foundation Project and the results to date.

Table 16-1: Experience Gained from the Foundation Project relevant to the Fourth Train Proposal

Activity	Status[1]	Experience Gained to Date
Offshore Drilling Installation of the Offshore Feed Gas Pipeline System	Offshore production well drilling has commenced for the Gorgon Gas Field and is complete in Jansz–Io gas fields. Offshore pipe-lay preparation works have been completed. The offshore pipe-lay activities, including installation of umbilicals and rock to stabilise the Offshore Feed Gas Pipeline System, are substantially completed.	• Marine vessel based Marine Fauna Observers have implemented mitigation including changes to vessel course, and continued observation. There have been no instances of physical interaction with Giant Manta Rays, Whale Sharks, Dugongs, whales or dolphins attributable to Foundation Project activities (Section 13.4.2). • Auditing found the pre-lay preparation activities at the escarpment for the approved Jansz Feed Gas Pipeline were conducted in line with the Environment Plan and its standards and objectives (Chevron Australia 2011). This included compliance with MARPOL for emissions and discharges, personnel education, and correct recording and reporting of incidents (Chevron Australia 2011). • One Green Turtle hatchling was found deceased after being trapped in the seawater intake system of an offshore pipe-lay vessel. In response to the incident a review of the screen and strainer design was undertaken, consultation with recognised marine turtle subject matter experts within Chevron Australia was undertaken, and an investigation was completed. A review of the management measures for the vessel activity in the area, and other construction activity in the area confirmed that the management measures were being implemented appropriately (Chevron Australia 2012). • Two Level 1 hydrocarbon spills[2] of less than 0.1 L occurred into the marine environment during installation of the Feed Gas Pipeline System. Both spills were assessed against the Offshore Feed Gas Pipeline Installation Management Plan as having no impact (Chevron Australia 2013). An additional Level 1 non-hydrocarbon spill[2] occurred into the marine environment during installation of the Feed Gas Pipeline System. The spill is subject to ongoing monitoring and is not expected to result in any significant impact (Chevron Australia 2013). • Consultation with stakeholders including State and Commonwealth governments, commercial fisheries, and commercial mariners has been regularly undertaken. Consultation with the fishing industry included providing regular updates of marine vessel locations, petroleum safety zones, and proposed activities.

Activity	Status[1]	Experience Gained to Date
Construction of the horizontal directional drilling site and installation of the Feed Gas Pipeline System at the shore crossing.	Construction at the horizontal directional drilling site has been completed.	Onshore Horizontal Directional Drilling • Four Level 1 Spills[2] have occurred onshore. Successful remediation was undertaken, where it was required (Chevron Australia 2012). • Artificial light from construction activities at the Horizontal Directional Drilling site and offshore areas did not result in a significant difference in spread angle or offset angle of emerging hatchlings in the 2011–2012 season, compared to the combined baseline season's data from 2005–2006, 2007–2008 and 2009–2010 (Pendoley Environmental 2012). Beach surveillance of hatchling fan angles during the 2012–2013 hatchling season found no recurrent deviation or significance difference from the baseline in spread or offset angles at Whites Beach (Pendoley Environmental 2013; Chevron Australia 2013). • Narrow band ambient noise levels on the west coast have not increased with construction activities associated with the Foundation Project (SVT Engineering Consultants 2012). Marine Component of the Horizontal Directional Drilling • No significant impacts have occurred to ecological elements including benthic cover, macroalgae and seagrass biomass, and macroinvertebrate species composition and abundance, as a result of horizontal directional drilling activities (Oceanica 2012, 2012a). • Six Level 1 Spills[2] occurred within the Marine Disturbance Footprint (MDF) (Chevron Australia 2012). Five of these spills were a result of frac-outs during drilling activities affecting the seabed. Low-toxicity, water-based drilling fluid, which was used to minimise environmental impacts, was an effective management measure (Chevron Australia 2012). • The observed sediment dispersion plume from drilling break out directional drilling activities was smaller than that predicted by the sediment dispersion modelling (Section 10.4.2.1). • There were no reportable incidents involving harm to marine turtles associated with the horizontal directional drilling site (Chevron Australia 2010, 2011a, 2012, 2013). • The proportion of Green Turtle activity on beaches within a 2 km radius of Foundation Project sites has not changed substantially since the 2008–2009 season (Chevron Australia 2012, 2013).

Activity	Status[1]	Experience Gained to Date
Installation of the Onshore Feed Gas Pipeline System Gas Treatment Plant and associated land-based infrastructure construction	The Onshore Feed Gas Pipeline route has been cleared and the pipeline trench has been excavated. Pipe-lay activities have commenced. Bulk earthworks at the Gas Treatment Plant site have been completed. The modules for the Gas Treatment Plant began arriving on Barrow Island in mid-2012. Construction of the LNG tanks has commenced and is ongoing. Hydrotesting of one LNG tank has been completed. Butler Park (Construction Village) has been completed and is occupied.	• Management of potential construction-related impacts to fauna has been successful, with the following results from the environmental monitoring (Chevron Australia 2012, 2013): ▪ Mammal populations in both 'At Risk' and 'Reference' zones indicates the construction of the Foundation Project to date is not affecting the population viability of the Barrow Island Euro, Spectacled Hare-wallaby, Golden Bandicoot, and the Boodie inside the Foundation Project Terrestrial Disturbance Footprint (TDF). ▪ There has been no evidence to suggest that noise from construction activities is affecting populations of mammals or the White-winged Fairy-wren (Barrow Island). ▪ Similar encounter rates, density estimates, and population estimates for the White-winged Fairy-wren (Barrow Island) were experienced at both the 'At Risk' and 'Reference' zones, suggesting external causal factors. ▪ Monitoring results indicate that Foundation Project activities are not affecting the abundance and distribution of Silver Gulls on Barrow Island. This species is known to respond positively to disturbances that result in increased food availability (e.g. poor waste management). ▪ Monitoring results indicate the Foundation Project activities are not having an adverse effect on the mortality, breeding numbers, or breeding success of the Double and Boodie Island Wedge-tailed Shearwater, and Double and Parakeelya Island Bridled Terns. (Chevron Australia 2012, 2013). There was no variation in nest/burrow density, breeding participation rate, and breeding success rates between islands monitored or between the At Risk and Reference sites. (Chevron Australia 2011b, 2011c, 2012, 2013). ▪ Foundation Project monitoring has shown that nesting Flatback Turtles returned in comparable numbers to Barrow Island beaches despite increases in light emissions during construction (Chevron Australia 2011d). ▪ Monitoring results for marine turtles (nesting and hatchlings) currently show no Project-attributable changes to nesting or hatchling behaviour outside normal inter-annual variations (Pendoley 2012). The Flatback Turtle Nest Success Program found hatch success on Barrow Island was significantly higher in the 2012 nesting season compared to the baseline seasons (2006–2007 to 2008–2009). • Disturbing/breaking up termite mounds prior to site clearance has been successful in initiating egress of fauna. Fauna found residing in termite mounds during destructive searches are relocated to nearby uncleared areas of appropriate comparable habitat (Section 9.6.2.8.4). • Boodie warrens close to major Foundation Project infrastructure showed continued levels of high activity and occupancy, with no significant lowering of Boodie numbers at warrens within At Risk zones during 2012 monitoring (Chevron Australia 2013). • An individual of the subterranean fauna species, the Barrow Cave Gudgeon, was identified from a

Activity	Status[1]	Experience Gained to Date
		sampling bore at the Administration and Operations Complex, which had been subject to construction activities of the Foundation Project. This indicates that construction activities may not have affected this species. • The mitigation and management measures to protect fauna are regularly reviewed to identify and address possible gaps and or implement improvements, and to take into account changes, such as natural fluctuations in mammal populations and monitoring results. Adaptive management implemented in response to fauna fatalities from vehicle interactions includes the inclusion of In-Vehicle Monitoring Systems to monitor vehicle speeds, erecting signage in areas identified as potential fauna-interaction hotspots, and incorporating these locations into driver education (Section 9.6.2.5). • There was no significant difference observed in any parameters between vegetation within the Foundation Project (TDF and vegetation outside the TDF (Chevron Australia 2012, 2013). • Rainfall, rather than dust, is most likely the main factor affecting the health of plants (Chevron Australia 2012, 2013). Plant health did not significantly differ with distance from dust source (pairwise comparisons of distance from the dust source were not statistically significant) (Table 8-4). • One Foundation Project-attributable fire was recorded outside the TDF but was managed through existing management measures and responses (Section 9.5.2.4). A post fire investigation identified that blasting is a fire-risk activity and therefore appropriate procedures to manage this risk need to be adhered to (i.e. Hot Works Permit, and Job Hazard Analysis). • 21 small fires have occurred within the TDF (Chevron Australia 2012, 2013). Existing measures were effective in quickly extinguishing the fires and restricting them to Foundation Project equipment or facilities. An investigation and review of procedures relating to fire-risk activities identified lessons learnt, including improved identification of fire hazards (Chevron Australia 2012, 2013). • Spills and leaks at the Gas Treatment Plant site were contained in the hardstand area (unsealed and sealed) and the spill procedures were effective in preventing environmental impacts (Section 9.3.2.2). • Perimeter bunding at the Gas Treatment Plant site has been effective in capturing run-off and sediment. From the surface water landform monitoring, no significant impact on surface water landforms is apparent (Chevron Australia 2012, 2013). • Vibration monitoring data collected between 2009 and 2012 from the east and west coast of Barrow Island has not detected any increasing trend in vibration levels from construction activities near vibration monitoring locations (SVT Engineering Consultants 2012).

Activity	Status[1]	Experience Gained to Date
Quarantine	The Quarantine Management System (QMS) has been developed and implemented.	• No introduced Non-indigenous Terrestrial Species or Marine Pests and no proliferations of existing weeds or new weed establishment as a result of the Foundation Project have occurred on Barrow Island (Section 12.4). • Level 2 Incidents[3] occurred in the 2010, 2011, and 2013 reporting periods, and Level 1 Incidents occurred in the 2011, 2012, and 2013 reporting periods, although all incidents were eliminated at the time of detection (Chevron Australia 2010, 2011a, 2012, 2013). As a result of these incidents and observations from implementation of the QMS, responses, such as the following, were made: ▪ training modules were updated and personnel involved in the delivery of training were advised to adjust the presentation of training ▪ operating procedures, surveillance methods, and risk zones were reviewed and updated ▪ pest control practices were reviewed ▪ initiatives to raise awareness were undertaken ▪ additional surveillance strategies were explored ▪ increased surveillance was implemented at certain equipment ▪ additional surveillance sites and a new Weed Hygiene Zone were introduced ▪ baiting and trapping programs were implemented ▪ Quarantine Species Action Plans were developed ▪ Improvements to perimeter fencing were made. • There were no Level 2 Quarantine Incidents in the 2012 reporting period and no Level 1 Incidents[3] in the 2010 reporting period (Chevron Australia 2010, 2012). • No Level 3 Quarantine Incidents[3] have occurred (Chevron Australia 2010, 2011a, 2012, 2013). The QMS is continually reviewed, audited, and updated. It has effectively managed quarantine risks and is suitable for the Fourth Train Proposal.

1. *Status: Reflects the status of Foundation Project activity at the end of the reporting period (9 August 2013) of the Environmental Performance Report 2013 (Chevron Australia 2013).*
2. *Level 1 Spill: 20 to 795 L of hydrocarbon to land, less than 15.9 L of hydrocarbon to water, or a chemical spill of 20 to 160 kg*
   Level 3 Spill: more than 7950 L of hydrocarbon to land, more than 159 L of hydrocarbon to water, or a chemical spill of more than 8000 kg
3. *Level 1 Quarantine Incident:*
   i. *The detection of a confirmed Non-indigenous Species on freight, people, vessels or aircraft, after final quarantine clearance, within the Quarantine Terrestrial Controlled Access Zone and confined to the Quarantine Terrestrial Controlled Access Zone.*
   ii. *Declaration of a quarantine incident is subject to positive identification of a suspect specimen as Non-indigenous Species.*
   iii. *The detection of species in the Limited Access Zone where the invasive risk of such species is assessed to be low.*
   iv. *Records of new populations of existing weed species on Barrow Island due to Gorgon Project activities (proliferation of existing weeds).*

   Level 2 Quarantine Incident:
   i. *The detection of a confirmed Non-indigenous Species in the Quarantine Terrestrial Limited Access Zone on Barrow Island except where the species assessed to be low risk (refer to Level 1)*

ii. Declaration of a quarantine incident is subject to positive identification of a suspect specimen as Non-indigenous Species.

Level 3 Quarantine Incident:

i. The detection of a confirmed NIS in the Quarantine Terrestrial Restricted Access Zone on Barrow Island, except where the species are assessed to be low risk (refer to Level 1)

ii. Declaration of a quarantine incident is subject to positive identification of a suspect specimen as Non-indigenous Species

The detection of NIS in any Access Zone on BWI where the invasive risk of such species is assessed to be high.

These EMPs (and their Subsidiary Documents) are also updated from time to time to reflect any changing circumstances, experience, and lessons learnt from ongoing Foundation Project construction and monitoring activities. This may occur as part of regular ongoing reviews and updates where required by Ministerial Conditions, as a result of audit findings or on the basis of recommendations from the Expert Panels. When the Foundation Project EMPs are approved to incorporate and manage the environmental impacts of the Fourth Train Proposal, any adaptive management measures approved up to that time will therefore also apply to the Fourth Train Proposal.

16.2.2 Tier 1 –Operational Excellence Management System and Chevron Policy

Tier 1 of the Environmental Management Framework comprises Chevron Corporation's OEMS and ABU Policy 530 (Sections 1.7.2 and 1.7.3), which are central to the implementation of the OEMS in Australia (Chevron Corporation 2009).

The OEMS, as currently being implemented for the approved Foundation Project, will be extended to cover the Fourth Train Proposal. This includes extending and/or revising the following aspects of the OEMS for the approved Foundation Project to incorporate the Fourth Train Proposal:

- organisational responsibilities
- documentation for implementing and maintaining the OEMS system, including relevant system implementation, maintenance, and monitoring procedures
- operational control mechanisms, including environmental mitigation and management commitments and environmental approval requirements
- legislative and regulatory controls, including legal and commitment registers and permit tracking mechanisms
- contractor requirements
- internal and external reporting requirements, including incident reporting mechanisms
- staff induction and training processes
- environmental monitoring programs
- stakeholder engagement
- auditing and compliance management processes, including non-conformance and corrective action procedures
- emergency preparedness and response framework and processes; including the management of facilities in the event of cyclones or other severe weather events.

In addition, adequate budgets and resources will be provided by the GJVs to enable effective implementation of the OEMS for the Fourth Train Proposal.

16.2.3 Tier 2 – Environmental Assessment and Monitoring Program

Tier 2 of the Environmental Management Framework incorporates both this Environmental Impact Assessment (EIA) process for the Fourth Train Proposal and the key environmental management documents, including Ministerial Conditions and statutory EMPs.

16.2.3.1 EIA Documentation

The Fourth Train Proposal is required to meet both Chevron Corporation's corporate governance requirements and Commonwealth and State Government regulatory requirements. The principal document of this assessment for the Fourth Train Proposal is this PER/Draft EIS. This PER/Draft EIS sets out the basis for which regulatory approval is sought under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Western Australian *Environmental Protection Act 1986* (EP Act).

16.2.3.2 Ministerial Conditions

On approval of the Foundation Project, the Commonwealth and State Ministers for Environment imposed a series of Ministerial Conditions, as described in Section 3.4.2.1.

The Fourth Train Proposal is not expected to pose any substantial, new, different, or additional impacts compared to the approved Foundation Project. The GJVs believe that the existing Foundation Project Ministerial Conditions effectively manage the environmental aspects of the Foundation Project. The GJVs believe that the conditions consistent with the Foundation Project will also effectively manage the environmental impacts of the Fourth Train Proposal, except for Condition 27 from Statement No. 800, which requires a Greenhouse Gas Abatement Program. Given recent changes in Commonwealth and Western Australian policy regarding the regulation of greenhouse gas emissions, discussed in Section 11.1 and in particular the Western Australian Government's document Adapting to our Changing Climate (DEC 2012), a requirement for a Greenhouse Gas Abatement Program is no longer warranted and is not proposed for the Fourth Train Proposal.

16.2.3.2.1 Commonwealth Conditions

The potential impacts of the Fourth Train Proposal on matters of National Environmental Significance (NES) are anticipated to be managed through the extension of the Foundation Project's existing environmental management framework discussed in this section. The Foundation Project's existing Ministerial Conditions regulate several aspects that are relevant to the EPBC Act controlling provisions of the Fourth Train Proposal. These aspects are described in detail in Section 13.6. The key aspects are summarised below and include:

- prevention of, and response to, hydrocarbon spills and leaks occurring as a result of the drilling[23] of production wells and the installation of the Feed Gas Pipeline System in the Commonwealth Marine Area (e.g. Conditions 16 and 16A of EPBC Reference: 2003/1294 and Condition 1 of EPBC Reference: 2005/2184 details requirements for the installation of the Offshore Gas Pipeline and management of the Offshore Impacts)
- operational atmospheric emissions and the reduction of emissions and thereby associated impacts on the controlling provisions
- management and monitoring of potential impacts on listed threatened terrestrial species and their communities through various EMPs and a monitoring program for the Carbon Dioxide Injection System to identify seepage of injected carbon dioxide to environments
- management and monitoring of potential impacts on listed threatened and migratory coastal and marine species and their communities through various EMPs, identification of sensitive marine habitats in the Commonwealth Marine Area, plans requiring specific measures to mitigate, manage, and monitor potential impacts on cetaceans and marine turtles in the Commonwealth Marine Area, and the establishment of a Marine Turtle Expert panel to oversee marine turtle monitoring and management
- prevention and management of the introduction of Non-indigenous Terrestrial Species and Marine Pests through implementation of a Terrestrial and Marine Quarantine Management System
- management of potential impacts on the Commonwealth Marine Area associated with the construction of offshore facilities in the Commonwealth Marine Area (Conditions 16A and 16B of EPBC Reference: 2003/1294 and Conditions 1 and 2 of EPBC Reference: 2005/2184)[24].

[23] Given the establishment of the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) on 1 January 2012, it is acknowledged that this condition may be changed for the Fourth Train Proposal and the requirement with respect to drilling activities covered under a Subsidiary Document requiring NOPSEMA approval.

[24] Given the establishment of the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) on 1 January 2012, it is acknowledged that this condition may be changed for the Fourth Train Proposal and the requirement with respect to drilling activities covered under a Subsidiary Document requiring NOPSEMA approval.

These existing management mechanisms reflect the objects and principles of the EPBC Act, including the adoption of a conservative approach where potential impacts to matters of NES are not fully understood or are unknown. The GJVs essentially propose only minor changes which do not affect the objectives or legal requirements of the EMPs prescribed under the Ministerial Conditions. In particular, the changes will not affect the management measures, monitoring programs, performance standards or management triggers in the EMPs. Rather, the changes will simply be to increase the scope of the EMPs' coverage so that they clearly regulate the potential impacts of the Fourth Train Proposal.

In addition to Commonwealth Ministerial conditions and the EMPs required under those conditions, Subsidiary Documents will also be used to manage potential impacts associated with the Fourth Train Proposal. These subsidiary documents will include Environment Plans required under the *Offshore Petroleum and Greenhouse Gas Storage Act and Offshore Petroleum and Greenhouse Gas Storage Regulations 2009* (Cth), which will be developed for Fourth Train Proposal activities (e.g. drilling) within the Commonwealth Marine Area). Further detail on matters of NES through the implementation of relevant EMPs is provided in Section 13.6.

16.2.3.2.2 State Conditions

The potential impacts of the Fourth Train Proposal on matters relevant to the EP Act are anticipated to be managed through the extension of the Foundation Project's existing environmental management framework discussed in this section. The Foundation Project's existing Ministerial Conditions regulate several aspects that are relevant to the protection of the environment under State legislation from the potential impacts of the Fourth Train Proposal. These aspects include:

- operational atmospheric emissions and the reduction of emissions and thereby associated potential impacts on the environment and protected species
- management and monitoring of protected species of flora and fauna, and environmental factors (such as ground water level and coastal stability) through various EMPs
- prevention and management of the introduction of Non-indigenous Terrestrial Species and Marine Pests through implementation of a Terrestrial and Marine Quarantine Management System, and establishment of a Quarantine Expert Panel
- management of potential impacts on marine water quality and the seabed in State waters from dredging, marine construction and pipe installation activities, and establishment of a Construction Dredging Environmental Expert Panel
- management and monitoring of impacts to the terrestrial and subterranean environment and protected species of flora and fauna from the construction of the Gas Treatment Plant and Horizontal directional Drilling, through various EMPs.

16.2.3.2.3 Applicability to the Fourth Train Proposal

These existing management mechanisms reflect the objects and principles of the EPBC Act and the EP Act, including the adoption of a conservative approach where potential impacts to matters of NES, or matters protected under the EP Act are not fully understood or are unknown. The GJVs essentially propose only minor changes which do not affect the objectives or legal requirements of the EMPs prescribed under the existing Ministerial Conditions, except for Condition 27 from Statement No. 800 requiring a Greenhouse Gas Abatement Program. Due to changes in the regulatory regime governing greenhouse gas emissions (Sections 11.1.2.4and 11.1.3), this abatement program is not proposed for the Fourth Train Proposal.

The proposed changes will not affect the management measures, monitoring programs, performance standards or management triggers in the EMPs. Rather, the changes will simply be to increase the scope of the EMPs' coverage so that they clearly regulate the potential impacts of the Fourth Train Proposal.

16.2.3.3 Statutory EMPs

EMPs required under the Ministerial Conditions for the approved Foundation Project detail the specific actions and responsibilities to address environmental impacts of the approved Foundation Project. Further detail on the EMPs for the Foundation Project is provided in Section 3.4.2 and Table 3-1.

Based on the conclusions of the environmental impact assessment presented in Section 5 and Sections 9 to 15, the GJVs propose to apply, the same mitigation and management measures, performance objectives and management triggers, and subject to the same objectives and legal requirements as contained in the most recent approved Foundation Project EMPs. If the Fourth Train Proposal is approved, the GJVs propose that minor changes are incorporated into the relevant approved Foundation Project EMPs to ensure that these documents also appropriately address the impacts of the Fourth Train Proposal. The proposed amendments to incorporate the Fourth Train Proposal were developed based on the current approved revisions of Foundation Project EMPs that are in force when construction is proposed to commence on the Fourth Train Proposal.

Table 16-2 describes in more detail the changes required to the EMPs for the Foundation Project that are relevant to the Fourth Train Proposal. This table also includes hyperlinks to the current approved revisions of Foundation Project EMPs that are required to be made publicly available under Ministerial Conditions. Two new plans are proposed to be developed for the horizontal directional drilling activities and the offshore feed gas pipeline installation, covering the Fourth Train Proposal activities, locations, and potential impacts. These plans will need to be prepared and approved. Management of the installation of the Feed Gas Pipeline will be implemented through an Offshore Feed Gas Pipeline Installation Management Plan to meet Ministerial Conditions (if required) and/or an Environment Plan to meet State and Commonwealth Petroleum (Environment) Regulations (Section 16.2.4.3). Refer to Table 3-1 for the scope, objectives, and current status of the Foundation Project EMPs.

The primary amendments that will be required to be made to the Fourth Train Proposal EMPs will be to increase their scope so that they regulate the potential impacts of the Fourth Train Proposal. This will include:

- revise the project description to include Fourth Train Proposal elements (facilities and activities)
- update the Approvals section to include Fourth Train Proposal approval
- update details of stakeholder consultation
- review standards and best-practice guidelines referred to, to ensure applicability to the Fourth Train Proposal
- revise risk assessments to include risks as identified in this PER/Draft EIS
- update risk assessments to use the revised Chevron Australia risk assessment process, as used in PER/Draft EIS, if required
- update risk assessment section in accordance with assessment undertaken in the PER/Draft EIS; updates will include adaptive management measures as detailed in Section 16.2, and will consider Foundation Project experience gained prior to submission of the EMPs
- amend Reference and At Risk sites so that the monitoring program incorporates the Fourth Train Proposal
- update to reflect the interaction between Foundation Project operations and Fourth Train Proposal construction (if relevant)
- update government department and agency names, as required
- review the Deliverable Development, Review, and Approval Flow Chart

- review planned activities to ensure they are relevant to the Fourth Train Proposal scope.

These amendments will not affect the objectives or legal requirements of the EMPs prescribed under the Ministerial Conditions, and are not expected to affect the management measures, performance standards, or management triggers in the EMPs.

Other amendments may also be made to EMPs based on experience gained from implementing, auditing, and reviewing the Foundation Project EMPs. The EMPs are expected to be revised to improve the definition of the EMP scope and simplify the usability of the environmental management framework, as well as individual EMPs. Other changes could include a shift in focus from being facility- or infrastructure-focused to being activity-focused, and improving the auditability of measures contained in the EMPs.

It is expected that Ministerial Conditions imposed on the Fourth Train Proposal will require the EMPs to be approved or endorsed, as necessary, from the Commonwealth DotE and the Western Australian OEPA.

Table 16-2: Approved Foundation Project EMPs Relevant to the Fourth Train Proposal

Approved Foundation Project EMPs[1]	Jurisdictional Requirement		Relevant Fourth Train Proposal Scope	Proposed Amendments to Approved Foundation Project EMPs for the Fourth Train Proposal[2]
	Cth	State		
Terrestrial and Subterranean Baseline State and Environmental Impact Report	X	X	Construction and operation of the following terrestrial facilities: • additional facilities at the Gas Treatment Plant • additional Onshore Feed Gas Pipeline System Use of the following approved Foundation Project terrestrial facilities: • Carbon Dioxide Injection System • associated Terrestrial Infrastructure forming part of the Foundation Project	• Update the definition and map of the pre-development baseline state for the ecological elements within the areas that are expected to be, or may be, at risk of Material or Serious Environmental Harm to include any works associated with the Fourth Train Proposal terrestrial facilities. • Revise and define the Terrestrial Disturbance Footprint to create a Combined Gorgon Gas Development footprint. • Define and map the ecological elements within the revised Terrestrial Disturbance Footprint. • Define and map the ecological elements which are at risk of Material or Serious Environmental Harm due to construction or operation of the terrestrial facilities. • Consideration of Fourth Train Proposal data on the baseline biological, physical, and chemical variables including any significant relationships, for the ecological elements. • Review the construction-related stressors considered in determining the Terrestrial Disturbance Footprint for the Fourth Train Proposal (or Combined Gorgon Gas Development).

Approved Foundation Project EMPs[1]	Jurisdictional Requirement		Relevant Fourth Train Proposal Scope	Proposed Amendments to Approved Foundation Project EMPs for the Fourth Train Proposal[2]
	Cth	State		
Terrestrial and Subterranean Environment Protection Plan and associated procedures, including • Fauna Handling and Management Common User Procedure	X	X	Construction and operation of terrestrial facilities, and use of approved Foundation Project terrestrial facilities as described in the Terrestrial and Subterranean Baseline State and Environmental Impact Report	• Update erosion control measures for Class 3 and Class 4 drainage systems to reflect measures that were effective in the Foundation Project. • Revise prevention of sediment run-off: to reflect Class 3 and 4 drainage systems are already installed. • Review clearing procedures for applicability due to the restricted clearing required for the Fourth Train Proposal. • Update to postpone the rehabilitation of the Foundation Project sites, where required by the Fourth Train Proposal. • Review performance standards in line with the Fourth Train Proposal Project Description. • Update stormwater drainage system design in line with basis of design for Fourth Train Proposal.
Terrestrial and Subterranean Environment Monitoring Program	X	X	Construction and operation of terrestrial facilities, and use of approved Foundation Project terrestrial facilities as described in the Terrestrial and Subterranean Baseline State and Environmental Impact Report	• Review the terrestrial and subterranean ecological elements that will be monitored on Barrow Island for the Fourth Train Proposal. • Review the construction monitoring programs given the scope of the Fourth Train Proposal. • Review the location of the 'Reference' and 'At Risk' Sites to the Combined Gorgon Gas Development and associated Terrestrial Disturbance Footprint.* • Review the frequency of the monitoring and the sampling intensity given the environmental performance, changes in environmental risks, changes in business conditions, and any relevant emerging environmental issues. • Review the integrated framework within which the Terrestrial and Subterranean Environment Monitoring Program has been designed.

Approved Foundation Project EMPs[1]	Jurisdictional Requirement		Relevant Fourth Train Proposal Scope	Proposed Amendments to Approved Foundation Project EMPs for the Fourth Train Proposal[2]
	Cth	State		
Terrestrial and Marine Quarantine Management System (QMS) and associated Procedures • Non-indigenous Species Management Procedure • Weed Hygiene Common User Procedure	X	X	Construction and operation of terrestrial facilities and use of approved Foundation Project terrestrial facilities as described in the Terrestrial and Subterranean Baseline State and Environmental Impact Report. Construction and operation of the following marine facilities: • additional Offshore Feed Gas Pipeline System (in State Waters only) Use of the following approved Foundation Project marine facilities: • Materials Offloading Facility • LNG Jetty • marine upgrade of the existing West Australian Petroleum Pty Ltd. (WAPET) Landing	• Update to reflect current status of terrestrial and marine facilities. • Update Section 2.1.5 [Areas Impacted for Seismic Data Acquisition] to indicate that seismic surveys have been undertaken, and provide an approximate timeline for future surveys.
Fire Management Plan	X	X	Construction and operation of terrestrial facilities, and use of approved Foundation Project terrestrial facilities as described in the Terrestrial and Subterranean Baseline State and Environmental Impact Report	• Review and if necessary update the fire TDF.

Approved Foundation Project EMPs[1]	Jurisdictional Requirement		Relevant Fourth Train Proposal Scope	Proposed Amendments to Approved Foundation Project EMPs for the Fourth Train Proposal[2]
	Cth	State		
Coastal and Marine Baseline State and Environmental Impact Report: Feed Gas Pipeline and the Marine Component of the Shore Crossing **Coastal and Marine Baseline State and Environmental Impact Report** (Materials Offloading Facility, LNG Jetty, Dredge Spoil Disposal Ground, and WAPET Landing)		X	Construction and operation of the following marine facilities: • additional Offshore Feed Gas Pipeline System (in State Waters only) • marine component of the shore crossing • alterations to the LNG Jetty (if required) Use of the following approved Foundation Project marine facilities: • Materials Offloading Facility • LNG Jetty • WAPET Landing	• Update the baseline to incorporate the Fourth Train Proposal Area. • Revise and define the Marine Disturbance Footprint to create a Combined Gorgon Gas Development footprint. • Review the location of the monitoring sites and at risk sites given changes to the revised MDF for the Combined Gorgon Gas Development.
Long-term Marine Turtle Management Plan	X	X	Construction and operational activities related to these terrestrial facilities: • additional facilities at the Gas Treatment Plant Use of the following approved Foundation Project marine facilities: • Materials Offloading Facility • LNG Jetty • marine upgrade of the existing WAPET Landing	• Review and if necessary update the proposed marine construction activities to compare against the Barrow Island marine turtle breeding cycle calendar to consider the potential for interaction between marine turtles at Barrow Island and Fourth Train Proposal activities.
Marine Facilities Construction Environmental Management Plan	X	X	Construction activities related to these marine facilities: • Materials Offloading Facility • LNG Jetty • Marine component of the Barge (WAPET) Landing upgrade	• Review and if necessary update the proposed marine construction activities.

Approved Foundation Project EMPs[1]	Jurisdictional Requirement		Relevant Fourth Train Proposal Scope	Proposed Amendments to Approved Foundation Project EMPs for the Fourth Train Proposal[2]
	Cth	State		
Horizontal Directional Drilling Management and Monitoring Plan	X	X	Horizontal directional drilling shore crossing activities for the Fourth Train Proposal from the onshore horizontal directional drilling site at North Whites Beach, Barrow Island, to the tail end of the inserted horizontal directional drilling pipeline	• A new plan will be produced for the Fourth Train Proposal. However, the GJVs anticipate that the mitigation and management measures included within the Foundation Project Horizontal Directional Drilling Management and Monitoring Plan will also be applicable to and will prevent and manage any potential impact to relevant environmental factors, including protected species, as a result of the Fourth Train Proposal. • Update the environmental aspects and impact risk assessment, the associated management and mitigation measures, based on the contracted construction vessels, and monitoring requirements to incorporate the Fourth Train Proposal horizontal directional drilling activity.
Offshore Feed Gas Pipeline Installation Management Plan	X	X	Construction activities associated with the installation of the Feed Gas Pipeline System	• A new plan will be produced for the Fourth Train Proposal. This plan may be an Offshore Feed Gas Pipeline Installation Management Plan to meet Ministerial Conditions (if required) and/or an Environment Plan to meet State and Commonwealth Petroleum (Environment) Regulations. The plan will be aligned with NOPSEMA and DMP objectives and requirements.
Marine Environmental Quality Management Plan		X	Operational activities that have the potential to affect the marine environmental quality in the Barrow Island Port area and any other areas of State Waters (except as outlined within the Objectives)	• Plan not yet developed or approved for the Foundation Project. • Depending on the timing of the submission of this EMP for approval for the Foundation Project, this EMP will cover and be submitted for approval for the Combined Gorgon Gas Development, or, if approved for Foundation Project, this EMP will be revised accordingly for the Fourth Train Proposal.

Approved Foundation Project EMPs[1]	Jurisdictional Requirement		Relevant Fourth Train Proposal Scope	Proposed Amendments to Approved Foundation Project EMPs for the Fourth Train Proposal[2]
	Cth	State		
Reservoir Carbon Dioxide Injection Monitoring Program	X	X	Monitoring the injection of reservoir CO_2 during operation of the Fourth Train Proposal	• Program not yet developed or approved for the Foundation Project. • Depending on the timing of the submission of this EMP for approval for the Foundation Project, this EMP will cover and be submitted for approval for the Combined Gorgon Gas Development, or, if approved for Foundation Project, this EMP will be revised accordingly for the Fourth Train Proposal.
Best Practice Pollution Control Design Report[3]		X	Major sources of atmospheric pollutants and air toxics related to the start-up and operation of the additional Gas Treatment Plant facilities on Barrow Island	• Update the process description to account for the Fourth Train Proposal Gas Treatment Plant. • Include demonstration of best-practice pollution control measures from the Fourth Train Proposal Gas Treatment Plant. • Update the base emissions rates to include the Fourth Train Proposal Gas Treatment Plant.
Air Quality Management Plan[4]		X	Atmospheric pollutants and air toxics emissions associated with the start-up, commissioning, and operation of the additional Gas Treatment Plant facilities on Barrow Island	• Update the process description to account for the Fourth Train Proposal Gas Treatment Plant. • Update the atmospheric pollutant emission sources, Air Quality Modelling Studies, and assessment of modelling results. • Assess risk of Material or Serious Environmental Harm to flora, vegetation communities, fauna, and subterranean fauna on Barrow Island.
Solid and Liquid Waste Management Plan	X	X	Construction and operation of terrestrial facilities, and use of approved Foundation Project terrestrial facilities as described in the Terrestrial and Subterranean Baseline State and Environmental Impact Report	• Revise predicted waste streams to incorporate the Fourth Train Proposal. • Remove the management of dredged spoil as there is no dredging for the Fourth Train Proposal.

Approved Foundation Project EMPs[1]	Jurisdictional Requirement		Relevant Fourth Train Proposal Scope	Proposed Amendments to Approved Foundation Project EMPs for the Fourth Train Proposal[2]
	Cth	State		
Reverse Osmosis Brine Disposal via Ocean Outfall Environmental Management and Monitoring Plan	X	X	Extending duration of the disposal of reject reverse osmosis brine by temporary ocean outfall	• Extend the duration of use of the Foundation Project temporary marine outfall to cover the Fourth Train Proposal construction period. • Update the Environmental Impact Assessment based on the PER/Draft EIS to reflect the extended duration. • Review the Monitoring Program to reflect any changes to risks and impacts.
Aboriginal Cultural Heritage Management Plan		X	Construction and operation of terrestrial facilities, and use of approved Foundation Project terrestrial facilities as described in the Terrestrial and Subterranean Baseline State and Environmental Impact Report	• Update references to the project activity. • Review and if necessary update the findings of surveys completed to encompass the Combined Gorgon Gas Development Terrestrial Disturbance Footprint.
Post-Construction Rehabilitation Plan and sub-Plan • **Topsoil Management Plan**		X	Sites disturbed as part of the construction of the additional facilities at the Gas Treatment Plant and the additional Onshore Feed Gas Pipeline System and areas within the Terrestrial Disturbance Footprint, but which are not required for the future construction and operation of the Fourth Train Proposal	• Update topsoil volumes for the Fourth Train Proposal. • Review timeframe for the rehabilitation of the Foundation Project sites. • Review training and induction requirements for Fourth Train Proposal.
Project Site Rehabilitation Plan		X	Decommissioning activities related to the terrestrial areas described under the Post-Construction Rehabilitation Plan	• Plan not yet developed or approved for Foundation Project. • Depending on the timing of the submission of this EMP for approval for the Foundation Project, this EMP will cover and be submitted for approval for the Combined Gorgon Gas Development, or, if approved for Foundation Project, this EMP will be revised accordingly for the Fourth Train Proposal.

Approved Foundation Project EMPs[1]	Jurisdictional Requirement		Relevant Fourth Train Proposal Scope	Proposed Amendments to Approved Foundation Project EMPs for the Fourth Train Proposal[2]
	Cth	State		
Decommissioning and Closure Plan	X	X	Decommissioning activities related to the terrestrial and marine infrastructure facilities	• Plan not yet developed or approved for Foundation Project. • This EMP will cover and be submitted for approval for the Combined Gorgon Gas Development, or, if approved for Foundation Project, this EMP will be revised accordingly for the Fourth Train Proposal.

Note: The Greenhouse Gas Abatement Program as required by Foundation Project State Ministerial Conditions is discussed in Section 11.3.

1 The underlined EMPs are hyperlinks to the relevant current approved revision Foundation Project EMPs on Chevron Australia's website. The EMPs that are not underlined or hyperlinked are not yet approved by the Government as they are not yet required or are currently being prepared.

2 These proposed amendments are based on the current approved revision of the Foundation Project EMPs. Other amendments to these EMPs may be approved under the Foundation Project from time to time. This should not affect the types of amendments required by the Fourth Train Proposal, as these other amendments must meet the objectives and specific requirements of the Ministerial Conditions and be approved.

3, 4 As per requirements of the Ministerial Conditions, the Report was developed to the satisfaction of the Western Australian DEC (now DER) and submitted with the Works Approval, and approved as part of the Works Approval for the Gas Treatment Plant (W5178/2012/1).

** The Terrestrial Disturbance Footprint is determined from the update of the Terrestrial and Subterranean Baseline State and Environmental Impact Report*

16.2.4 Tier 3 – Subsidiary Documents

Subsidiary Documents will be developed for the implementation of the Fourth Train Proposal; these may include:

- approval documentation, which is required under legislation and/or which imposes relevant legal obligations on Chevron Australia, but which is not legally binding under the Ministerial Approval of the EPBC Act and EP Act
- internal documentation, which is required for Chevron Australia’s internal purposes but which is not legally binding under legislation.

16.2.4.1 Other Approval Documentation

With the exception of this PER/Draft EIS, no other environmental impact assessment approvals and requirements under the EPBC Act or under Part IV of the EP Act are anticipated to be needed for the Fourth Train Proposal. However, approval documentation for the Fourth Train Proposal will be developed to satisfy other regulatory requirements. A list of key additional Commonwealth and State approvals that may be required for the Fourth Train Proposal after approval of this PER/Draft EIS is provided in Table 16-3. These approval documents will be submitted to the relevant regulatory agencies for approval when and if required, independent of the submission of this PER/Draft EIS.

Investigation works have been undertaken to assist in the route selection of the offshore pipelines for the Fourth Train Proposal; an Environment Plan for this offshore geotechnical and geophysical survey was submitted by the company engaged to undertake the survey, and accepted by NOPSEMA. No other specific approvals have been sought for the implementation of the Fourth Train Proposal at the time of submission of this PER/Draft EIS. A number of existing Gorgon Foundation approvals may be amended in future to incorporate the Fourth Train Proposal.

The sections below contain additional detail on some approvals which may be required for the Fourth Train Proposal.

Table 16-3: Key Subsequent Approvals that may be required for the Fourth Train Proposal

Approvals	Associated Statutes
Access Authorities	*Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth)
Approval to Dispose of Carbon Dioxide by Injection	*Barrow Island Act 2003* (WA)
Australian Industry Participation Plan	*Customs Tariff Act 1995* (Cth)
Authority to Excavate, Disturb or Alter Cultural Heritage Sites	*Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth) *Aboriginal Heritage Act 1972* (WA)
Building Permits	*Building Act 2011* (WA)
Dangerous Goods Licences	*Dangerous Goods Safety Act 2004* (WA) Dangerous Goods Safety (Storage and Handling of Non-Explosives) Regulations 2007 (WA)
Development Approval	*Planning and Development Act 2005* (WA) Shire of Ashburton Town Planning Scheme No. 7
Development Proposals	Gorgon Gas Processing and Infrastructure Project Agreement (Schedule 1 to the *Barrow Island Act 2003* [WA])

Approvals	Associated Statutes
Offshore Drilling Approvals including Environment Plans (includes Oil Pollution Emergency Plan and Oil Spill Contingency Plan) and safety cases	*Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth) Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth)
Pipeline Approvals including Environment Plans (includes Oil Spill Contingency Plan) and safety cases	*Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth) Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth) *Petroleum (Submerged Lands) Act 1982* (WA) Petroleum (Submerged Lands) (Environment) Regulations 2012 (WA) *Petroleum Pipelines Act 1969* (WA) Petroleum Pipelines (Environment) Regulations 2012 (WA)
Barrow Island Land Tenure	*Land Administration Act 1997* (WA) *Barrow Island Act 2003* (WA) Gorgon Gas Processing and Infrastructure Project Agreement (Schedule 1 to the *Barrow Island Act 2003* [WA])
Licence to Operate	*Environmental Protection Act 1986* (WA) Environmental Protection Regulations 1987 (WA)
Major Hazard Facility Safety Report	*Dangerous Goods Safety Act 2004* (WA) Dangerous Goods (Major Hazard Facilities) Regulations 2007 (WA)
Pipeline Licenses	*Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth) *Petroleum Pipelines Act 1969* (WA) *Petroleum (Submerged Lands) Act 1982* (WA)
Production Licence	*Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth)
Works Approval	*Environmental Protection Act 1986* (WA) Environmental Protection Regulations 1987 (WA)

16.2.4.2 Development Proposals

Schedule 1 to the *Barrow Island Act 2003* (WA) requires the submission of development proposals for various matters associated with the project on Barrow Island. The GJVs obtained approval for the Foundation Project under Schedule 1 in September 2009. The GJVs will be required to submit additional development proposals under Schedule 1 for the Fourth Train Proposal. The proposals will be submitted to the Minister for State Development (as the Barrow Island Act Minister) for approval. The Minister is unable to approve the proposals until environmental approval is in place, under Part IV of the *Environmental Protection Act 1986* (WA).

16.2.4.3 Environment Plans

Environment Plans are used to regulate to the environmental management of petroleum exploration and production activities. Environment Plans are typically required for activities including drilling petroleum wells, and installing and operating petroleum pipelines, and are required in both Commonwealth and State jurisdiction. The Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth) require an Environment Plan, including an Oil Pollution Emergency Plan, to be approved by NOPSEMA for petroleum activities in Commonwealth Waters. In the State jurisdiction, Environment Plans and associated Oil Spill Contingency Plans are assessed by the DMP.

Environment Plans are intended to set appropriate performance objectives and standards, as well as measurement criteria for these petroleum activities (NOPSEMA 2012; DMP 2012). Oil Pollution Emergency Plans and Oil Spill Contingency Plans, which may form part of the

Environment Plan, are intended to set out appropriate responses in the case of an oil spill (NOPSEMA 2012a; DMP 2012).

Approved Environment Plans for activities in both State and Commonwealth Waters by the Fourth Train Proposal will be required to be in place before commencement of petroleum construction or operations activities.

16.2.4.4 Works Approvals and Licences

Works Approvals and Licenses under Part V of the *Environmental Protection Act 1986* (WA) are required for the construction, alteration and operation of a range of types of premises with the potential to pose significant environmental risks. These 'prescribed premises' are defined in the Environmental Protection Regulations 1987 (WA), and include 'premises on which crude oil, condensate or gas is refined or processed' (Category 34, Schedule 1, Environmental Protection Regulations 1987 [WA]), as well as other categories that may apply to the Fourth Train Proposal. As such, a Works Approval for the construction (or alteration), and a Licence for the operation, of the Fourth Train Proposal are required under the *Environmental Protection Act 1986* (WA).

Other new Works Approvals and Licenses for infrastructure and activities may be required to support the Fourth Train Proposal, and Foundation Project Works Approvals or Licenses may also need to be amended to cater for Fourth Train Proposal activities. These new or amended Works Approvals and Licences may be required for abrasive blasting, sewage treatment, waste treatment, screening of material, power generation, chemical storage, gas production and refining. These approvals will be in place before commencement of either construction or operations activities (as appropriate) of the Fourth Train Proposal.

16.2.4.5 Safety Cases and Safety Reports

Safety cases are required under Commonwealth and State petroleum legislation for various petroleum construction and operational activities similar to the petroleum legislation Environment Plan regime. For example, prior to the construction of a pipeline, a safety case must be accepted by the relevant authorities (DMP and NOPSEMA) and prior to the operation of a pipeline a Safety Case must also be accepted by the relevant authorities (DMP and NOPSEMA). A Major Hazard Facilities Safety Report must also be submitted to DMP for approval for a Major Hazard Facility under the Dangerous Good Safety (Major Hazard Facilities [MHF]) Regulations 2007. The Safety Report for the Foundation Project will need to be amended to cover the Expansion Project prior to operation of the additional LNG train.

16.2.4.6 Reservoir CO_2 Disposal

Under Section 13 of the Barrow Island Act 2003 (WA), a person must obtain an Approval to Dispose of CO_2 by injection into a subsurface formation beneath Barrow Island. A Section 13 approval for the Foundation Project was granted to the GJVs in September 2009. To inject additional CO_2 from the Fourth Train Proposal, the GJVs will seek the necessary approvals under the Barrow Island Act.

16.2.4.7 Internal Documentation

Chevron Australia requires its contractors and suppliers to implement a document management system that fully embraces the policies and objectives of the OEMS and to develop and implement their own, activity- and/or site-specific EMPs, procedures, work method statements, etc. These internal documents are not legally binding under legislation, but build on and reflect the environmental protection measures contained within the EMPs for the Foundation Project, as described in Section 3. The internal documentation will manage environmental impacts specifically related to the Fourth Train Proposal's various works programs, and will build on and reflect the mitigation and management measures contained within the EMPs described in Table 16-1.

16.3 Environmental Offsets

As part of the assessment phase, the Commonwealth DotE and the Western Australian EPA consider the requirement for environmental offsets under the EPBC Act (Cth) and EP Act (WA) respectively. Environmental offsets are a component in the Western Australian and Commonwealth Governments' broader approach to the environment. Under the respective governments' offsets policies, environmental offsets will be used as a last resort, after due consideration of avoidance and mitigation measures, and only as measures to compensate for environmental impacts that cannot be adequately reduced through avoidance or mitigation. Only after all reasonable avoidance and mitigation measures have been identified will an offset be considered, as avoidance and mitigation can reduce and, in some cases, remove the need for offsets. As detailed in Section 16.2.1, the Fourth Train Proposal will use experience gained from the Foundation Project to validate the predictions of no significant impacts. Based on the performance of the approved Foundation Project to date, the GJVs are confident that the existing environmental management framework is sufficient.

The policies also make clear that offsets will not be applied to minor environmental impacts; they are only able to be proposed for significant, adverse, residual impacts.

The GJVs have a clear objective in the development of the Fourth Train Proposal to avoid, minimise, rectify, and restore/remediate potential impacts associated with the Fourth Train Proposal. This approach is consistent with the Commonwealth and State Government's Environmental Offsets Policies. The Fourth Train Proposal has been designed to avoid, prevent or reduce the potential for unacceptable adverse impacts. The GJVs are confident that residual incremental and additional impacts can be acceptably managed within the context of the existing Foundation Project environmental management framework such that they are acceptable and the objectives established for this assessment are met. Therefore, the Fourth Train Proposal has been assessed to have no unacceptable residual impacts and thus no environmental offsets are considered to be required.

16.4 Net Conservation Benefits

Under the varied Clause 11 of Schedule 1 to the *Barrow Island Act 2003* (WA), the GJVs have agreed to pay AU$60 million (indexed) in instalments to fund Net Conservation Benefits for a 15 MTPA LNG development. Using the Net Conservation Benefits funding, four conservation projects have been established by DPaW to date (Section 3.6.3).

Net Conservation Benefits are defined in the *Barrow Island Act 2003* (WA) as 'demonstrable and sustainable additions to, or improvements in, biodiversity conservation values of Western Australia targeting, where possible, the biodiversity conservation values affected or occurring in similar bioregions to Barrow Island'.

16.5 Conclusion

The GJVs are committed to protecting the environmental and conservation values of Barrow Island and its surrounding waters during the construction, operation, and future decommissioning of the Fourth Train Proposal. To assist in meeting this commitment, the GJVs intend to extend the environmental management framework that has been successfully established and implemented for the approved Foundation Project. This includes management of the potential impacts of the Fourth Train Proposal, in combination with those of the approved Foundation Project, through the OEMS and the approved Foundation Project EMPs (with changes to those EMPs to increase the scope of the EMPs coverage so that they clearly regulate the potential impacts of the Fourth Train Proposal).

The GJVs consider that the required amendments described in Section 16.2 and Table 16-1 will not result in a change to the illustrative measures applicable to the approved Foundation Project, and are minor amendments necessary to incorporate the Fourth Train Proposal activities and infrastructure.

Based on the performance of the approved Foundation Project to date, the GJVs are confident that the implementation of this environmental management framework will achieve the goal of protecting the environmental and conservation values of Barrow Island and its surrounding waters for current and future generations.

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17. Terms and Acronyms List

The following acronyms and abbreviations are commonly used in the Fourth Train Proposal Public Environmental Review / Draft Environmental Impact Statement.

µg.N/L	Micrograms of nitrogen per litre
µg.P/L	Micrograms of phosphorus per litre
µg/m^3 (at normal conditions)	Micrograms per cubic metre; 1 µg/m^3 = one millionth of a gram per cubic metre of air (referenced to a temperature of 0 degrees Celsius and an absolute pressure of 101.325 kilopascals)
µm	Micrometre; 1 µm = 10^{-6} metre = 0.000001 metre, or one millionth of a metre
µPa	Micro pascal
Abiotic	Non-living chemical and physical factors in the environment
ABS	Australian Bureau of Statistics
ABU	Australasia Business Unit
Acceptably Low Risk	A risk that is judged to be not greater than ‘a slight chance of infection’ after final quarantine clearance, as per the community Standards for Acceptable Risk published in the Final EIS/ERMP for the Proposed Gorgon Development. The interpretation of this qualitative statement is informed by the large body of evidence of such judgements made by independent experts in quarantine hazard risk assessments of all pathways.
Acute	Rapid effect due to short-term exposure; usually of short duration
Adaptive Management	A systematic process for continually improving policies and practices by learning from the outcome of previously used policies and practices
Additional	Refers to the total emissions, discharges, wastes, impacts, likelihood, or risk due to the Fourth Train Proposal when added to that of approved Foundation Project
Additional Support Area	Gorgon Gas Development Additional Construction, Laydown and Operations Support Area; use of additional uncleared land for the Gorgon Gas Development as approved under Ministerial Implementation Statement No. 965 and regulated through variations to EPBC References: 2003/1294 and 2008/4178.

Additive Impact	Where a particular factor is affected by more than one stressor from the Fourth Train Proposal or Foundation Project or both
AEMT	(Chevron Australia's) Asset Emergency Management Team
AFMA	Australian Fisheries Management Authority
AHD	Australian Height Datum; a geodetic datum for altitude measurement in Australia; it is the agreed sea level
AIP	Australian Industry Participation
Air Toxics	As described in the National Environment Protection (Air Toxics) Measure ; includes benzene, formaldehyde, benzo(a)pyrene (as a marker for polycyclic aromatic hydrocarbons), toluene, and xylenes (as total of ortho, meta and para isomers)
ALARP	As Low As Reasonably Practicable; a level of risk that is not intolerable, and cannot be reduced further without the expenditure of costs that are grossly disproportionate to the benefit gained
Ambient Air	As described in the National Environment Protection (Ambient Air Quality) Measure, ambient air is considered the external air environment, and does not include the air environment inside buildings or structures.
Ambient Air NEPM	National Environment Protection (Ambient Air Quality) Measure
a-MDEA	Activated methyldiethanolamine
AMOSC	Australian Marine Oil Spill Centre
AMOSPlan	Australian Marine Oil Spill Plan
AMSA	Australian Maritime Safety Authority
Anoxic	The absence or deficiency of oxygen
Anthropogenic	Derived or originating from human beings
ANZECC	Australian and New Zealand Environment and Conservation Council
APASA	Asia-Pacific Applied Science Associates
APCI	Air Products and Chemicals Inc
API	Assessment on Proponent Information; for the Gorgon Gas Development Additional Construction Laydown and Operations Support Area Assessment on Proponent Reference Category A dated December 2013

APPEA	Australian Petroleum Production and Exploration Association
Areal Cover, areal coverage	A measure of dominance that defines the degree to which above-ground portions of plants cover the ground surface
ARI	Assessment on Referral Information; for the proposed Jansz Feed Gas Pipeline dated September 2007
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
Aromatic Hydrocarbon	A hydrocarbon that contains one or more benzene rings with alternating double and single bonds between carbon atoms. Aromatic hydrocarbons can be monocyclic or polycyclic.
AS	Australian Standard
As far as practicable, where practicable, practicable	All mean reasonably practicable have regard to, among other things, local conditions and circumstances (including costs) and to the current state of technical knowledge
Assemblage	A taxonomic subset of a community
Atmospheric Emissions	Any emission or discharge to air, for any period of time, of solid, liquid or gaseous matter; examples include, but are not limited to, dust and atmospheric pollutants
Atwood (company)	Atwood Oceanics Pacific Pty Ltd
AU$	Australian dollar
Backshore	The inland limit of the nearshore area that may be subject to inundation, although infrequently, during extreme tides or weather events
Ballast Water	Water held within tanks or cargo holds on a marine vessel; used to regulate the vessel's draft and its stability
Barrow Island Act	*Barrow Island Act 2003* (WA)
Bathymetry	Measurement of water depth and the study of floor topography
BBG (company)	Bowman Bishaw Gorham
Bedform	A depositional feature on the bed of flowing water that is formed by the movement of the bed material due to the flow
Benthic	Living upon the surface or within the sea floor sediment substrate

Benthic Habitats	Areas of the seabed that support living organisms; examples include limestone pavement, reefs, sand, and soft sediments
BIAs	Biologically Important Areas; 'spatially and temporally defined areas where protected species display biologically important behaviours (including breeding, foraging, resting, or migration), based on the best available scientific information. Parts of a marine region particularly important for the conservation of protected species' (as defined by the Department of Sustainability, Environment, Water, Population and Communities)
BICC	Barrow Island Coordination Council
Bioaccumulation	A substance becoming concentrated inside the cells of living organisms
Biocide	Any substance that can destroy living organisms
Bioregion	A region defined by physical and biological characteristics of the natural environment (e.g. oceanography, climate) rather than by man-made divisions
Biotic	Of or relating to living organisms
Bioturbation	The displacement and mixing of sediment particles by benthic fauna (animals) or flora (plants)
Black Start	The process of starting the Gas Turbine Generators from a complete shutdown using diesel generators
Blowout Preventer	A device consisting of valves and hydraulic jaws used to stop an uncontrolled escape of gas during the drilling process
BOD	Biological Oxygen Demand
BOG	Boil-off Gas; vapours produced as a result of heat input and pressure variations that occur within various LNG storage and offloading operations stages
BOM	Australian Bureau of Meteorology
Bombora	Raised, dome-shaped, limestone feature, >1 m high, often formed by coral of the genus Porites
Bonn Convention	Convention on the Conservation of Migratory Species of Wild Animals 1979
BP	Before (the) Present

BPPH	Benthic Primary Producer Habitats; defined in the EPA Environmental Assessment Guidelines No. 3 as 'functional ecological communities that inhabit the seabed within which algae (e.g. macroalgae, turf, and benthic microalgae), seagrass, mangroves, corals, or mixtures of these groups are prominent components. Benthic Primary Producer Habitats also include areas of seabed that can support these communities.'
Bq	Becquerel; unit of radioactivity
Broadscale	Broad in extent, range, or effect
Broadscale vegetation	A higher level grouping of vegetation units or regional ecosystems
Brownfield	A development that occurs within an existing approved development
BTEX	Benzene, Toluene, Ethylbenzene and Xylene compounds
Bund	An area of containment, such as a dam, wall, or other artificial embankment
C_1	Methane
C_2	Ethane
C_3	Propane
C_4	Butane
C5+	A hydrocarbon consisting of five or more carbon atoms (pentane or larger)
Calcarenite	Rock formed by the percolation of water through a mixture of calcareous shell fragments and quartz sand causing the dissolved lime to cement the mass together
CALM	Former Western Australian Department of Conservation and Land Management (now DEC)
CALM Act	*Conservation and Land Management Act 1984* (WA)
CAMBA	China–Australia Migratory Bird Agreement
Carbon Dioxide (CO_2) Injection System	The mechanical components required to be constructed to enable the injection of reservoir carbon dioxide, including but not limited to compressors, pipelines, and wells
Carbon pricing scheme	*Clean Energy Act 2012* (Cth) and associated Acts
CDEEP	Construction Dredging Environmental Expert Panel
CEFAS	Centre for Environment Fisheries and Aquaculture Science

Cetacean	Various aquatic (mainly marine) mammals of the order Cetacea, (including whales, dolphins, and porpoises) characterised by a nearly hairless body, front limbs modified into broad flippers and a flat notched tail
CFC	Chlorofluorocarbon
CFI	Carbon Farming Initiative
CFI Act	*Carbon Credits (Carbon Farming Initiative) Act 2011* (Cth)
CH_4	Methane
Chevron	Chevron Corporation
Chevron Australia	Chevron Australia Pty Ltd
Chevron Australia Camp	Shared accommodation facility, which consists of a main camp, operations workforce accommodation, recreational facilities, power generation facilities, reserve osmosis plant, wastewater treatment facilities, and car parks
Claypan	A dense, relatively impervious subsurface soil layer with a higher clay content than that of the overlying material from which it is separated by a sharply defined boundary
Clean Energy Act	*Clean Energy Act 2011* (Cth)
Cluster Manifold	A subsea arrangement of a manifold and adjacent production wells drilled from a single rig location
CMS	Convention on the Conservation of Migratory Species of Wild Animals 1979 (commonly known as the Bonn Convention)
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
COAG	Council of Australian Governments
Coamings	A rail used to contain potential spills and leaks from a given area (e.g. machinery space)
Combined Gorgon Gas Development	The combined Foundation Project and the future Fourth Train Proposal (if approved)
Combined Gorgon Gas Development Footprint	Consists of the areas of cleared and uncleared land on Barrow Island that will be required for the construction and operation of the approved Foundation Project and the construction and operation of the Fourth Train Proposal

Combined Gorgon Gas Development MDF	Combined Gorgon Gas Development Marine Disturbance Footprint; the area to be disturbed by construction or operations activities associated with the Marine Facilities of the Fourth Train Proposal and the approved Foundation Project; *see also* Foundation Project Marine Disturbance Footprint
Commensal	A form of symbiosis in which one organism derives a benefit while the other is unaffected
Commonwealth Marine Area	As defined in Section 24 of the EPBC Act, the Commonwealth Marine Area comprises: • any waters of the sea inside the seaward boundary of the exclusive economic zone (except waters, rights in respect of which have been vested in a State by section 4 of the *Coastal Waters (State Title) Act 1980* [Cth] or in the Northern Territory by section 4 of the *Coastal Waters (Northern Territory Title) Act 1980* [Cth]; and waters within the limits of a State or the Northern Territory) including its seabed and airspace • any waters over the continental shelf (except waters, rights in respect of which have been vested in a State by section 4 of the *Coastal Waters (State Title) Act 1980* [Cth] or in the Northern Territory by section 4 of the *Coastal Waters (Northern Territory Title) Act 1980* [Cth]; and waters within the limits of a State or the Northern Territory), including its seabed and airspace
Commonwealth Marine Environment	A Controlling Provision for the Fourth Train Proposal under the EPBC Act; encompasses the Commonwealth Marine Area associated with the Fourth Train Proposal Area
Concrete Mattress	Structure used in the protection, support, and stabilisation of subsea structures and pipelines
Consequence	The implication of the potential impact on a factor(s)
Considered Action	Present, and reasonably foreseeable future actions that have the potential to impact the environment in a similar manner to the Fourth Train Proposal
Controlling Provision	A term used in the EPBC Act to denote elements of the environment, protected under the EPBC Act, that justify why a development proposal is a Controlled Action under the EPBC Act. When a proposal is referred to the Commonwealth Minister for Environment and is determined to be a Controlled Action, his/her decision must detail the Controlling Provisions applicable to that proposal.
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cth	Commonwealth of Australia

Cumulative Impact	Potential incremental impacts of the Fourth Train Proposal when combined with the approved Foundation Project and other present and reasonably foreseeable future actions
DAA	Western Australian Department of Aboriginal Affairs
DAFF	Commonwealth Department of Agriculture, Fisheries and Forestry
Datum	A point, plane, or surface to which systems of measurement are referred or related to one another
dB	Decibel; a unit to measure sound
dB re 1 µPa	Decibels relative to one micro pascal; the unit used to measure the intensity of an underwater sound
dB re 1 µPa at 1 m	Decibels relative to one micro pascal; the unit used to measure the intensity of an underwater sound, with the measurement taken one metre away from the noise source
dB(A)	Decibel; a unit to measure sound with an 'A' weighted filter
DEC	Former Western Australian Department of Environment and Conservation (now DPaW and DER)
Declared Plant	A plant belonging to a class of plants declared under section 35 of the *Agricultural and Related Resources Protection Act 1976* (WA) and includes (a) any part of such a plant; and (b) the product of such a plant
DEH	Former Commonwealth Department of Environment and Heritage (now DotE)
Demersal	Living on the seabed or just above it
DER	Western Australia Department of Environment Regulation (formerly DEC)
DEWHA	Former Commonwealth Department of the Environment, Water, Heritage and the Arts (now SEWPaC)
DFAT	Commonwealth Department of Foreign Affairs and Trade
Different	An emission, discharge, waste, or impact predicted for the Fourth Train Proposal that was not relevant or assessed for the approved Foundation Project
Direct Impact	As defined in SEWPaC's Tailored Guidelines, an impact that occurs as a direct result of the Fourth Train Proposal (e.g. change in air quality due to air emissions generated by the Fourth Train Proposal)

Distance Sampling	A method for estimating the density and/or abundance of biological populations
Diurnal	Occurring or active during the daytime rather than at night; occurring every 24 hours
DMA	Decision Making Authorities
DMP	Western Australian Department of Mines and Petroleum (formerly DoIR)
DO	Dissolved Oxygen
DoIR	Former Western Australian Department of Industry and Resources (now DMP)
DoT	Western Australian Department of Transport
DotE	Commonwealth Department of the Environment (formerly SEWPaC)
DP	Dynamic Positioning; a computer-controlled system to automatically maintain a marine vessel's position and heading by using the vessel's propellers and thrusters
DPaW	Western Australian Department of Parks and Wildlife (formerly DEC)
Draft EIS	Draft Environmental Impact Statement
DRDL	Western Australian Department of Regional Development and Lands (formerly part of the Department for Planning and Infrastructure)
Drilling Cuttings	Any material removed from a borehole while drilling wells
Drilling Fluid	A fluid circulated through the borehole during drilling and workover operations to remove rock cuttings made by the drill. Drilling fluid also helps to cool the bit, prevent the sides of the borehole from caving, and controls the flow of rock fluids into the borehole.
DSD	Western Australian Department of State Development
Earthworks	The movement or removal of dirt, rocks, and soil; includes activities such as levelling, grading (removing topsoil), scraping, digging, creating embankments, and creating stockpiles
Ecological Community	All the interacting organisms living together in a specific habitat
EEO Act	*Energy Efficiency Opportunities Act 2006* (Cth)
EIA	Environmental Impact Assessment

EIS	Environmental Impact Statement
EIS/ERMP	The Environmental Impact Statement/Environmental Review and Management Programme for the Proposed Gorgon Gas Development dated September 2005 as amended or supplemented from time to time
Elasmobranches	Cartilaginous fishes (i.e. skeleton made of cartilage rather than bone); includes sharks, rays, and skates
EMP	Environmental Management Plan; a document that describes the specific environmental risks, mitigation and management measures, monitoring requirements, and implementation responsibilities associated with a particular activity, site, or environmental factor. In the context of this PER/Draft EIS, the term EMP refers to the Environmental Management and Monitoring Plans, Environment Plans, Programs, Systems, Procedures and Reports required under Commonwealth EPBC References: 2003/1294, 2008/4178 and 2005/2184 and Western Australian Ministerial Implementation Statements No. 769, 800, and 865 for the approved Foundation Project to manage its environmental risks. These EMPs are identified in Table 3-1, Section 3.4.2.3 of this PER/Draft EIS.
Endemic	Unique to an area; found nowhere else
eNGO	Environmental Non-government Organisation
Environmental Harm	As defined in the EP Act Section 3A, 'environmental harm means direct or indirect – (a) harm to the environment involving removal or destruction of, or damage to (i) native vegetation; or (ii) the habitat of native vegetation or indigenous aquatic or terrestrial animals; (b) alteration to the environment to its detriment or degradation or potential detriment or degradation; (c) alteration of the environment to the detriment or potential detriment of an environmental value; or (d) alteration of the environment of a prescribed kind.'
Environmental Quality Criteria	Numerical values or narrative statements that serve as benchmarks to determine whether a more detailed assessment of environmental quality is required or whether a management response is required
Environmental Quality Objective	A specific management goal for a part of the environment; it is either ecologically based by describing the desired level of health of the ecosystem, or socially based by describing the environmental quality required to maintain specific human uses
EP Act	*Environmental Protection Act 1986* (WA)

EPA	Western Australian Environmental Protection Authority
EPA Assessment No. 1889	The EPA's Notice under Section 39A(3) of the *Environmental Protection Act 1986* (WA) providing its decision on the referral of the Fourth Train Proposal
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EPBC Act-listed (species)	Species afforded protection under the *Environmental Protection and Biodiversity Conservation Act 1999* (Cth)
EPBC Reference: 2003/1294	Commonwealth Government of Australia: Ministerial Approval (for the Gorgon Gas Development) as amended or replaced from time to time
EPBC Reference: 2005/2184	Commonwealth Government of Australia: Ministerial Approval (for the Jansz Feed Gas Pipeline) as amended or replaced from time to time
EPBC Reference: 2008/4178	Commonwealth Government of Australia: Ministerial Approval (for the Revised Gorgon Gas Development) as amended or replaced from time to time
EPBC Reference: 2011/5942	Commonwealth Government of Australia: Department of Sustainability, Environment, Water, Population and Communities' Notification of Referral Decision on the Gorgon Gas Development – Fourth Train Expansion
EPCM	Engineering Procurement Construction Management
Epifauna	Sessile benthic species such as sea fans and sea pens that live on the surface of the substrate
EQO	Environmental Quality Objective
ERF	Emissions Reduction Fund
ERMP	Environmental Review and Management Plan
ESE	Environmental, Social, and Economic
Eutrophication	Enrichment of a water body with nutrients that results in the stimulation of excessive plant growth, especially algae
EV	Environmental Value
Exclusive Economic Zone	The area beyond and adjacent to the territorial sea; the exclusive economic zone does not extend beyond 200 nautical miles from the territorial sea baseline from which the breadth of the territorial sea is measured

Facilitated Impact	As defined in SEWPaC's Tailored Guidelines, an impact that results from the actions of third parties that are facilitated by the Fourth Train Proposal, such as increased shipping or road traffic as a result of the construction of a port or expansion of a facility
Factor	Includes physical environmental resources (e.g. air, water resources) that are valued by society for their intrinsic worth and/or their social, cultural, or economic contribution and receptors (e.g. people, communities, and ecological entities)
Fall-pipe	An extendable pipe through which rocks can be accurately delivered to the seabed; may include video relay to assist with target and placement confirmation
Feed Gas	Unprocessed hydrocarbons gathered from the offshore wells comprising natural gas, natural gas condensate (condensate), and produced formation water (produced water)
Feed Gas Pipeline System	Pipeline from the offshore gas wells to the Gas Treatment Plant including associated power umbilicals etc.
FIFO	Fly-in fly-out
Footprint	Consists of the cleared areas, and uncleared areas approved to be cleared, on Barrow Island used for the construction and operation of the Gorgon Project. May refer to the areas used by specific proposals, i.e. Foundation Project Footprint, Fourth Train Proposal Footprint, Combined Gorgon Gas Development Footprint. May also relate specifically to the Footprint for infrastructure, i.e. Feed Gas Pipeline Systems Footprint, Gas Treatment Plant Footprint.
Foreshore	An area that extends from mean high water springs to the backshore area that may be subject to infrequent inundation during extreme tides or weather events; includes the beach areas where marine turtles typically nest
Foundation Project	Gorgon Gas Development Foundation Project, which consists of the initial Gorgon Gas Development, Revised and Expanded Gorgon Gas Development, Jansz–Io Development Project and Feed Gas Pipeline, all of which are approved, and , Gorgon Gas Development Additional Construction, Laydown and Operations Support Area

Foundation Project MDF	Foundation Project Marine Disturbance Footprint; the area of the seabed to be disturbed by construction or operations activities associated with the Marine Facilities of the approved Foundation Project. The MDF is defined in the Coastal and Marine Baseline State and Environmental Report required under Condition 14.2 of Statement No. 800, Condition 12.2 of Statement No. 769, and Condition 11.2 of EPBC Reference: 2003/1294 and 2008/4178.
Foundation Project TDF	Foundation Project Terrestrial Disturbance Footprint; the area to be disturbed by construction or operations activities associated with the Terrestrial Facilities of the approved Foundation Project. The TDF is defined in the Terrestrial and Subterranean Baseline State and Environmental Impact Report required under Condition 6.1 of Statement No. 800, Statement No. 965, Condition 6.1 of Statement No. 769, and Condition 5.1 of EPBC Reference: 2003/1294 and 2008/4178.
Fourth Train Proposal	Gorgon Gas Development Fourth Train Expansion Proposal, the development being proposed in this PER/Draft EIS, which is yet to gain approval
Fourth Train Proposal Area	The area within which Fourth Train Proposal primary activities will be undertaken – i.e. the area encompassing the Greater Gorgon Area and Barrow Island, as depicted in Figure 1-1, Section 1.3.4 of this PER/Draft EIS
Fourth Train Proposal Footprint	The areas of cleared and uncleared land on Barrow Island that will be required for the construction and operation of the Fourth Train Proposal
FPSO vessel	Floating production, storage, and offloading vessel
Frac-out	Caused when drilling fluid pressure exceeds ground strength, typically resulting in drilling mud rupturing to the surface (ground or seabed) and collapse of the drill hole
Fractionation	A process by which saturated hydrocarbons are removed from natural gas and separated into distinct products or fractions, such as propane and ethane
g/m^2	Grams per square metre
Gas Treatment Plant	The infrastructure used in the treatment, storage, and export of gas and condensate; it includes components such as Liquefied Natural Gas (LNG) Trains, LNG Tanks, Gas Processing Drivers, Power Generators, Flares, Condensate Tanks, Utilities Area, and LNG Jetty. Reference to the Foundation Project Gas Treatment Plant relates to the Gas Treatment Plant facilities for the three LNG trains approved as part of the Foundation Project.

Gas Treatment Plant site	The footprint to tenure boundaries of the Gas Treatment Plant approved under the Foundation Project
GDP	Gross Domestic Product
Geomorphological	Pertaining to geological structure; of or relating to the form or surface features of the earth
GIS	Geographic Information System
GJVs	Gorgon Joint Venturers; the Joint Venturers from time to time as defined in the Gorgon Gas Processing and Infrastructure Project Agreement
Gorgon Gas Development	The Gorgon Gas Development as approved under Statements No. 800, 865 and 965, and EPBC Reference: 2003/1294 and 2008/4178 as amended or replaced from time to time
Gorgon Gas Development Foundation Project	*see* Foundation Project
Gorgon Gas Development Fourth Train Expansion Proposal	*see* Fourth Train Proposal
Gorgon Project	The Project as defined in the Gorgon Gas Processing and Infrastructure Project Agreement. (Definition as per the Approved Proposals, as amended from time to time.)
Greater Gorgon Area	As defined under the Barrow Island Act, comprises the areas that are the subject of Retention Leases WA-15-R, WA-17-R, WA-18-R, WA-19-R, WA-20-R, WA-21-R, WA-22-R, WA-23-R, WA-24-R, WA-25-R, and WA-26-R; Exploration Permits WA-253-P, WA-267-P, and WA-268-P; and graticular blocks 439, 440, 511, 512, 583, and 584 of Exploration Permit WA-205-P, or of titles derived from those titles, which are held during the term of the Gorgon Gas Processing and Infrastructure Project Agreement by any person under such titles granted pursuant to the *Petroleum (Submerged Lands) Act 1967* (Cth)
Greenhouse Gases	Components of the atmosphere that contribute to the greenhouse effect; include the six commonly reported greenhouse gases under the Kyoto Protocol – methane (CH_4), carbon dioxide (CO_2), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6)
Greywater	Wastewater (other than sewage) from sinks, showers, galleys/kitchens, and laundry and cleaning activities at terrestrial facilities and on board marine vessels
Groundwater	Water that exists beneath the Earth's surface in underground streams and aquifers

GRP	Gross Regional Product
GSP	Gross State Product
GST	Goods and Services Tax
GUFT	Gorgon Upstream Facilities Team
H_2S	Hydrogen sulfide
ha	Hectare
Habitat	The area or areas in which an organism and/or assemblage of organisms lives; includes the abiotic factors (e.g. substrate and topography) and the biotic factors
Hardstand	Open ground, having a hard surface made of gravel, asphalt, concrete etc., used for the storage of material or the parking of vehicles
Hatchling	Newly hatched marine turtle. This period refers to the stage between hatching from the egg shell and feeding offshore during which the neonate turtle uncurls and absorbs the egg yolk, emerges on to the beach surface, crawls across the beach, and swims offshore to begin feeding, ceasing reliance on its internal yolk sac. At this stage the turtle is termed a 'post-hatchling'.
Hazard	A source of potential harm, or a situation with a potential to cause loss or adverse effect; has the same meaning as 'threat'
Hazardous Material	Any substance (liquid or solid) that has the potential to cause harm to the environment or living organisms; examples include concentrated reverse osmosis brine, cement dust, paint, fuels, and solvents
HCFC	Hydrochlorofluorocarbon
HES	Health, Environment, and Safety
Hg	Mercury
High Water Mark	The mark left by the tide at high water; also the line or level reached by the tide, usually the highest
HMA	Hazard Management Agency
Hydrate	A compound of hydrocarbons and water that is formed under reduced temperature and pressure in gathering and transmission facilities for gas; can impede fluid flow
Hydrocarbons	A large class of organic compounds composed of hydrogen and carbon; e.g. crude oil, natural gas, and natural gas condensate are all mixtures of various hydrocarbons

Hydrodynamic Forces	Forces associated with waves, tides, and currents
Hydrological Regime	The long-term spatial variation in water depths and period of inundation within a wetland system
Hydrotest	Method whereby water is pressurised within pipes and vessels to detect leaks
Hz	Hertz or cycles per second; something that repeats a cycle once each second moves at a rate of 1 Hz
IBA	Important Bird Area
ICNWA	Industry Capability Network Western Australia
IF1, IF2, etc.	Introduced Flora categories
Illustrative Measures	Mitigation and management measures taken from Foundation Project EMPs and/or Subsidiary Documents requiring regulatory approval that have been used in this PER/Draft EIS for assessment purposes (see Section 8.3.5 for an explanation of the status of the measures). The GJVs intend to apply the illustrative measures for the implementation of the Fourth Train Proposal; however, the final mitigation and management measures that will be required to be implemented will be those stipulated in the relevant EMPs and/or Subsidiary Documents that are approved to apply to the Fourth Train Proposal.
IMO	International Maritime Organization
Impact	Interaction of a stressor with an environmental or social factor(s)
Incremental	Refers to the change in emissions, discharges, wastes, impacts, likelihood, or risk due to the implementation of the Fourth Train Proposal from that of the approved Foundation Project
Indirect Impact	As defined in SEWPaC's Tailored Guidelines, an impact that is not a direct result of the Fourth Train Proposal, and that may include offsite or downstream impacts, such as impacts on migratory species from changes to the hydrology of estuarine areas
Infauna	Animals living within sediments
Initial Gorgon Gas Development	The development proposed in the EIS/ERMP and subsequently approved under Ministerial Implementation Statement No. 748 and EPBC Reference: 2003/1294

Internesting Period	The period between successive ovipositions within a single breeding season. The females move to offshore internesting grounds while they form the next clutch of eggs. Internesting grounds may be close to or remote from the nesting beach.
Intertidal Zone	The area of seabed between the mean high water spring and the mean low water spring
Intrafield	Within the gas field
IOCI	Indian Ocean Climate Initiative
IOPP	International Oil Pollution Prevention
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
Isobath	A line on a chart joining places of equal depth of water; a depth contour
Isolux Contour	Contour lines (lines connecting points on a map of a constant value) illustrating areas of equal illuminance, and graphically displaying isolux variations over space
IUCN	International Union for Conservation of Nature
JAMBA	Japan–Australia Migratory Bird Agreement
Jansz–Io Development Project and Jansz Feed Gas Pipeline	The development assessed via EPBC Referral assessment processes and Environmental Impact Statement/Assessment on Referral Information and subsequently approved under EPBC Reference: 2005/2184 and Ministerial Implementation Statement No. 769
Karst	An area of irregular limestone in which erosion has produced fissures, sinkholes, underground streams, and caverns
kg	Kilogram
kg/ha/year	Kilograms per hectare per year
kHz	Kilohertz
KJVG	Kellogg Joint Venture Gorgon
kL	Kilolitre
km	Kilometre
km^2	Square kilometres
kW	Kilowatt

L	Litre
$L_{A\ 1}$	Assigned noise level from the Environmental Protection (Noise) Regulations 1997 (WA) that is not to be exceeded for more than 1% of the representative assessment period
$L_{A\ 10}$	Assigned noise level from the Environmental Protection (Noise) Regulations 1997 (WA) that is not to be exceeded for more than 10% of the representative assessment period
LC_{50}	Lethal Concentration 50, Median lethal concentration; concentration of a substance that is estimated to produce death in 50 percent of the population within a certain time
LiDAR	Light Detection and Ranging
Light Attenuation	The absorption and scattering of light
Likelihood	The probability of a stressor impacting on an environmental factor
Likely Impact	An impact that has a real or not remote chance or possibility of occurring, as defined in SEWPaC's Tailored Guidelines; likely impacts have been incorporated into the term 'potential impacts' in this PER/Draft EIS
Liquefaction	The process to turn a gas into a liquid either by cooling or pressurising
Littoral	A shore; the zone between high tide and low tide; of, or related to the shore, especially the seashore
LNG	Liquefied natural gas
Local / Localised	Impacts restricted to the area directly affected by the Fourth Train Proposal and in its immediate vicinity; i.e. the area confined to the limits of the Terrestrial or Marine Disturbance Footprints
London Convention	International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 as modified by the Protocol of 1996
Long term	More than five years
Low Water Mark	The line along the coast to which the sea recedes at low water
Luminaires	A complete lighting unit that produces and distributes light, including the fixture, ballast, mounting, and lamps
Lux	A standard for measuring light; equal to the amount of visible light per square metre incident on a surface; 1 lux = 1 lumen/square metre or 0.093 foot-candles

m	Metre
m^3	Cubic metres
Macroalgae	An ancient class of large multicellular plants that resemble vascular plants, but lack the complex array of tissues used for reproduction and water transport. They are important elements of shallow coastal waterways and are found in red (Rhodophyta), green (Chlorophyta), and brown (Phaeophyta) divisions. Macroalgae typically grow attached to hard substrates such as rocks, shells, and coral skeletons.
Macroinvertebrates	An invertebrate animal (an animal without a backbone [vertebral column]) large enough to be seen without the aid of magnification; includes sponges, crinoids, hydroids, sea pens, sea whips, gorgonians, snails, clams, crayfish, and sea cucumbers
Macrophyte	Angiosperms (predominantly seagrass in marine or coastal waters) or macroalgae that are visible to the unaided eye; can grow in or near water, either emergent, submerged, or floating within marine, estuarine, or freshwater environments
Magnitude	A descriptor of the nature, size, scale, intensity, geographic extent, distribution, duration, frequency, and reversibility of an impact. For unplanned events, the magnitude of an impact also takes into account the probability of the unplanned event (e.g. spill) occurring, and, if it does occur, the probability of the spill reaching a sensitive part of the environment.
Manifold	An arrangement of piping and valves designed to commingle or distribute fluid flow
Marine Conservation Reserves	Areas declared under either Commonwealth or State legislation for the purposes of the conservation and protection of marine biodiversity and to ensure the long-term viability of marine and estuarine ecosystems

Marine Facilities	In relation to the Fourth Train Proposal, the Marine Facilities are the: • Materials Offloading Facility • LNG Jetty • Offshore Feed Gas Pipeline System (for the Fourth Train Proposal), and the marine component of its shore crossing • WAPET Landing. In relation to the approved Foundation Project, the Marine Facilities are defined in Statement No. 800 and EPBC Reference: 2003/1294 and 2008/4178 to also include the: • Dredge Spoil Disposal Ground • Offshore Feed Gas Pipeline System (for Gorgon and Jansz–Io) and the marine component of their shore crossing • Domestic Gas Pipeline. For the purposes of Statement No. 800, Marine Facilities also include: • Marine upgrade of the existing WAPET Landing.
Marine Pests	Species other than the native species known or those likely to occur in the waters of the Indo–West Pacific region and the Pilbara Offshore marine bioregion in Interim Marine and Coastal Regionalisation for Australia: An Ecosystem Based Classification for Marine and Coastal Environments, of which Barrow Island is a part, that do or may threaten biodiversity in the Pilbara Offshore marine bioregion, excluding Marine Pests or Species of Concern that already exist in Western Australian waters at present or in the future. As a minimum, the National Introduced Pest Information System Database (Department of Environment and Water Resources, Commonwealth Government), National Priority Pests listed in the document National Priority Pests, Part II, Ranking of Australian Marine Pests will guide the interpretation of this definition. Additional species may be added on the advice of experts from the WA Department of Fisheries and the Quarantine Expert Panel.
MARPOL	The International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978; also known as MARPOL 73/78
Material Environmental Harm	As defined in the EP Act Section 3A, 'material environmental harm means environmental harm that – (a) is neither trivial nor negligible; or (b) results in actual or property loss, property damage or damage costs of an amount, or amounts in aggregate, exceeding the threshold amount.'

MDF	Marine Disturbance Footprint
Mean Sea Level	The sea level halfway between the mean levels of high and low water
MEG	Monoethylene glycol; used as a hydrate inhibitor
Megafauna	Large vertebrate animals
Metocean	Meteorological and oceanographic conditions
MFO	Marine Fauna Observer
mg/kg	Milligrams per kilogram
mg/L	Milligrams per litre
MHF	Major Hazard Facilities
MHWS	Mean High Water Springs
Migratory Species	Species listed as migratory under section 209 of the EPBC Act
Ministerial Conditions	Refers to the conditions of Ministerial approval for either the approved Foundation Project and/or any future Ministerial Conditions issued for the Fourth Train Proposal, if approved, as relevant. Where used in the context of the approved Foundation Project, Ministerial Conditions relate to the conditions contained within EPBC References: 2003/1294, 2005/2184, and 2008/4178 (for Commonwealth approval) and Statement Nos. 748, 769, 800, and 865 (for State approval), as amended or replaced from time to time.
mm	Millimetres
Morphology	Particular form, shape or structure
Motile	Capable of movement
MOU	Memorandum of Understanding
MSDS	Material Safety Data Sheet; a widely used system for cataloguing information on substances, such as chemicals, chemical compounds, and chemical mixtures; MSDS information may include instructions for the safe use and potential hazards associated with a particular material or product.
MSP	Management System Process
MTEP	Marine Turtle Expert Panel (established under Condition 15 of Statement No. 800)
MTPA	Million Tonnes Per Annum

MU1	Management Unit 1; for Benthic Primary Producer Habitat
MW	Megawatt
n.d.	No date
n/a; N/A	Not applicable
N_2	Nitrogen
N_2O	Nitrous oxide
NADF	Non-aqueous Drilling Fluids
National Plan	Australia's National Plan for Maritime Environmental Emergencies
National Plan State Committee	Western Australian National Plan State Committee for Combating Marine Oil Pollution
Native	Species that are native to (naturally occurring in) a region.
NC	No contact
Neap Tide	A less than average tide occurring at the first and third quarters of the moon
Nearshore	Close to shore; or within three nautical miles of Barrow Island
Nekton	Aquatic animals that actively swim in the water column
NEPC	National Environment Protection Council (Australia)
NEPM	National Environmental Protection Measure (Australia)
NES	[Matters of] National Environmental Significance, as defined in Part 3, Division 1 of the EPBC Act
NGER Act	*National Greenhouse and Energy Reporting Act 2007* (Cth)
NIS	Non-indigenous Terrestrial Species; any species of plant, animal or microorganism not native to Barrow Island. Native: Species that are native to (naturally occurring in) a region
nm	Nautical mile
NMVOC	Non-methane Volatile Organic Compound
NO	Nitric oxide
NO_2	Nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration

NOHSC	National Occupational Health and Safety Commission (now Safe Work Australia)
Nominal	Representative value of a measurable property determined under a set of conditions, by which a product may be described. The actual value will be close to, but may not be exactly the same as this representative value once real-world factors have been taken into account in accordance with standard engineering practice
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority (Australia)
NORM	Naturally occurring radioactive material
NO_x	Oxides of nitrogen
NPC	Net Present Cost
NPI	National Pollution Inventory (Australia)
NPV	Net Present Value
NRC	National Research Council (United States)
NSW	New South Wales
NT	Northern Territory
NVIS	National Vegetation Information System (Australia)
O_3	Ozone
Obligate	Restricted to a particular condition in life
ODS	Ozone Depleting Substance
OE	Operational Excellence; a term used by Chevron Corporation to describe the systematic management of safety, health, environment, reliability, and efficiency to achieve world-class performance
OEMS	Operational Excellence Management System; the standardised approach to consistently deliver and continuously improve OE that applies to all Chevron Corporation's capital projects and operational activities
OEPA	Western Australian Office of the Environmental Protection Authority

Offshore Marine Environment	Refers to the Commonwealth Marine Area and areas affected by drilling of offshore wells, installation of subsea gathering systems and the marine component of the Feed Gas Pipeline System; the operation of this infrastructure; and the movement of marine supply vessels and LNG and condensate offtake vessels associated with the Fourth Train Proposal to and from the Materials Offloading Facility and LNG Jetty
Onshore	Above the water level at low tide
OSPAR	Oslo–Paris Convention for the Protection of the Marine Environment of the North East Atlantic
OSRL	Oil Spill Response Ltd (Australia)
Oxygen Scavenger	A substance that reacts with and removes oxygen, or prevents/minimises oxygen corrosion
PAH	Polycyclic Aromatic Hydrocarbons; also known as polyaromatic hydrocarbons
PDC	Pilbara Development Commission
PEC	Priority Ecological Community
Pelagic	Associated with open oceans and seas, generally in the mid-water column or near the surface
PER	Public Environmental Review
Permanent	Impacts that may arise from irreversible changes in conditions caused by the Fourth Train Proposal, such as the removal of a natural feature
PESA	Petroleum Exploration Society of Australia
pH	Measure of acidity or basicity of a solution
Photic Zone	The depth of the water in a lake or ocean that is exposed to sufficient sunlight for photosynthesis to occur; photic zone depth can be greatly affected by turbidity
Phytoplankton	Small (often microscopic) photosynthetic organisms that reside in the water column.
Pig	Pipeline Inspection Gauge; a tool that is sent down a pipeline and propelled by the pressure of the product in the pipeline or by another fluid; pigging is usually undertaken during commissioning
Pipe String	Numerous sections of pipe joined together
PKF1, PKF2, etc.	Poorly Known Flora categories

Plankton	Small (often microscopic) plants and animals floating, drifting, or weakly swimming in bodies of fresh or salt water
PM	Particulate matter
PM_{10}	A dust fraction with an aerodynamic diameter of less than 10 micrometres
$PM_{2.5}$	A dust fraction with an aerodynamic diameter of less than 2.5 micrometres
Potential Impact	An impact that can be reasonably expected or is likely to occur in the lifetime of the Fourth Train Proposal; potential impacts include relevant, likely, direct, indirect, and facilitated impacts, as defined in SEWPaC's Tailored Guidelines
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per thousand
Practicable	*See* As far as practicable
Priority Flora	Priority flora is a non-legislative category aimed to manage those plant taxa listed by DPaW on the basis that they are known from only a few collections, or a few sites, but which have not been adequately surveyed. Such flora may be rare or threatened, but cannot be considered for declaration as rare flora until such survey work has been undertaken.
Priority 1 (Flora)	Priority One—P1—Poorly Known Taxa; taxa that are known from one or a few collections or sight records (generally fewer than five), all on lands not managed for conservation, and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities, but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.
Priority 1 Ecological Community	Ecological community listed under Priority One (Poorly known ecological communities) of the DPaW listing of species and ecological communities

Priority 2 (Flora)	Priority Two—P2—Poorly Known Taxa; taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities, but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.
Priority 2 Species	Fauna listed under Priority Two (Species that are known from one or a few collections or sight records [generally less than five], some of which are on lands not under imminent threat of habitat destruction or degradation) of the DPaW Priority Fauna ranking
Priority 3 (Flora)	Priority Three—P3—Poorly Known Taxa; taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities, but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.
Priority 3 Species	Fauna listed under Priority Three (taxa with several, poorly known populations, some on conservation lands) of the DPaW Priority Fauna ranking
Produced Formation Water	Water extracted from the subsurface with oil and gas; includes water from the reservoir, water that may be injected into the formation, and water vapour from the reservoir that condenses with a temperature or pressure change, often due to production
PRRT	Petroleum Resource Rent Tax
Putative	Species for which distribution or taxonomic status is in question and awaits scientific resolve as to whether such species is native or non-indigenous to an area
QAC	Quarantine Advisory Committee
QEP	Quarantine Expert Panel
QHAZ	Quarantine Hazard Analysis
QMS	Quarantine Management System

Quarantine Incident	A quarantine incident is declared if: a) a Non-indigenous Terrestrial Species or a Marine Pest is detected after final quarantine clearance; or b) project-related activities cause the proliferation of existing weed populations
Quarantine Intercept	Any case where quarantine inspection prior to final quarantine clearance leads to the detection, containment, and removal of contamination or Non-indigenous Terrestrial Species
RBR1, RBR2, etc.	Restricted Vegetation (Botanical Relicts) categories
RD1, RD2, etc.	Restricted Vegetation (Distribution) categories
Receptor	A biophysical entity (e.g. species, population, community, habitat) or social/community entity (e.g. people, community, local businesses etc.)
Recruitment	The number of new young animals that enter a population in a given year
Re-equalisation	To return to a state of equilibrium/balance
Relevant Impact	Impacts that the Fourth Train Proposal has or will have or is likely to have on each controlling provision for the Fourth Train Proposal, as defined in SEWPaC's Tailored Guidelines; relevant impacts have been incorporated into the term 'potential impacts' in this PER/Draft EIS
Relict	A plant or animal species living in an environment that has changed from that which is typical for it; a geological feature that is a remnant of a pre-existing formation after other parts have disappeared
Residual Impact	Impact remaining after the application of proposed mitigation and management measures
Revised and Expanded Gorgon Gas Development	Changes to the Gorgon Gas Development as described in the Gorgon Gas Development Revised and Expanded Proposal PER and subsequently approved under EPBC Reference: 2008/4178 and Ministerial Implementation Statements No. 800 and 865 (Statement No. 800 and Statement No. 865)
RF	Restricted Vegetation (Flora) category
Rock Bolting	Placing a long bolt into the rock to stabilise the pipeline
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
ROV	Remotely operated vehicle
RVA	Rapid Visual Assessment

Scupper	An opening in the side of a ship at or just below the level of the deck, to allow water to run off
Seagrass	Benthic marine plants, which have roots, stems, leaves, and inconspicuous flowers with fruits and seeds much like terrestrial flowering plants; unrelated to seaweed
Semidiurnal	Occurring every 12 hours
Serious Environmental Harm	As defined in the EP Act Section 3A, 'serious environmental harm means harm that - a) is irreversible, of a high impact or on a wide scale; b) is significant or in an area of high conservation value or special significance; c) results in actual or potential loss, property damage or damage costs of an amount, or amounts in aggregate, exceeding five times the threshold limit.'
Sessile	Permanently attached directly to the substratum by its base (i.e. immobile), without a stalk or stem
SEWPaC	Former Commonwealth Department of Sustainability, Environment, Water, Population and Communities (now DotE)
SEWPaC's Tailored Guidelines	Refers to the Tailored Guidelines for the Preparation of a Draft Environmental Impact Statement of the Fourth Train Proposal (EPBC Reference: 2011/5942) issued by SEWPaC to Chevron Australia
Short term	Fewer than five years
SIMOPS	Simultaneous Operations
Slug Catcher	A unit in the gas refinery or petroleum industry in which slugs at the outlet of pipelines are collected or 'caught'; a slug is a large quantity of gas or liquid that exits the pipeline
SO_2	Sulfur dioxide
SO_3	Sulfur trioxide
SO_x	Oxides of sulfur
SPE	Society of Petroleum Engineers
Species of Concern	A non-indigenous marine species that is likely to cause significant negative impacts on Australia's maritime industries and environment, should such a species establish in the waters surrounding Barrow Island
SPF	Specially Protected Flora

SPF1, SPF2, etc.	Specially Protected Flora categories
Spring Tide	The highest tides in a lunar month, occurring near new and full moons
SRE	Short-range Endemic
State Agreement	The Gorgon Gas Processing and Infrastructure Project Agreement, Schedule 1 of the *Barrow Island Act 2003* (WA)
State Government	Government of Western Australia
State Waters	The marine environment within three nautical miles of the coast of Barrow Island or the mainland of Western Australia
Statement No. 748	Western Australian Ministerial Implementation Statement No. 748 (for the Gorgon Gas Development) [superseded by Statement No. 800]
Statement No. 769	Western Australian Ministerial Implementation Statement No. 769 (for the Jansz Feed Gas Pipeline) as amended from time to time
Statement No. 800	Western Australian Ministerial Implementation Statement No. 800 (for the Gorgon Gas Development) as amended from time to time (*see also* Statement No. 865)
Statement No. 865	Western Australian Ministerial Implementation Statement No. 865 to Amend Conditions Applying to a Proposal (under section 46 of the *Environmental Protection Act 1986* (WA)) for the Gorgon Gas Development; this Statement amends Conditions 18, 20, and 21 of Statement No. 800 relating to the management of dredging and dredge spoil disposal
Statement No. 965	Western Australian Ministerial Implementation Statement No. 965, issued for the Gorgon Gas Development Additional Construction, Laydown, and Operations Support Area, as amended from time to time. Statement No. 965 applies the conditions of Statement No. 800 to the Gorgon Gas Development Additional Construction, Laydown, and Operations Support Area.
Statistical Power	The probability of detecting a meaningful difference or effect, if one was to occur
Stereo-BRUV	Baited remote underwater stereo-video
Stormwater	Natural rainwater run-off that occurs during or after storms or heavy rainfall events
Stressor	A source of potential harm, or a situation with a potential to cause loss or adverse effects

Stygofauna	Groundwater-dwelling aquatic fauna
Subsea Tree	An assembly of valves, piping, fittings, and instruments that contain and monitor reservoir fluids
Substrate	The surface a plant or animal lives upon; can include biotic or abiotic materials (e.g. encrusting algae that lives on a rock can be substrate for another animal that lives above the algae on the rock)
Subterranean Fauna	Fauna that have adapted to subterranean conditions, including stygofauna and troglofauna
Subtidal Zone	Seaward of the defined mean low water mark and always covered by water
Surface Water	Includes water in a watercourse, lake, or wetland; any water flowing over or lying on land after having precipitated naturally or after having risen to the surface naturally from underground
Surfactant	Any substance that, when added to a liquid, reduces its surface tension and thus increases its spreading or wetting properties
SWA	Safe Work Australia
Swale	A low tract of land
T	Tonnes
TAPL	Texaco Australia Pty Ltd
Taxon (plural: taxa)	A name designating an organism or a group of organisms
TBT	Tributyltin
TDF	Terrestrial Disturbance Footprint
TEC	Threatened Ecological Community
Terminal Tanks	The existing WA Oil storage tanks located just north of the Gas Treatment Plant site
Terrestrial	Of or on the ground or land, as opposed to in water
Thermocline	A layer within a body of water or air where the temperature changes rapidly with depth

Title Areas	As defined under the Barrow Island Act, the areas which, at the Commencement Date [of the Barrow Island Act], are the subject of Retention Leases WA-2-R, WA-3-R, WA-4-R, WA-5-R, WA-14-R, and WA-16-R; and graticular blocks 153, 154, 225, 226, 296, 297, 368, and 369 within Exploration Permit WA-205-P and in which interests are held during the term of this Agreement by any or all of the Joint Venturers under titles granted pursuant to the *Petroleum (Submerged Lands) Act 1967* of the Commonwealth
TJ	Terajoules
TP	Total Phosphorus
Troglofauna	Obligate cave- or karst-dwelling terrestrial subterranean fauna occurring above the watertable
Turbidity	The cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air; the measurement of turbidity is a key test of water quality
Umbilical	A bundle of tubes, cables, and fibres that convey power, communication signals, and chemicals from the onshore production facilities to the subsea equipment
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UWA	University of Western Australia
Vibration	Motions felt when ‘shock’ waves are passing through a medium (e.g. soil, metal, water, plastic, concrete)
VOC	Volatile Organic Compounds; organic chemical compounds that have high enough vapour pressures under normal conditions to vaporise and enter the atmosphere
VSP	Vertical Seismic Profiling
WA	Western Australia
WA Oil	Within Chevron Australia, the Barrow Island Petroleum Lease L1H is assigned to the WA Oil Asset (WA Oil), which is the responsible operator of Lease LH1 within the Barrow Island Joint Venture.
WAPC	Western Australian Planning Commission
WAPET	West Australian Petroleum Pty Ltd

WAPET Landing	Proper name referring to the site of the barge landing existing on the east coast of Barrow Island prior to the date of Statement No. 800 (also known as the barge landing in the approved Foundation Project environmental approval documentation)
Wastewater	Sewage and other contaminated liquid waste streams; examples include, but are not limited to, washdown water, oily water, greywater, and chemically contaminated water
Well Workover	The process of performing major maintenance or remedial treatments on an oil or gas well
Wellhead	The surface termination of a wellbore that incorporates systems to provide pressure control, suspension of casing strings, and sealing functionality for oil wells
WestPlan – Marine Oil Pollution	Western Australian State Emergency Management Plan for Marine Oil
Wetsides	All parts of a vessel that are regularly immersed or wetted with sea water during normal operation
WHA	World Heritage Area
Where practicable	*See* As far as practicable
WHO	World Health Organization
WHO Guidelines	World Health Organization Air Quality Guidelines for Europe (as amended from time to time)
Widespread	Impacts extending beyond the limits of the Terrestrial and Marine Disturbance Footprints as defined for the Fourth Train Proposal
Wildlife Conservation Act	*Wildlife Conservation Act 1950* (WA)
Wrack	Any marine vegetation, terrestrial plants, and animal remains cast up on the shore
Zone of High Impact	For the approved Foundation Project, the Zone of High Impact is set out in Schedule 1 of Statement No. 800 and Schedule 5 of EPBC Reference: 2003/1294 (as amended) and 2008/4178. It is an area where long-term impacts to corals are predicted to result directly from disturbance during horizontal directional drilling, dredging, or construction of infrastructure on the seabed and burial during dredge spoil disposal, or indirectly from smothering due to elevated sedimentation and/or from deterioration in water quality.

Appendix A: Project Characteristics

Project Characteristics

A Key Characteristics table has been prepared to describe the elements of the Foundation Project (as described in Statement No. 800, as amended) and changes introduced by the Fourth Train Proposal (this proposal). The Combined Gorgon Gas Development is the combined Foundation Project and Fourth Train Proposal. If the Fourth Train Proposal is approved, the description of the Combined Gorgon Gas Development description is proposed to be used as the Summary of Key Proposal Characteristics in the new approval.

This table only applies to Western Australian state jurisdiction.

Element	Description of the Foundation Project (Statement No. 800)	Description of the Fourth Train Proposal	Description of the Combined Gorgon Gas Development
TERRESTRIAL FACILITIES			
Gas Treatment Plant			
Location	Town Point	No change	Town Point
Number of Liquefied Natural Gas (LNG) trains	3	1	4
Size of LNG trains	5 MTPA nominal (each)	5 MTPA nominal	5 MTPA nominal (each)
LNG tank size	2 × 180 000 m^3 nominal	1 × 180 000 m^3 nominal tank may be required	3 × 180 000 m^3 (nominal)
Gas Processing Drivers	6 × 80 MW (nominal) gas turbines fitted with dry low nitrogen oxide burners	2 × 80 MW (nominal) gas turbines fitted with dry low nitrogen oxide burners	8 × 80 MW (nominal) gas turbines fitted with dry low nitrogen oxide burners
Power Generation	5 × 116 MW (nominal) conventional gas turbines fitted with dry low nitrogen oxide burners	1 × 116 MW (nominal) conventional gas turbine fitted with dry low nitrogen oxide burners	6 × 116 MW (nominal) conventional gas turbines fitted with dry low nitrogen oxide burners
Flare design [1]	Ground flare for main plant flare. Boil Off Gas (BOG) flares (two separate enclosed ground flares, one duty burner and one spare burner) in proximity to the LNG storage and loading area	No change to main plant flare. Boil Off Gas (BOG) flare (one separate enclosed burner and one spare burner) in proximity to the LNG storage and loading area	Ground flare for main plant flare. Boil Off Gas (BOG) flare (two separate enclosed ground flares, one duty burner and one spare burner) in proximity to the LNG storage and loading area
Domestic gas production rate	300 TJ/day	No change	300 TJ/day
Condensate production rate	3600 m^3/day (nominal) hydrocarbon condensate	2900 m^3/day (nominal) hydrocarbon condensate	6500 m^3/day (nominal) hydrocarbon condensate
Condensate tank size	4 × 35 000 m^3 (nominal)	No change	4 × 35 000 m^3 (nominal)

Element	Description of the Foundation Project (Statement No. 800)	Description of the Fourth Train Proposal	Description of the Combined Gorgon Gas Development
Volume of earthworks	6 million m^3 (nominal)	3 million m^3 (nominal)	9 million m^3 (nominal)
Associated Terrestrial Infrastructure			
Terrestrial component of the Barge Landing (WAPET Landing) upgrade	Terrestrial components of the upgrade of the existing WAPET Landing.	No change	Terrestrial components of the upgrade of the existing WAPET Landing
Construction Village (now Butler Park)	Approximately 2.6 km south of Gas Treatment Plant	No change	Approximately 2.6 km south of Gas Treatment Plant
Operations Workforce Accommodation	Within an extension to the existing Chevron Australia Camp	No change	Within an extension to the existing Chevron Australia Camp
Administration and Operations Complex	Near the Gas Treatment Plant outside the Plant boundary	No change	Near the Gas Treatment Plant outside the Plant boundary
Utilities Area	Permanent Utilities Area to be located within the Gas Treatment Plant Site	No change	Permanent Utilities Area to be located within the Gas Treatment Plant Site
Utilities Corridors	Between Utilities Area, Construction Village, and Gas Treatment Plant	No change	Between Utilities Area, Construction Village (now Butler Park), and Gas Treatment Plant
Road Upgrades	WAPET landing to Town Point; Town Point to the Airport (via Construction Village); Feed Gas Pipeline System route	No change	WAPET landing to Town Point; Town Point to the Airport (via Construction Village [[now Butler Park]); Feed Gas Pipeline System route
Airport Modifications	Extension of existing runway to the south No realignment Vegetation clearing within current airport perimeter required	No change	Extension of existing runway to the south No realignment Vegetation clearing within current airport perimeter required
Communications	Microwave communications tower and associated infrastructure to be installed on Barrow Island	No change	Microwave communications tower and associated infrastructure to be installed on Barrow Island
Water Supply	Onshore infrastructure	No change	Onshore infrastructure
Onshore Feed Gas Pipeline Systems			
Length onshore (Barrow Island)	Approximately 14 km	No change (approximately 14 km)	Approximately 14 km
Design onshore	Buried, between North Whites Beach and the Gas Treatment Plant	No change (new infrastructure will be within the Foundation	Buried, between North Whites Beach and the Gas Treatment Plant

Element	Description of the Foundation Project (Statement No. 800)	Description of the Fourth Train Proposal	Description of the Combined Gorgon Gas Development
		Project Feed Gas Pipeline Systems footprint)	
Construction easement (onshore)	Approximately 42 ha	Approximately 15 ha, within the Foundation Project easement	Approximately 42 ha
Terrestrial component of the shore crossing	North Whites Beach Area of disturbance (horizontal directional drilling onshore construction area) approximately 7 ha	North Whites Beach Area of disturbance (horizontal directional drilling onshore construction area) approximately 10 ha	North Whites Beach Area of disturbance (horizontal directional drilling onshore construction area) approximately 17 ha
Onshore Domestic Gas Pipeline			
Route onshore (Barrow Island)	Within Gas Treatment Plant Boundary	No change	Within Gas Treatment Plant Boundary
Length onshore (mainland)	30 to 40 km	No change	30 to 40 km
Construction easement (mainland)	90 to 120 ha	No change	90 to 120 ha
Shore crossing (mainland)	Specific location to be determined by the Proponent	No change	Specific location to be determined by the Proponent
Carbon Dioxide (CO_2) Injection System			
CO_2 Compression Facilities	Located within Gas Treatment Plant boundary	No change	Located within Gas Treatment Plant boundary
CO_2 Pipeline [2]	Length approximately 10 km Easement approximately 8 ha Depth of pipeline trench not more than 9 m from ground surface	No change	Length approximately 10 km Easement approximately 8 ha Depth of pipeline trench not more than 9 m from ground surface
CO_2 Injection Wells	8 to 9 injection wells directionally drilled from 3 to 4 surface locations	No change	8 to 9 injection wells directionally drilled from 3 to 4 surface locations
Observation Wells	Observation well (or wells) may be drilled at each cluster of injection wells	No change	Observation well (or wells) may be drilled at each cluster of injection wells
Pressure Management Wells	Four pressure management water wells (or water production wells) will be required to manage pressure in the Dupuy Formation. Note: the final location of these wells is subject to ongoing technical assessment	No change	Four pressure management water wells (or water production wells) will be required to manage pressure in the Dupuy Formation. Note: the final location of these wells is subject to ongoing technical assessment

Element	Description of the Foundation Project (Statement No. 800)	Description of the Fourth Train Proposal	Description of the Combined Gorgon Gas Development
Pressure Management Water Injection Wells	Four pressure management water injection wells for the re-injection of water produced from the Lower Dupuy Formation by pressure management wells. The water will be re-injected into the Barrow Group from a vertical depth of 1200–1600 m. Note: the final location of these wells is subject to ongoing technical assessment	No change	Four pressure management water injection wells for the re-injection of water produced from the Lower Dupuy Formation by pressure management wells. The water will be re-injected into the Barrow Group from a vertical depth of 1200–1600 m. Note: the final location of these wells is subject to ongoing technical assessment
Anode Wells	Four shallow drilled anode wells are required for each CO_2 drill centre for the purposes of cathodic protection of pressure management wells and pressure management water injection wells (one anode well pair per water producer/injector pair). An anode well will also be required for each observation bore not on a drill centre. Total anode well count is up to 19 (subject to final cathodic protection design). Note: the final location of these wells is subject to ongoing technical assessment	No change	Four shallow drilled anode wells are required for each CO_2 drill centre for the purposes of cathodic protection of pressure management wells and pressure management water injection wells (one anode well pair per water producer/injector pair). An anode well will also be required for each observation bore not on a drill centre. Total anode well count is up to 19 (subject to final cathodic protection design). Note: the final location of these wells is subject to ongoing technical assessment
Monitoring	Monitoring activities, including the acquisition of seismic data, will be undertaken as part of ongoing reservoir performance management	No change	Monitoring activities, including the acquisition of seismic data, will be undertaken as part of ongoing reservoir performance management
Wastewater			
Wastewater Treatment Plant	Wastewater Treatment Plant installed during pre-construction (with sufficient capacity for construction workforce) will be modified as necessary to support operations workforce	No change	Wastewater Treatment Plant installed during preconstruction (with sufficient capacity for construction workforce) will be modified as necessary to support operations workforce

Element	Description of the Foundation Project (Statement No. 800)	Description of the Fourth Train Proposal	Description of the Combined Gorgon Gas Development
Treated effluent disposal	Deep well injection of surplus treated effluent	No change	Deep well injection of surplus treated effluent
Reverse osmosis brine disposal	Deep well injection or ocean outfall (east coast Barrow Island)	No change	Deep well injection or ocean outfall (east coast Barrow Island)
Contaminated wastewater disposal	Deep well injection of contaminated wastewater streams when practicable	No change	Deep well injection of contaminated wastewater streams when practicable
Process water disposal	Deep well injection of process water	No change	Deep well injection of process water
Discharge of waste from vessels	Discharge of waste from marine vessels in accordance with MARPOL 73/78	No change	Discharge of waste from marine vessels in accordance with MARPOL 73/78
MARINE FACILITIES			
Materials Offloading Facility (MOF)			
Causeway design	Solid	No change	Solid
MOF design	Solid with offloading facilities including wharf, dock, mooring dolphins, ramp, and tug pens to support a range of vessel sizes and loads	No change	Solid with offloading facilities including wharf, dock, mooring dolphins, ramp, and tug pens to support a range of vessel sizes and loads
Causeway length/ MOF length	Combined length from the nominated onshore set out point (E 340013.006 N 7700404.460 – approximately 250 m inland from Town Point) to the top of batter at interface with start of the LNG Jetty is approximately 2120 m Note: for this component, 'approximately' means ± 5%	No change	Combined length from the nominated onshore set out point (E 340013.006 N 7700404.460 – approximately 250 m inland from Town Point) to the top of batter at interface with start of the LNG Jetty is approximately 2120 m Note: for this component, 'approximately' means ± 5%
MOF access	Constructed channel approximately 750 m long × 165 m wide; channel dredged to approximately 6.5 m (relative to chart datum); Berthing Pocket dredged to approximately 8 m (relative to chart datum)	No change	Constructed channel approximately 750 m long × 165 m wide; channel dredged to approximately 6.5 m (relative to chart datum); Berthing Pocket dredged to approximately 8 m (relative to chart datum)

Element	Description of the Foundation Project (Statement No. 800)	Description of the Fourth Train Proposal	Description of the Combined Gorgon Gas Development
LNG Jetty			
LNG jetty design	Open pile structure	No change	Open pile structure
LNG jetty length	LNG Jetty length from the end of the MOF to the end of the LNG Jetty, midway between the two LNG berths, is approximately 2.1 km. Note: for this component, 'approximately' means ± 5%	No change	LNG Jetty length from the end of the MOF to the end of the LNG Jetty, midway between the two LNG berths, is approximately 2.1 km. Note: for this component, 'approximately' means ± 5%
LNG and Condensate load-out	Via dedicated lines installed to the LNG Berth (eastern end of LNG Jetty)	No change	Via dedicated lines installed to the LNG Berth (eastern end of LNG Jetty)
Turning basin and access channel design	Turning basin shape shown in Figure 2 (of Statement 800). Dual Berth facility (designed to meet safety requirements). Turning Basin and Access Channel dredged to approximately 13.5 m (relative to chart datum); Berthing Pocket dredged to approximately 15 m (relative to chart datum)	No change	Turning basin shape shown in Figure 2 (of Statement 800). Dual Berth facility (designed to meet safety requirements). Turning Basin and Access Channel dredged to approximately 13.5 m (relative to chart datum); Berthing Pocket dredged to approximately 15 m (relative to chart datum)
Dredging			
MOF volume	1.1 million m^3 (nominal)	No change	1.1 million m^3 (nominal)
LNG Turning Basin and Shipping Channel volume	6.5 million m^3 (nominal, dual berth)	No change	6.5 million m^3 (nominal, dual berth)
Dredge Spoil Disposal Ground			
Location	Closest point is approximately 10 km from the east coast of Barrow Island	No change	Closest point is approximately 10 km from the east coast of Barrow Island
Area	Approximately 900 ha Note: for this component, 'approximately' means ± 5%	No change	Approximately 900 ha Note: for this component, 'approximately' means ± 5%
Drill and Blast			
Associated with the dredging component of the construction of the Causeway, MOF and LNG Jetty	50 000 m^3 (nominal)	No change	50 000 m^3 (nominal)

Element	Description of the Foundation Project (Statement No. 800)	Description of the Fourth Train Proposal	Description of the Combined Gorgon Gas Development
(access channels and berthing pockets).			
Offshore Feed Gas Pipeline Systems			
Length in State waters	Approximately 5.6 km (3 nautical miles) (Gorgon Feed Gas Pipeline System)	Approximately 5.4 km (Northern Pipeline Route) or 6.5 km (Southern Pipeline Route) (Fourth Train Proposal Feed Gas Pipeline System)	Approximately 5.6 km (3 nautical miles) (Gorgon Feed Gas Pipeline System) Approximately 5.4 km (Northern Pipeline Route) or 6.5 km (Southern Pipeline Route) (Fourth Train Proposal Feed Gas Pipeline System)
Marine component of the shore crossing	Offshore from North Whites Beach	No change	Offshore from North Whites Beach
Offshore Domestic Gas Pipeline			
Length offshore	Approximately 70 km	No change	Approximately 70 km
Offshore route	East coast of Barrow Island to mainland shore crossing	No change	East coast of Barrow Island to mainland shore crossing
Barge Landing			
Marine components of the Barge Landing (WAPET Landing) upgrade	Marine components of the upgrade of the existing WAPET Landing	No change	Marine components of the upgrade of the existing WAPET Landing
Water Supply			
Source	Seawater intake required	No change	Seawater intake required
Location	Preferred intake location under or adjacent to MOF structure	No change	Preferred intake location under or adjacent to MOF structure
Volume [1]	5150 m^3/day (nominal) raw water supply during normal operations, and up to 12 000 m^3/day (nominal) during the Construction Period	No change	5150 m^3/day (nominal) raw water supply during normal operations, and up to 12 000 m^3/day (nominal) during the Construction Period
Construction water supply [3]	Use of treated greywater, produced fresh water, and sea water for construction earthworks on the LNG treatment plant site	No change	Use of treated greywater, produced fresh water, and sea water for construction earthworks on the LNG treatment plant site
APPLICABLE TO THE ENTIRE PROPOSAL			
Clearing			
All elements of the Proposal	Clearing of native vegetation for the	No change	Clearing of native vegetation for the

Element	Description of the Foundation Project (Statement No. 800)	Description of the Fourth Train Proposal	Description of the Combined Gorgon Gas Development
	purpose of implementing the Proposal		purpose of implementing the Proposal
Discharges of waste from vessels			
Discharges of waste from vessels [4]	Discharges of waste from marine vessels in accordance with MARPOL 73/78	No change	Discharges of waste from marine vessels in accordance with MARPOL 73/78

Notes:

1 Description amended through Attachment 2 to Statement No. 800

2 Description amended through Attachment 5 to Statement No. 800

3 Element added through Attachment 3 to Statement No. 800

4 Element added through Attachment 1 to Statement No. 800

Appendix B: Regulatory Submissions

Appendix B1: EPA Checklist for Documents Submitted for EIA on Marine and Terrestrial Biodiversity

EPA Checklist for Documents Submitted for EIA on Marine and Terrestrial Biodiversity

This checklist is from Appendix 2 of the EPA's Draft Environmental Assessment Guideline No. 6 on Timelines for Environmental Impact Assessment of Proposals.

Purpose

It is hoped that this checklist will be useful to environmental consultants and proponents both during the proponent's initial project planning and environmental scoping process, and specifically in the final checking of documents they intend to submit to the Environmental Protection Authority (EPA) for environmental impact assessment (EIA). This checklist may be refined and reviewed periodically to refer to additional EPA guidance documents.

The purpose of this checklist is to provide the basis for consultants and proponents to conduct initial in-house screening of the quality of their EIA documents. The intent is to more clearly define a minimum standard for the fundamental elements of EIA documentation that is expected to be met before documents are submitted to the EPA. Meeting this minimum standard should, in turn, facilitate timely consideration of documents by the EPA.

The checklist has been set out in four parts. Part 1 addresses general elements of document quality. Parts 2 and 3 deal with key EIA requirements specific to marine and terrestrial biodiversity/marine water quality impacts respectively. Part 4 sets out the requirements for proponent certification of the checklist.

To confirm that each element has been addressed, proponents are asked to place a tick in the boxes provided. Where an element of the checklist is not relevant to the proposal, checking the box with 'N/A' will be adequate.

A copy of this checklist certified by an appropriate proponent representative as complete and accurate must be lodged with EIA documentation submitted to the EPA. Completed checklists will be reviewed by the EPA when documents are lodged. **Incomplete or inaccurate checklists will be returned for proponents to address outstanding matters before the EPA will commence its review of EIA documents.**

It should be noted that the EPA's acceptance of a complete and accurate checklist simply indicates that basic requirements in terms of document quality and general comprehensiveness have been met. **The EPA's acceptance of the checklist does not imply adequacy of technical work or appropriateness of 'policy' application / interpretation.** These matters are reviewed in more detail later in the EIA process.

THE CHECKLIST

Part 1 – General Quality of Documents

Ensure that the following standard elements are present in all documentation (including appendices):

- A clear and concise title that outlines basic information about the proposal and purpose of the document. ✓
- Date and document revision number. ✓
- Information identifying the document's author and publishing entity. ✓
- All issues identified in a scoping guideline or scoping document have been addressed and covered in the report. ✓
- Complete and correct tables of contents, maps, tables and figures. ✓
- Suitably-sized scale maps placing the proposal into both a regional and local context. ✓
- Figures, plates, maps, technical drawings or similar including scale bar, legend, informative caption, labels identifying important or relevant locations/features referred to in the document text. ✓
- All survey site locations and derived data products (e.g. benthic habitat maps, vegetation maps) have been provided in map and appropriate GIS-based electronic database forms. ✓
- All survey data from terrestrial biological surveys have been provided in electronic database form (Access/Excel). ✓
- Proposed infrastructure is shown on scale maps and associated spatial data and are provided in an appropriate GIS-based electronic database form. ✓
- A list of references that have been cross-checked to ensure that all references in the reference list are cited in the text (and vice versa). ✓
- All information based on 'expert' opinion/judgement are explicitly attributed, by name and qualification, to a person/s or organisation. ✓
- Where relevant, appendices are attached to the main EIA document that describe the details of technical work undertaken to underpin the content of the main document, and explicitly attributed by name to the author/s and (if applicable) their organisation. ✓
- Description(s) of the proposal are internally consistent throughout all documentation and are couched to allow potential environmental impacts to be placed in local and regional contexts, including cumulative impacts of existing and approved developments. ✓

Please identify relevant sections of the report in the box below.

- [Executive Summary], [Section 9 Terrestrial Environment – Impacts and Management], [Section 10 Coastal and Nearshore Environment – Impacts and Management] and [Section 13 Matters of National Environment Significance – Impacts and Management] and [Section 15 Cumulative Impacts]

Descriptions of the local and regional environmental features most likely to be directly or indirectly affected by the proposal.

Please identify relevant sections of the report in the box below.

- [Section 6 Environmental and Social Baseline] and [Section 5 Emissions, Discharges and Wastes]

Part 2 – Marine Environmental Issues

For proposals likely to impact on arid zone tropical mangroves in the Pilbara, the EIA document describes how potential impacts have been addressed in the context of Guidance Statement No. 1 (April 2001).

If applicable, please identify relevant sections of the report in the box below.

Not Applicable

For proposals likely to impact on benthic primary producer habitat, the EIA document describes how potential impacts have been addressed in the context of Environmental Assessment Guideline No. 3 (December 2009), including:

- Details of the measures taken to address the Overarching Environmental Protection Principles;
- Scale benthic habitat maps showing the current extent and distribution of benthic habitats and the areas of habitat predicted to be lost if the proposal proceeds;
- Descriptions of technical work (e.g. benthic habitat surveys) carried out to underpin the benthic habitat map (e.g. a technical appendix); and
- Clearly set out calculations of cumulative loss.

If applicable, please identify relevant sections of the report in the box below.

- [Section 1 Introduction] in [Table 1.1 Objects and Principles of the EPBC Act and EP Act]
- [Section 6 Environmental and Social Baseline] in [Figure 6-12 Benthic Primary Producer Habitat Communities Present off the West Coast of Barrow Island in the Vicinity of the Horizontal Directional Drilling Site and the Feed Gas Pipeline System], [Figure 6-13 Benthic Primary Producer Habitat Communities Present off the East Coast of Barrow Island] and [Section 10.7 Benthic Primary Producer Habitats]
- [Section 6 Environmental and Social Baseline] in [Section 6.6.1 Benthic Habitats], [Appendix E1 Key Foundation Project Survey, Audit and Environmental Reporting] and [Appendix E3 Restricted Distribution Flora Species on Barrow Island]
- [Section 10 Coastal and Nearshore Environment – Impacts and Management] in [Section 10.7 Benthic Primary Producer Habitat] and [Section 15 Cumulative Impacts] in [Section 15.5.2.4 Benthic Primary Producer Habitat]

For proposals that involve any type of waste discharge or disposal in State coastal waters between Mandurah and Yanchep, or off the Pilbara coast, potential impacts are couched in the context of the *State Environmental (Cockburn Sound) Policy 2005, Perth's Coastal Waters: Environmental Values and Objectives* (EPA, 2000), or *Pilbara Coastal Water Quality Project Consultation Outcomes* document (DoE, 2006) and relevant guidance provided in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ, 2000).

If applicable, please identify relevant sections of the report in the box below.

- [Section 10: Coastal and Nearshore Environment – Impacts and Management] in [Section 10.7.2.1 Discharges to Sea] and [Section 5 Emissions, Discharges and Wastes]

For proposals that involve any type of waste discharge or disposal in State coastal waters outside of the areas described above, potential impacts are couched in the context of the guidance provided in the *State Water Quality Management Strategy Document No. 6* (Government of WA, 2004) and the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ, 2000).

If applicable, please identify relevant sections of the report in the box below.

Not Applicable

For proposals with potential to impact on an existing or proposed marine conservation reserve, potential impacts are couched in the context of the guidance provided in the relevant indicative or final Management Plan for the reserve on the advice of DEC (now Department of Parks and Wildlife; DPaW) or another designated management agency.

If applicable, please identify relevant sections of the report in the box below.

- [Section 6 Environmental and Social Baseline] in [Section 6.7.1 Montebello/Barrow Island Marine Conservation Reserves], [Section 10 Coastal and Nearshore Environment – Impacts and Management] in [Section 10.8 Conservation Areas], [Section 14.4 Conservation Areas] and [Section 16 Environmental Management Framework] in Section 16.2.2 [Tier 2 – Environmental Assessment and Monitoring Program]

If numerical modeling has been carried out to inform the prediction of environmental impacts, the report(s) associated with this modeling, including the key assumptions, is (are) provided as a technical appendix.

If applicable, please identify the relevant appendix in the box below.

- [Appendix D Technical Studies]

Part 3 – Terrestrial Biodiversity Issues

For proposals with the potential to impact on areas of native vegetation, or other natural environments.

For proposals likely to impact on native flora and vegetation/plant communities, the EIA document describes how potential impacts have been addressed in the context of EPA Guidance Statement No. 51, *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment* (June 2004), including:

- Determining the level of flora and vegetation survey consistent with that expected in Table 3 (Appendix 2);
- Describing the survey area and methodologies, including reference to timing, duration, survey effort, any survey limitations, and the nomenclature used (WA Herbarium);
- Maps and text describing the survey area/plot sites, location of significant species, vegetation mapping, vegetation condition assessment and predicted extent of impact on the vegetation,
- A comprehensive list of flora species identified and assessment of threatened, priority or other significant flora / Ecological Communities (TECs, PECs) known or reasonably expected to occur in the area (as defined in Guidance Statement No. 51); and
- Evaluating the impact of the proposal on the species/communities, including reference to the extent of regional clearing of the vegetation complex/type and ecological linkage.

If applicable, please identify relevant sections of the report in the box below.

- [Section 9 Terrestrial Environment – Impacts and Management] and [Appendix E3 Restricted Distribution Flora Species on Barrow Island]
- [Section 6 Environmental and Social Baseline] in [Section 6.5.1.2 Vegetation] and [Appendix E1 Key Foundation Project Survey, Audit and Environmental Reporting] and [Appendix E3 Restricted Distribution Flora Species on Barrow Island]
- [Section 6 Environmental and Social Baseline] in [Section 6.5.1.2 Vegetation],[Section 9 Terrestrial Environment – Impacts and Management],[Section 9.5 Vegetation and Flora] and [Appendix E1 Key Foundation Project Survey, Audit and Environmental Reporting]
- [Section 6 Environmental and Social Baseline] in [Section 6.5.1.5 Flora of Conservation Significance], [Section 6.5.1.4 Flora], [Appendix E3 Restricted Distribution Flora Species on Barrow Island] and [Section 9 Terrestrial Environment – Impacts and Management]
- [Section 9 Terrestrial Environment – Impacts and Management] in [Section 9.5.2 Assessment and Mitigation of Potential Impacts and [Section 15 Cumulative Impacts]]

For proposals likely to impact on vertebrate fauna or fauna habitat, the EIA document describes how potential impacts have been addressed in the context of EPA Guidance Statement No. 56, *Terrestrial Fauna Surveys for Environmental Impact Assessment* (June 2004), including:

- Determining the level of fauna survey consistent with that expected in Table 3 (Appendix 2) of Guidance Statement No. 56;
- Describing the survey methodologies, including reference to timing, duration and survey effort used to sample each of the fauna groups sampled, any survey limitations and the nomenclature used (WA Museum/Birds Australia);

- Maps and text describing the survey area, fauna habitats and predicted extent of impact on the habitat; and
- A comprehensive list and assessment of vertebrate fauna known or reasonably expect to occur in the area, including Specially Protected and other significant fauna (as defined in Guidance Statement No. 56), and an evaluation of the impact of the proposal on the species and key habitat/s.

If applicable, please identify relevant sections of the report in the box below.

- [Section 9 Terrestrial Environment – Impacts and Management] and [Appendix E1 Key Foundation Project Survey, Audit and Environmental Reporting]
- [Section 9 Terrestrial Environment – Impacts and Management] and [Appendix E1 Key Foundation Project Survey, Audit and Environmental Reporting]
- [Section 6 Environmental and Social Baseline] in [Section 6.5.3 Terrestrial Fauna Species] and [Section 9.6 Terrestrial Fauna] in [Section 9.6.2 Assessment and Mitigation of Potential Impacts]
- [Section 6 Environmental and Social Baseline] in [Section 6.5.2 Terrestrial Fauna Habitat], [Section 6.5.3 Terrestrial Fauna Species], [Section 9.6 Terrestrial Fauna] in [Section 9.6.2 Assessment and Mitigation of Potential Impacts], [Section 9.6.2.8 Conservation significant Species and Habitats], [Section 9.6.4 Predicted Environmental Outcome] and [Appendix E2 Conservation Significant Species Considered for Assessment in this PER/Draft EIS

For proposals with the potential to impact on short range endemic (SRE) invertebrate fauna or SRE habitat, the EIA document describes how potential impacts have been addressed in the context of EPA Guidance Statement No. 20, *Sampling of Short Range Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (May 2009), including:

- Early initial assessment for restricted habitat types that have potential to support SRE fauna, including advice from the WA Museum and the DPaW/OEPA.
- Maps and text describing the survey area, potential SRE habitats and regional context and extent of predicted impact on the habitat.
- Describing the survey methodologies, including reference to timing, duration and survey effort used to sample each of the fauna groups sampled, and any survey limitations.
- A survey report with assessment of SRE fauna found or reasonably expected to occur in the area, including any Specially Protected and other significant fauna, their known occurrence/habitats locally and their wider status if known, and an evaluation of the risk of the proposal to long-term survival of the species and community.

If applicable, please identify relevant sections of the report in the box below.

- [Section 9 Terrestrial Environment – Impacts and Management] and [Appendix E1 Key Foundation Project Survey, Audit and Environmental Reporting]
- [Section 6 Environmental and Social Baseline] in [Section 6.5.3.4 Terrestrial Invertebrates] and [Section 9.6.2 Assessment of Potential Impacts]
- [Appendix E1 Key Foundation Project Survey, Audit and Environmental Reporting]
- [Section 9 Terrestrial Environment – Impacts and Management] and [Appendix E2 Conservation Significant Species Considered for Assessment in this PER/Draft EIS]

For proposals with the potential to impact on subterranean (stygofauna and troglofauna) fauna, the EIA document describes how potential impacts have been addressed in the context of EPA Guidance Statement No. 54 and 54a, *Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia* (Draft 2007), including:

- Early initial desktop review to determine if the site has potentially suitable geology/ substrate habitat that could support subterranean fauna, including advice from the WA Museum and the DPaW/OEPA and a pilot study, if appropriate;
- A subterranean fauna survey report, if the site has a very high or high likelihood of supporting subterranean fauna, or a pilot study indicated that the site supports a significant subterranean fauna;
- Maps and text identifying and describing the survey sites/area, and the geology/ habitat supporting subterranean fauna, and extent of predicted impacts on the habitat (Note the survey area should extend beyond the predicted impact zone);
- Describing the survey methodologies (see Guidance Statement No. 54a), including reference to timing, duration and survey effort used to sample each of the fauna groups sampled, species identification, and any survey limitations; and
- An assessment of subterranean fauna recorded or reasonably expected to occur in the area, including any Specially Protected and other significant fauna and their known occurrence/habitats locally and their wider status if known, and an evaluation of the risk of the proposal to long-term survival of the species and community.

If applicable, please identify relevant sections of the report in the box below.

- [Section 9 Terrestrial Environment – Impacts and Management] and [Appendix E1 Key Foundation Project Survey, Audit and Environmental Reporting]
- [Section 6 Environmental and Social Baseline] in [Section 6.5.3.5.1 Subterranean Fauna Habitat]
- Section 6 Environmental and Social Baseline]in[Section 6.5.3.5 Subterranean Fauna] and [Section 9.7 Subterranean Fauna]
- [Appendix E1 Key Foundation Project Survey, Audit and Environmental Reporting]
- [Section 9 Terrestrial Environment – Impacts and Management] in [Section 9.7 Subterranean Fauna] and [Appendix E2 Conservation Significant Species Considered for Assessment in this PER/Draft EIS]

Part 4 – Proponent's Certification of Completeness and Accuracy of Responses

Name

David Lee

Position

Government Approvals Manager – Greater Gorgon

Signature ....

Date

25 June 2014

Appendix B2: State (Environmental Scoping Document) Requirements for the Contents of this PER

State (Environmental Scoping Document) Requirements for the Contents of this PER

Scoping Document Section Ref.	Detailed State Requirements for the PER/Draft EIS	Section in the PER/Draft EIS where Requirement is Addressed
Scope of the Assessment		
6.2	Identify and consider potential impacts from construction, commissioning and operation of the Fourth Train Proposal on the environmental and socio-economic factors identified in Section 5.3.2 of the Environmental Scoping Document	Section 9 (Terrestrial Environment - Impacts and Management), Section 10 (Coastal and Nearshore Environment - Impacts and Management), Section 11 (Greenhouse Gas Emissions and Energy Management) Section 12 (Quarantine Management); Section 14 (Social, Cultural and Economic Impacts and Management), and Section 15 (Cumulative Impacts)
6.2	Identify impacts reasonably expected from the decommissioning of the Fourth Train Proposal	Section 5.2.3.5 (Atmospheric Emissions from Decommissioning Activities), Section 5.3.3.4 (Light Sources from Decommissioning Activities), Section 5.4.3.3 (Noise Generated by Decommissioning Activities), Section 5.6.2.2.6 (Solid and Liquid Waste from Decommissioning Activities), Section 11.2.2.3 (Greenhouse Gas Emissions [Decommissioning Phase]) Section 9.9 (Decommissioning Activities), Section 10.9 (Potential Impacts during Decommissioning), and Section 14.9 (Decommissioning Activities)
6.1	The PER/Draft EIS should meet the following objectives:	
6.1	- Describe the components of the Fourth Train Proposal	Section 4 (Proposal Description)
6.1	- Place the Fourth Train Proposal in the context of the local and regional receiving environment	Section 6 (Environmental and Social Baseline)
6.1	- Outline the potential impacts of the proposal on factors of the environment	Section 9 (Terrestrial Environment - Impacts and Management), Section 10 (Coastal and Nearshore Environment - Impacts and Management), Section 11 (Greenhouse Gas Emissions and Energy Management) Section 12 (Quarantine Management); Section 14 (Social, Cultural and Economic Impacts and Management) and Section 15 (Cumulative Impacts)
6.1	- Describe Chevron Australia's environmental management program for the Fourth Train Proposal, including a description of how the environmental impacts have been reduced and managed	Section 16 (Environmental Management Framework), Section 5 (Emissions, Discharges and Wastes), Section 9 (Terrestrial Environment - Impacts and Management), Section 10 (Coastal and Nearshore Environment - Impacts and Management), and Section 14 (Social, Cultural and Economic Impacts and Management)
6.1	- Communicate clearly with stakeholders	Executive Summary
6.1	- Address the principles of environmental protection	Section 1, Table 1.1 (Objects and Principles of the EPBC Act and EP Act)
6.1	- Provide comprehensive documentation which demonstrates how the Fourth Train Proposal is environmentally acceptable	ALL (Whole PER/Draft EIS Document)
Stakeholder Engagement		
EPA PER Guidelines Section 5	Describe the public participation and consultation activities undertaken by Chevron Australia in preparing the PER/Draft EIS. This should include a description of the activities undertaken, the dates, the groups/individuals involved and the objectives of the activities. Cross-references should be made to clearly indicate how community concerns have been addressed, and any concerns dealt with outside of the EPA process should be noted and referenced	Section 7 (Stakeholder Engagement), Section 7.4 (Methods of Stakeholder Engagement), Section 7.2 (Purpose of Stakeholder Engagement), Section 7.5 (Stakeholder Issues), and Appendix C (Key Stakeholder List)

State (Environmental Scoping Document) Requirements for the Contents of this PER

Scoping Document Section Ref.	Detailed State Requirements for the PER/Draft EIS	Section in the PER/Draft EIS where Requirement is Addressed
Legal Framework		
6.3	Undertake the assessment of impacts within the legal framework outlined in Section 3.0 of the Environmental Scoping Document	Section 2 (Legislative Framework), Section 5.2.1 (Atmospheric Emissions - Assessment Framework or Policy), Section 5.3.1 (Light Emissions - Assessment Framework or Policy), Section 5.4.1 (Noise and Vibration Emissions - Assessment Framework or Policy), Section 5.5.1 (Discharges to Land and Water - Assessment Framework or Policy), Section 5.6.1 (Solid and Liquid Waste Management - Assessment Framework or Policy), Section 5.7.1 (Accidental Releases - Assessment Framework or Policy), Section 9.3.1.2 (Soils and Landforms - Relevant Plans, Policies and Guidelines), Section 9.4.1.2 (Surface Water and Groundwater - Relevant Plans, Policies and Guidelines), Section 9.5.1.2 (Vegetation and Flora - Relevant Plans, Policies and Guidelines), Section 9.6.1.2 (Terrestrial Fauna - Relevant Plans, Policies and Guidelines), Section 9.7.1.2 (Subterranean Fauna - Relevant Plans, Policies and Guidelines), Section 10.3.1.2 (Foreshore - Relevant Plans, Policies and Guidelines), Section 10.4.1.2 (Seabed [Intertidal and Subtidal] - Relevant Plans, Policies and Guidelines), Section 10.5.1.2 (Marine Water Quality - Relevant Plans, Policies and Guidelines), Section 10.6.1.2 (Marine Fauna - Relevant Plans, Policies and Guidelines), Section 10.7.1.2 (Benthic Primary Producer Habitat - Relevant Plans, Policies and Guidelines), Section 10.8.1.2 (Conservation Areas - Relevant Plans, Policies and Guidelines), Section 11.1.2 (Commonwealth Legislation and Policy), Section 11.1.3 (Western Australian Legislation and Policy) Section 13.2.1.2 (National Heritage Places - Relevant Plans, Policies and Guidelines), Section 13.3.1.2 (Terrestrial Environment - Relevant Plans, Policies and Guidelines), Section 13.4.1.2 (Marine Species and their Habitats - Relevant Plans, Policies and Guidelines), Section 13.5.1.2 (Commonwealth Marine Environment - Relevant Plans, Policies and Guidelines), Section 13.6 (Management Framework Relevant to the Controlling Provisions), Section 14.2.1.2 (Workforce and Public Health and Safety - Relevant Plans, Policies and Guidelines), Section 14.3.1.2 (Cultural Heritage - Relevant Plans, Policies and Guidelines), Section 14.4.1.2 (Conservation Areas - Relevant Plans, Policies and Guidelines), Section 14.5.1.2 (Land and Sea Use - Relevant Plans, Policies and Guidelines), Section 14.6.1.2 (Livelihoods - Relevant Plans, Policies and Guidelines), Section 14.7.1.2 (Local Communities - Relevant Plans, Policies and Guidelines), Section 14.8.1.2 (Commonwealth, State and Regional Economy - Relevant Plans, Policies and Guidelines), Section 16.2.3 (Tier 2 - Environmental Assessment and Monitoring Program), and Section 16.2.4 (Subsidiary Documents)
6.3	Predict and assess the likely environmental consequences in accordance with established guidelines and policies, as referenced in Section 3.4 of the Environmental Scoping Document	Section 2 (Legislative Framework), Section 5 (Emissions, Discharges and Wastes), Section 6 (Environmental Baseline), Section 9 (Terrestrial Environment - Impacts and Management), Section 10 (Coastal and Nearshore Environment - Impacts and Management), Section 11 (Greenhouse Gas Emissions and Energy Management), Section 12 (Quarantine), Section 13 (Matters of NES - Impacts and Management), and Section 14 (Social, Cultural and Economic Impacts and Management)

State (Environmental Scoping Document) Requirements for the Contents of this PER

Scoping Document Section Ref.	Detailed State Requirements for the PER/Draft EIS	Section in the PER/Draft EIS where Requirement is Addressed
Project Description		
6.4	Include a description of the Fourth Train Proposal in sufficient detail to support the subsequent discussion of environmental impacts. This should include:	Section 4 (Proposal Description and Alternatives)
6.4	• relevant maps, charts, and plans of the location and design of the Proposal	Figure 4-1 (Location of the Gas Fields to be Developed for the Fourth Train Proposal), Figure 4-2 (Overview of the Key Fourth Train Proposal Components on or near Barrow Island in Relation to the Approved Foundation Project), Figure 4-3 (Proposed Feed Gas Pipeline System Route Options Included in the Fourth Train Proposal), Figure 4-4 (Location of the Shore Crossing at Barrow Island and an Indicative Layout of the Shore Crossing Area), Figure 4-5 (Onshore Route of the Feed Gas Pipeline System for the Fourth Train Proposal), Figure 4-6 (Indicative Cross-section of the Fourth Train Proposal Onshore Feed Gas Pipeline System Installed within the Approved Foundation Project Feed Gas Pipeline Systems Footprint), Figure 4-7 (Indicative Layout of the Fourth Train Proposal Components of the Gas Treatment Plant), Figure 4-10 (Outline of Horizontal Directional Drilling Procedure), and Figure 4-11 (Location of Reverse Osmosis Facilities including Intake and Outfall Structures).
6.4	• the key characteristics of the Fourth Train Proposal in State (and Commonwealth) jurisdiction and how these relate to existing, approved activities - summarise this info in a table as per example in EPA's PER Guidelines	Table 4-2 (Summary of the Key Offshore Characteristics of the Fourth Train Proposal Compared to the Approved Foundation Project) Table 4-8 (Foundation Project Construction Utilities that are Planned to be Used by the Fourth Train Proposal and Approved Foundation Project), and Appendix A (Project Characteristics)
6.4	• a description of the supporting infrastructure and utilities, including any modifications to Foundation Project facilities	Section 4 (Proposal Description and Alternatives)
6.4	• a description of the nature and extent of the works proposed to construct, commission, and, in outline, to decommission the Fourth Train Proposal	Section 4.3 (Offshore Components), Section 4.4 (Onshore Components), Section 4.5 (Construction Activities), and Section 4.8 (Decommissioning Activities)
6.4	• a description of how the Fourth Train Proposal will be operated, including a process flow/indicative mass balance diagram and associated description of the operational process, and a description of non-routine events and their management	Section 4.7 (Operational Activities), Figure 4-8 [Indicative Block Flow Diagram of the Treatment Process Planned to be Used in the Fourth Train Proposal Gas Treatment Plant), Figure 5-1 [Process Flow Diagram and Approximate Volumes of Key Waste Streams Produced by the Fourth Train Proposal Gas Treatment Plant Operations)
6.4	• the proposed schedule for implementing the Proposal, including the expected design life of the Fourth Train Proposal	Section 1.3.6 (Development Timeline)
6.4	• workforce requirements	Section 4.5.5 (Construction Workforce and Accommodation)
6.4	• management of other aspects related to the Proposal such as waste management and disposal	Section 5.5 (Discharges to Land and Sea), and Section 5.6 (Solid and Liquid Waste Management)
6.4	Demonstrate how the Fourth Train Proposal has been designed to reflect forecast climatic conditions and constraints within the design life of the Proposal	Section 4.9 (Design for Predicted Climate Change)
6.4	Describe the alternatives considered, including location, technology, and technique options. This should provide information on the need, the ability to meet the general goals, the location alternatives, the timing and the implementation mechanisms of the Fourth Train Proposal	Section 4.2 (Alternatives to the Proposed Development), Section 4.3.4.1 (Pipeline Route Options), Section 4.3.4.6 (Offshore Feed Gas Pipeline System Stabilisation and Protection), Section 4.4.3.1 (Inlet Facilities), Section 4.4.3.7 (LNG and Condensate Storage and Offloading), Section 4.4.4.9 (Diesel Supply and Distribution), Section 4.5.1.1 (Drilling and Well Completion), Section 4.5.1.2 (Subsea Facilities), Section 4.5.1.3 (Intrafield Flowlines and Offshore Feed Gas Pipeline System), Section 4.5.3.3 (Laydown Areas), Section 4.5.5 (Construction Workforce and Accommodation), Section 4.5.6 (Pre-commissioning), Section 11.3.1 (Gas Turbine Drivers and Gas Turbine Generators), and Section 11.3.3 (Management of Reservoir Carbon Dioxide)

State (Environmental Scoping Document) Requirements for the Contents of this PER

Scoping Document Section Ref.	Detailed State Requirements for the PER/Draft EIS	Section in the PER/Draft EIS where Requirement is Addressed
Baseline		
6.5	The baseline environment for the Fourth Train Proposal is the status of the environment with all other activities already operational on Barrow Island (including the Foundation Project). Describe the existing environment in a local and regional context covering the environmental factors identified in the Environmental Scoping Document. This should include a description of: • physical environment and processes; • terrestrial biodiversity, ecosystems, and ecosystem processes; • coastal and nearshore biodiversity, ecosystems, and ecosystem processes; and • relevant socio-economic characteristics • existing site condition • other environmental issues that may be constraints or fatal flaws to the proposal	Section 5.2.2 (Baseline Ambient Air Quality), Section 5.3.2 (Baseline Light Sources), Section 5.4.2 (Baseline Noise Levels), and Section 6 (Environmental and Social Baseline)
6.5	Use the following sources to establish the baseline: • data gathered as part of the Foundation Project impact assessment studies, subsequent Environmental Management Plans (EMPs) and Monitoring Programs; • predictions about the status of the environment with an operational Foundation Project taken from Foundation Project impact assessment studies and EMPs, and modelling studies; and • secondary information available in the public domain	Section 6 (Environmental and Social Baseline)
6.5	Where relevant, consider known or predicted changes to the environment that may occur irrespective of, but in the design life of, the Fourth Train Proposal	Section 6.4.10 (Climate Change Projections)
Assessment of Environmental Impacts		
Assessment Method		
6.7.1	The environmental assessment process for the Fourth Train Proposal should follow these steps: 1. Systematic identification of potential impacts of the Fourth Train Proposal on the identified environmental and socio-economic factors compared to those assessed and approved for the Foundation Projects 2. Prediction of the magnitude and assessment of identified incremental and additional impacts taking into account known mitigation and management measures 3. Determining the predicted environmental outcome for each environmental and social factor	Section 8 (Assessment Method)
6.7.1	Ensure the environmental assessment approach addresses and reflects the Environmental Principles and Objectives respectively established in the EPA's Guide to EIA Environmental Principles, Factors and Objectives	Table 1-1 (Objects and Principles of the EPBC Act and the EP Act), and Section 5 (Emissions, Discharges and Wastes), Section 9 (Terrestrial Environment - Impacts and Management), Section 10 (Coastal and Nearshore - Impacts and Management), and Section 14 (Social, Cultural, and Economic Impact and Management).
6.7.1	Apply the following assumptions to the impact assessment for the Fourth Train Proposal: • the impact assessment will assume that the mitigation and management measures committed to by the Foundation Project will be applied where the Fourth Train Proposal activities and designs are alike. Practicable alternative technologies or techniques to those used by the Foundation Project will also be assessed where relevant; and • where available, experience gained from implementing the Foundation Project will be used. This aims to address some of the uncertainties introduced when relying on Foundation Project predictions	Section 8 (Assessment Method)
General - for all Impact Assessment sections		
6.7.1	Discuss the results of the environmental impact assessment, including: • the identification of all potential impacts on the identified environmental and socio-economic factors; • for those residual impacts assessed as key, the likely consequence, mitigation and management options, and predicted effectiveness of the proposed measures should be provided; and • a statement on whether any relevant impacts are likely to be unknown, unpredictable or irreversible	Section 5 (Emissions, Discharges and Wastes), Section 9 (Terrestrial Environment - Impacts and Management), Section 10 (Coastal and Nearshore - Impacts and Management), Section 11 (Greenhouse Gas Emissions and Energy Management), Section 12 (Quarantine Management); Section 14 (Social, Cultural and Economic Impact and Management), and Section 15 (Cumulative Impacts)
EPA PER Guidelines Section 4.3	Include reference to relevant *Environmental Protection Bulletins* and *Position Statements* and demonstrate compliance with associated *Environmental Assessment Guidelines* and *Guidance for the Assessment of Environmental Factors* in the discussion about environmental issues / factors	Section 5 (Emissions, Discharges and Wastes), Section 9 (Terrestrial Environment - Impacts and Management), Section 10 (Coastal and Nearshore - Impacts and Management), and Section 14 (Social, Cultural and Economic Impact and Management)

State (Environmental Scoping Document) Requirements for the Contents of this PER

Scoping Document Section Ref.	Detailed State Requirements for the PER/Draft EIS	Section in the PER/Draft EIS where Requirement is Addressed
EPA PER Guidelines Section 4.3	Discuss the extent to which best practice will be applied to the proposal	Section 5.2.4.2 (Atmospheric Emissions - Proposed Management Actions - Operations Phase)
Emissions, Discharges and Wastes from the Proposal		
6.6	Describe how the Fourth Train Proposal will change the emissions, discharges and wastes assessed and approved for the Foundation Project and explain how these are to be managed and, where relevant, disposed of.	Section 5 (Emissions, Discharges and Wastes)
6.6	This should include atmospheric emissions, noise and vibration, light spill and solid and liquid wastes reasonably expected from the construction and commissioning activities; routine and non-routine operation for the Fourth Train Proposal, and its future decommissioning	Section 5.2 (Atmospheric Emissions), Section 5.3 (Light Emissions), Section 5.4 (Noise and Vibration Emissions), Section 5.5 (Discharges to Land and Water), and Section 5.6 (Solid and Liquid Waste Management).
Table A5-2	Discuss the EPA objectives for emissions, discharges and wastes, and how the Fourth Train Proposal meets these objectives through best practice	Section 5 (Emissions, Discharges and Wastes)
6.6	Discuss emissions, discharges and wastes in context with those generated or predicted by the Foundation Project	Section 5 (Emissions, Discharges and Wastes)
6.6	Where the Fourth Train Proposal could use utilities or infrastructure already approved under the Foundation Project, document how this will affect the emissions, discharges and wastes already predicted and approved for the Foundation Project	Section 4 (Project Description and Alternatives), and Section 5 (Emissions, Discharges and Wastes)
6.6	If inclusion of the Fourth Train Proposal results in a significant change in associated impacts on environmental factors compared to the impacts assessed for the approved Foundation Project, evaluate the incremental and additional change further.	Section 5 (Emissions, Discharges and Wastes)
6.6	Where emissions, discharges, and wastes are expected to be significant (e.g. during routine and non-routine operations), they should be quantified and, where relevant, predicted using mathematical modelling/calculation	Section 5 (Emissions, Discharges and Wastes)
6.6	Interpret potential impacts of predicted incremental and additional emissions, discharges and wastes on relevant terrestrial and marine environmental factors using the results from any modelling studies	Section 9 (Terrestrial Environment - Impacts and Management), Section 10 (Coastal and Nearshore - Impacts and Management), and Section 14 (Social, Cultural and Economic Impact and Management)
6.6	Include a discussion on the likely frequency of non-routine events (e.g. spills, LNG train start-up and upset operating conditions) when discussing associated emissions, discharges, and wastes. Present this discussion in the context of Foundation Project approvals (i.e. if the frequency or duration of non-routine flaring is expected to increase as a result of the Fourth Train Proposal, the impact of that increase on environmental factors will be further assessed)	Section 5.2.3.2.3 (Atmospheric Emissions from Operational Activities - Non-routine Operations), Section 5.2.3.3 (Atmospheric Modelling Studies Methodology), Section 5.2.3.4, (Atmospheric Modelling Results), Section 5.3.3.2 (Light Sources from Operational Activities), Section 5.3.3.3 (Light Spill Modelling), Section 5.4.3.2.2 (Noise and Vibration Generated by Operations Activities - Onshore Components), and Section 5.6.2.2 (Solid and Liquid Waste from Operational Activities).
Atmospheric Pollutant Emissions		
6.6.1	Report the results of dispersion modelling studies predicting how ambient concentrations of atmospheric pollutants (NOx, SOx, CO, PM and O_3) and air toxics (BTEX and H2S) are expected to change as a result of the operation of the Fourth Train Proposal (compared to the baseline of the operational Foundation Project and other existing sources on Barrow Island) and whether these predicted concentrations will be within established air quality standards or maximum allowable concentrations of air toxics at sensitive receptor locations. The dispersion modelling studies should:	Section 5.2 (Atmospheric Emissions), Table 5-8 (Predicted Maximum Ground Level Concentrations for the Fourth Train Proposal and their Comparison to the Ambient Air NEPM), Table 5-9 (Sulfur and Nitrogen Deposition Loads Due to the Fourth Train Proposal and other Regional Sources), Table 5-10 (Maximum Ground-level Concentrations of Air Toxics, within the Gas Treatment Plant, from a Fourth Train Proposal Acid Gas Vent and Foundation Project Acid Gas Vents), and Table 5-11 (Maximum Ground-level Concentrations of Air Toxics, within Butler Park (Construction Village), from a Fourth Train Proposal Acid Gas Vent and Foundation Project Acid Gas Vents)
6.6.1.3	- be undertaken consistent with the Western Australian Department of the Environment's (now DEC) Air Quality Modelling Guidance Notes (for atmospheric pollutant modelling)	Section 5.2 (Atmospheric Emissions), Section 5.2.1.3.2, and Appendix D1 (Gorgon Gas Development Fourth Train Proposal Air Quality Assessment) - Section 4.6.1 (TAPM - Description) therein.
6.6.1.3	- review, analyse and describe local meteorology addressing long-term trends for temperature, wind speed, wind direction, humidity, and rainfall	Appendix D1 (Gorgon Gas Development Fourth Train Proposal Air Quality Assessment) - Section 5 (Model Validation Against Metrology) therein.

State (Environmental Scoping Document) Requirements for the Contents of this PER

Scoping Document Section Ref.	Detailed State Requirements for the PER/Draft EIS	Section in the PER/Draft EIS where Requirement is Addressed
6.6.1.1	- predict the ambient airborne concentrations of the key atmospheric pollutants and air toxics that may increase as a result of the operation of the fourth LNG train and associated infrastructure within the Gas Treatment Plant, under routine and non-routine operating conditions	Section 5.2 (Atmospheric Emissions), Table 5-8 (Predicted Maximum Ground Level Concentrations for the Fourth Train Proposal and their Comparison to the Ambient Air NEPM), Table 5-9 (Sulfur and Nitrogen Deposition Loads Due to the Fourth Train Proposal and other Regional Sources), Table 5-10 (Maximum Ground-level Concentrations of Air Toxics, within the Gas Treatment Plant, from a Fourth Train Proposal Acid Gas Vent and Foundation Project Acid Gas Vents), and Table 5-11 (Maximum Ground-level Concentrations of Air Toxics, within Butler Park (Construction Village), from a Fourth Train Proposal Acid Gas Vent and Foundation Project Acid Gas Vents)
6.6.1.2	- include the air emissions sources reasonably expected from the routine and non-routine operation of the fourth LNG train at the Gas Treatment Plant, and of emissions reasonably expected from additional condensate offloading and LNG shipping.	Section 5.2.3.2 (Atmospheric Emissions from Operational Activities), Table 5-4 (Inventory of Atmospheric Emissions from Routine Operations of the Fourth Train Proposal (tonnes/year) per Emission Source), and Appendix D1 (Gorgon Gas Development Fourth Train Proposal Air Quality Assessment) - Section 6 (Predicted Local Concentrations) and 7 (Predicted Regional Concentrations) therein
6.6.1.2	- include atmospheric pollutant emissions of the Fourth Train Proposal in combination with those of the Foundation Project and other existing industrial emissions sources on Barrow Island	Section 5.2.3.4.1 (Atmospheric Pollutant Air Quality Modelling Study Results), and Appendix D1 (Gorgon Gas Development Fourth Train Proposal Air Quality Assessment) - Section 6 (Predicted Local Concentrations) and 7 (Predicted Regional Concentrations) therein
6.6.1.3	- predict local concentrations of NO2, SO2, CO, and PM for the Fourth Train Proposal (covering the Fourth Train Proposal emissions in addition to those of the Foundation Project and WA Oil operations)	Section 5.2.3.4.1 (Atmospheric Pollutant Air Quality Modelling Study Results), and Appendix D1 (Gorgon Gas Development Fourth Train Proposal Air Quality Assessment) - Section 6 (Predicted Local Concentrations) therein
6.6.1.3	- predict regional concentrations of O3 and nitrogen dioxide NO2 (as representative for nitrogen oxides) for a number of scenarios.	Section 5.2.3.4.1 (Atmospheric Pollutant Air Quality Modelling Study Results), and Appendix D1 (Gorgon Gas Development Fourth Train Proposal Air Quality Assessment) - Section 7 (Predicted Regional Concentrations) therein
6.6.1.2	- assess the air toxics emissions of the Fourth Train Proposal in combination with those of the Foundation Project. Justify omitting WA Oil emissions from this air toxics study	Section 5.2.3.4.2 (Air Toxics Dispersion Modelling Study Results), and Appendix D2 (Gorgon Expansion Project Phase 2 Acid Gas Vent Dispersion Modelling) Section 4 (Results) therein
6.6.1.3	- Predict ground-level concentrations of air toxics reasonably expected from acid gas venting events from all four LNG trains at the Gas Treatment Plant. Incremental and additional impacts on ground-level concentrations of H_2S and BTEX from the operation of four LNG trains should be predicted and include a frequency assessment component	Section 5.2.3.4.2 (Air Toxics Dispersion Modelling Study Results), and Appendix D2 (Gorgon Expansion Project Phase 2 Acid Gas Vent Dispersion Modelling) Section 4 (Results) therein
6.6.1.3	Results of the air quality modelling should be presented as: - contour plots for the pollutants of concern, both for regional and local modelling;	Figure 5-2 (Predicted Maximum 4-hour Ozone Concentrations (ppb) including the Fourth Train Proposal and Foundation Project under Routine Operations), and Appendix D1 (Gorgon Gas Development Fourth Train Proposal Air Quality Assessment) - Figure 6-1 to 8-8 therein
6.6.1.3	- tables showing the change from the baseline for both regional and local modelling cases; and	Table 5-8 (Predicted Maximum Ground Level Concentrations for the Fourth Train Proposal and their Comparison to the Ambient Air NEPM), and Appendix D1 (Gorgon Gas Development Fourth Train Proposal Air Quality Assessment) - Tables 6-1 to 7-2 therein
6.6.1.3	- a comparison with relevant air quality criteria for human health and environmental (flora and fauna) receptors, including a justification of the appropriateness of the selected criteria	Section 5.2.1 (Assessment Framework or Policy), Table 5-8 (Predicted Maximum Ground Level Concentrations for the Fourth Train Proposal and their Comparison to the Ambient Air NEPM), and Appendix D1 (Gorgon Gas Development Fourth Train Proposal Air Quality Assessment) - Figure 6-2, 6-4, 7-2 therein.
Table A5-2	The following should also be reported: - potential impacts on air quality during construction of terrestrial infrastructure, operation of the Gas Treatment Plant, and reasonably expected emissions from the loading and export of additional LNG and condensate	Section 5.2.3 (Assessment of Potential Impacts), and Appendix D1 (Gorgon Gas Development Fourth Train Proposal Air Quality Assessment) - Tables 6-1 to 7-2 therein
6.6.1.2	- an inventory of predicted fugitive air emissions (such as VOCs) from the Fourth Train Proposal, Foundation Project and existing sources on Barrow Island (i.e. WA Oil operations) and justify why these are not included in dispersion modelling.	Table 5-4 (Inventory of Atmospheric Emissions from Routine Operations of the Fourth Train Proposal (tonnes/year) per Emission Source)
6.6.1.3	- a load inventory for National Pollutant Inventory substances emitted to air by the Fourth Train Proposal during routine and non-routine operations (including both point and fugitive sources)	Table 5-4 (Inventory of Atmospheric Emissions from Routine Operations of the Fourth Train Proposal (tonnes/year) per Emission Source)
6.6.1.3	- an emissions inventory for the region incorporating major industrial sources including the Karratha, Dampier, Onslow, and Cape Lambert regions. Anticipated major industrial sources to be included are listed in Appendix 7. Information on these major industrial sources are to be included, where available using data obtained from the NPI, or information supplied to, or by Chevron Australia. Include existing Chevron Australia operations on Barrow and Thevenard Islands. Consider the impact of fires in the Pilbara and their impact on ozone formation	Appendix D1 (Gorgon Gas Development Fourth Train Proposal Air Quality Assessment) - Table 2-7 therein

Public

State (Environmental Scoping Document) Requirements for the Contents of this PER

Scoping Document Section Ref.	Detailed State Requirements for the PER/Draft EIS	Section in the PER/Draft EIS where Requirement is Addressed
6.6.1.3	- assumptions made in determining emissions rates, volumes, and pollutant constituents, and the level of certainty in the results	Appendix D1 (Gorgon Gas Development Fourth Train Proposal Air Quality Assessment) - Section 2, 4, 5 therein
6.6.1.3	- the smokeless performance of the Gas Treatment Plant flares, and the scenarios under which this performance may be compromised. Information should be provided on the expected frequency of those scenarios and smoke mitigation measures	Section 5.2.3.2 (Atmospheric Emissions from Operational Activities)
Table A5-2	- a review of the effectiveness applying the same mitigation and management measures approved for the Foundation Project should be reviewed, and where relevant and applicable, the feasibility of realistic alternative technologies should be examined	Section 5.2.4 (Proposed Management Actions)
6.6.1.3	Air quality and dispersion modelling results are to be used to inform the assessment of impacts on the flora and fauna of Barrow Island, and of sensitive human and ecological receptors on the West Pilbara mainland. The results should also feed into detailed design work to maintain air quality impacts within acceptable risk levels	Section 9.5.2.2 (Vegetation and Flora - Atmospheric Emissions [except dust]), Section 9.6.2.3 (Terrestrial Fauna - Atmospheric Emissions [except dust]), Section 10.6.2.1 (Marine Fauna - Atmospheric Emissions [except dust]), and Section 14.2.2.1 (Atmospheric Emissions [except dust]).
Greenhouse Gas Emissions		
Table A5-2	The following should be reported and discussed • emissions generated from vessel, vehicle and equipment engines and power generation during construction • key GHG emission sources and predicted volumes reasonably expected from the operational Fourth Train Proposal • management of reservoir and process CO_2 at the Gas Treatment Plant during operation	Section 11.2 (Greenhouse Gas Emissions), and Section 11.3 (Proposed Greenhouse Gas Emissions and Energy Efficiency Management Measures)
6.6.2.3	Compile the Greenhouse Gas Emissions estimates using the factors and methodologies defined in the *National Greenhouse and Energy Reporting Act 2007* (Cth)	Section 11.2.2 (Predicted Emissions)
6.6.2.2	Investigate a range of viable options for greenhouse gas emissions management. This range of development and management options should be presented and evaluated together with: • average anticipated reservoir CO_2 content for the Fourth Train Proposal gas fields; and • total greenhouse gas emissions reasonably expected from each credible development and design option for the Fourth Train Proposal	Section 11.3 (Proposed Greenhouse Gas Emissions and Energy Efficiency Management Measures)
6.6.2.2	Present and evaluate a range of credible design options for managing both process and reservoir CO_2 emissions, and examine the full scope of emissions from the Fourth Train Proposal, including: • technical options for the management of reservoir CO2 such as injection of reservoir CO2 and venting; • the use of aero derivative gas turbines, industrial gas turbines, or electric drives to power the liquefaction compressors; • the use of aero derivative or industrial gas turbines for electrical power generation; • opportunities to recover and use waste heat and pressure let down; • opportunities to recover and use, or otherwise manage, emissions from vent streams that would otherwise be vented to the atmosphere; • where vents cannot be redirected into the process stream, the opportunity to reduce the environmental impact of these vents; and • opportunities to reduce and eliminate fugitive emissions streams	Section 11.3 (Proposed Greenhouse Gas Emissions and Energy Efficiency Management Measures)
6.6.2.2	Include an account of any technical, health, safety, environmental, or economic constraints reasonably expected for each viable option	Section 11.3 (Proposed Greenhouse Gas Emissions and Energy Efficiency Management Measures)
6.6.2.2	Draw on relevant assessments undertaken as part of the Foundation Project, complemented by additional studies. These additional studies include the detailed assessment of subsurface injection of reservoir CO2 under Foundation Project approved parameters.	Section 11.3.3 (Management of Reservoir Carbon Dioxide)
6.6.2.2	Consider the role that a national legislative framework for managing greenhouse gas emissions, including the *Clean Energy Act 2011* (Cth), may have on the range of greenhouse gas management options	Section 11.1.2 (Commonwealth Legislation and Policy)
6.6.2.2	Include the estimated volume of reservoir CO_2 generated as a result of the implementation of the Fourth Train Proposal and the results of CO_2 Dupuy Simulation Modelling predicting the behaviour of injected CO_2 from the Fourth Train Proposal and the Foundation Project in the Dupuy Formation	Section 11.2.2 (Operations Phase), and Section 11.3.3 (Management of Reservoir Carbon Dioxide)
6.6.2.2	Present the level of assurance of the Fourth Train Proposal, in addition to the Foundation Project CO_2 plume migration in the Dupuy Formation over time	Section 11.3.3.2 (Injection of Reservoir Carbon Dioxide)
6.6.2.2	For each viable design option, present the emissions profiles, as incremental (i.e. Fourth Train Proposal alone) and in combination with the Foundation Project.	Section 11.3.7 (Emissions Reduction from Proposed Management)

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6.6.2.2	Describe the timing of Foundation Project and Fourth Train Proposal emissions on the basis of each LNG train coming online	Section 11.2.2.1 (Methodology and Assumptions)
6.6.2.3	Assess the technical, economic, and environmental practicality of greenhouse gas management options using the following criteria: • health and safety risk (using Chevron Australia's internal standards); • economic (using Chevron Australia's estimate of Australia's forward emissions price curve); • operability and reliability (using Chevron Australia's internal standards); and • other environmental impacts (e.g. impacts on key atmospheric pollutants [e.g. NO_x, SO_x, CO, PM, and O_3], water usage, land requirements)	Section 11.3 (Proposed Greenhouse Gas Emissions and Energy Efficiency Management Measures)
6.6.2.3	Undertake the assessment with reference to the commitments on the Gorgon Joint Venturers within the Barrow Island Act, the State Agreement, previous approvals for the Foundation Project and the EPA's Guidance Statement No. 12 for Minimising Greenhouse Gas Emissions	Section 11 (Greenhouse Gas Emissions and Energy Management)
6.6.2.2	Benchmark the emissions intensity estimates for the Fourth Train Proposal against emissions from other comparable projects in Australia and a number of recent international projects (where data are publicly available). Provide life cycle emissions estimates against a range of competing fuel types	Section 11.4.1 (11.4.1 Greenhouse Gas Emissions Intensity Benchmark), and Section 11.2.4.1 (Global Emissions)
6.6.2.2	Provide a benchmark comparison of process technologies included in the Fourth Train Proposal with technologies used in other recent comparable Australian and international projects to demonstrate the use of currently available best practice technologies	Section 11.4 (Benchmarking), Figure 11-3 (Benchmarking Greenhouse Gas Emissions Intensity), and Table 11-6 (Technology Comparison of LNG Projects in Australia)
6.6.2.1	Demonstrate that GHG emissions from the Fourth Train Proposal have been reduced to a level that is as low as reasonably practicable	Section 11.3 (Proposed Greenhouse Gas Emissions and Energy Efficiency Management Measures), Section 11.4 (Benchmarking), and Table 11-7 (Technology Comparison of LNG Projects in Australia).
6.6.2.2	Consider the role that that practicable, cost-effective, technically feasible, and operationally compatible greenhouse gas offsets might play in managing emissions from the Fourth Train Proposal	Section 11.3.8 (Greenhouse Gas Emissions Offsets)
Noise Emissions		
Table A5-2	Describe how the Fourth Train Proposal will change environmental noise during construction and operation, taking into account an operational Foundation Project	Section 5.4.3 (Noise and Vibration Emissions - Assessment of Potential Impacts)
Table A5-2	Use noise modelling to establish the baseline and to predict changes introduced by addition of an operational Fourth Train Proposal at the Gas Treatment Plant	Section 5.4.2 (Baseline Noise Level), and Section 5.4.3 (Noise and Vibration Emissions - Assessment of Potential Impacts)
6.6.3.1	Update the predictions of noise levels from the Foundation Project using the noise emissions study to account for the addition of the Fourth Train Proposal infrastructure.	Section 5.4.2 (Baseline Noise Level), and Section 5.4.3 (Noise and Vibration Emissions - Assessment of Potential Impacts)
6.6.3.2	Predict noise levels from the operating Foundation Project and Fourth Train Proposal infrastructure at the Gas Treatment Plant during normal operating conditions and also during start-up of the Fourth Train Proposal infrastructure	Section 5.4.3 (Noise and Vibration Emissions - Assessment of Potential Impacts)
6.6.3.2	Predict both incremental and additional noise emissions for the operational Gas Treatment Plant	Section 5.4.3 (Noise and Vibration Emissions - Assessment of Potential Impacts)
6.6.3.3	Perform in-plant and surrounding noise predictions using the International Organization for Standardization's (ISO) 9613 prediction methods	Section 5.4.3 (Noise and Vibration Emissions - Assessment of Potential Impacts), and Appendix D4 (Cumulative Noise Impact Study for the Gorgon Expansion Project Barrow Island LNG Plant) - Section 4.1 therein
6.6.3.3	Undertake the noise study in accordance with EPA Guidance Statement No. 8 – The Assessment of Environmental Factors, Environmental Noise and other guidelines or legislation as applicable. The study should be used to update the predictions of noise levels made in the most recent Foundation Project noise study	Section 5.4.1.3 (State Guidelines), and Appendix D4 (Cumulative Noise Impact Study for the Gorgon Expansion Project Barrow Island LNG Plant) - Section 2.2 therein
6.6.3.3	Use recognised modelling software to calculate and graphically present both in-plant and surrounding noise levels generated by the Gas Treatment Plant	Section 5.4.3 (Noise and Vibration Emissions - Assessment of Potential Impacts), and Appendix D4 (Cumulative Noise Impact Study for the Gorgon Expansion Project Barrow Island LNG Plant) - Section 5, Appendix C therein
6.6.3.3	Benchmark the predicted noise levels at noise sensitive receptors on Barrow Island against the Environmental Protection (Noise) Regulations 1997 to assess the impacts on human (worker) health. Noise impacts on terrestrial fauna should be assessed with reference to a 50 dB(A) contour, and noise impacts on marine fauna will be assessed with reference to published research (e.g. OSPAR 2009, NRC 2003, Simmonds et al. 2004 and 2005 and Southall et al. 2007). A justification for the selection of noise criteria should also be provided	Section 5.4.3 (Noise and Vibration Emissions - Assessment of Potential Impacts), Section 9.6.2.6 (Terrestrial Fauna - Noise and Vibration) Section 10.6.2.4 (Marine Fauna - Noise and Vibration), Section 10.6.2.4.1 (Noise and Vibration - Cetaceans), and Section 10.6.2.4.3 (Noise and Vibration - Fish)
Table A5-2	Review the effectiveness of mitigation and management measures and revise these where necessary. Where relevant and practicable, examine the feasibility of realistic alternative technologies	Section 5.4.4 (Noise and Vibration - Proposed Management Actions)

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Table A5-2	Use results of noise prediction modelling to determine the expected impacts to terrestrial and marine fauna on and around Barrow Island (specifically on disturbance to and potential impacts on the behaviour and breeding of terrestrial and marine fauna as a result of noise generated during construction and operation of the Fourth Train Proposal)	Section 9.6.2.6 (Terrestrial Fauna - Noise and Vibration), Section 9.6.2.8.3 (White-winged Fairy-wren (Barrow Island)), and Section 10.6.2.4 (Marine Fauna - Noise and Vibration)
Light Spill		
Table A5-2	The change in light spill introduced by the Fourth Train Proposal compared to the Foundation Project should be predicted and used to assess impacts on the behaviour and breeding of terrestrial and marine fauna.	Section 5.3.3.3 (Light Spill Modelling), Section 9.6.2.7 (Terrestrial Fauna - Artificial Light), Section 10.6.2.2 (Marine Fauna - Artificial Light), 16.2.1 (Experience Gained), and Appendix D3 (Gorgon Light Emissions Study - Fourth Train Proposal) - Section 4 therein
6.6.4.3	Undertake light spill modelling for a number of scenarios, including the baseline of an operating Foundation Project, the operation of the four LNG trains under normal operating conditions and under maintenance conditions where work is being carried out on one of the LNG trains and/or the LNG tanks. Both the incremental change caused by the Fourth Train Proposal and the total light spill caused by the Foundation Project and the Fourth Train Proposal should be predicted and presented using light contours	Section 5.3.2 (Baseline Light Sources), Section 5.3.3.3 (Light Spill Modelling), and Appendix D3 (Gorgon Light Emissions Study - Fourth Train Proposal) - Section 4 therein
6.6.4.2	The scope of the modelling study should include lighting in all areas inside the Gas Treatment Plant site where practicable, including: • all lit process facilities; • ground flares; • Boil-off Gas flares; • utilities; • wavelength of luminaires; and • shielding and screening effects of structures	Section 5.3.3.3 (Light Spill Modelling), and Appendix D3 (Gorgon Light Emissions Study - Fourth Train Proposal) - Section 3 therein
6.6.4.2	Include an explanation of the selection of areas and facilities included in the light modelling. Where practicable, consider the effects of the following factors on light levels: • topography (including dune heights); and • cloud cover	Section 5.3.3.3 (Light Spill Modelling), and Appendix D3 (Gorgon Light Emissions Study - Fourth Train Proposal) - Sections 2 and 3 therein
6.6.4.3	Use the modelling results to compare the light spill attributable to the operation of the Fourth Train Proposal with predicted light spill levels for the Foundation Project. In particular, comparisons are to be made of how the Fourth Train Proposal and Foundation Project together could alter the natural light regime	Section 5.3.3.3 (Light Spill Modelling), and Table 5-13 (Illuminance Levels at Bivalve Beach)
6.6.4.3	Light modelling results should also be used to test the design of lighting systems at the Gas Treatment Plant, and demonstrate the effectiveness of light management controls in reducing light spill to levels that are as low as reasonably practicable	Section 5.3.3 (Light Emissions - Assessment of Potential Impacts), Section 5.3.4 (Light Emissions - Proposed Management Actions), and Appendix D3 (Gorgon Light Emissions Study - Fourth Train Proposal) - Section 4 therein
Table A5-2	Design the lighting systems and operational controls for the Fourth Train Proposal to reflect the Long-term Marine Turtle Management Plan prepared for the Foundation Project. However, include discussion which reviews the effectiveness of Foundation Project mitigation and management measures and propose any revisions to these where necessary	Section 3.5.2.1 (Marine Turtles), Section 5.3.4 (Light Emissions - Proposed Management Actions), and Appendix D3 (Gorgon Light Emissions Study - Fourth Train Proposal)
6.6.4.1	Use the light spill modelling outputs to inform an assessment of impacts on terrestrial fauna and marine turtles from the operation of the Fourth Train Proposal's Gas Treatment Plant	Sections 9.6.2.7 (Terrestrial Fauna - Artificial Light), and Section 10.6.2.2 (Marine Fauna - Artificial Light)

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Hydrocarbon Spills		
6.6.5.1	Undertake hydrocarbon spill modelling to predict the behaviour of marine hydrocarbon spills under different spill and environmental conditions.	Section 5.7.2.1 (Fate and Transport of Spilled Hydrocarbons [Oil Spill Modelling])
6.6.5.2	Develop and assess a series of hydrocarbon spill scenarios covering accidental releases occurring at sea during the construction and operation of the Fourth Train Proposal. Relevant scenarios should include: • well blow-outs; • pipeline ruptures; and • vessel collisions or groundings	Section 5.7.2.1 (Fate and Transport of Spilled Hydrocarbons [Oil Spill Modelling])
6.6.5.2	Assess the likelihood of spills occurring in the terrestrial environment as a result of the Fourth Train Proposal relevant to those assessed for the approved Foundation Project. (note this is outside the scope of the hydrocarbon spill modelling).	Section 9.3.2.2 (Soils and Landforms - Spills and Leaks), Section 9.4.2.3 (Surface Water and Groundwater - Spills and Leaks), Section 9.5.2.3 (Vegetation and Flora - Spills and Leaks), Section 9.6.2.2 (Terrestrial Fauna - Spills and Leaks), and Section 9.7.2.3 (Subterranean Fauna - Spills and Leaks).
6.6.5.3	Selected scenarios are to reflect: • weather conditions, including cyclones; and • seasonality	Appendix D5 (Assessment of Environmental Risk - Hydrocarbon Spill) - Appendix 1 therein
6.6.5.3	Plot modelling results as risk contours on a spatial area, incorporating relevant areas of the Western Australian coastline	Appendix D5 (Assessment of Environmental Risk - Hydrocarbon Spill) - Appendix 1 therein
6.6.5.1	Use the results of this modelling to assess impacts of accidental releases of hydrocarbons to the marine and coastal environment and any change in likelihood due to the Fourth Train Proposal compared to that assessed and approved for the Foundation Project. Results should also be used to determine the need for, and design of, mitigation measures to reduce the risk of spills occurring, and the impact they may have if they do occur	Section 5.7.2.1.3 (Hydrocarbon Spill Modelling Results), Appendix D5 (Assessment of Environmental Risk - Hydrocarbon Spill) - Appendix 2 therein, Section 10.3.2.1 (Foreshore - Spills and Leaks), Section 10.4.2.4 (Seabed [Intertidal and Subtidal] - Spills and Leaks), Section 10.5.2.3 (Marine Water Quality - Spills and Leaks), Section 10.6.2.8 (Marine Fauna - Spills and Leaks), Section 10.7.2.4 (Benthic Primary Producer Habitat - Spills and Leaks), Section 13.2.2.2 (National Heritage Places - Spills and Leaks), Section 13.4.2 (Assessment and Mitigation of Potential Impacts), Section 13.5.9 (Commonwealth Marine Environment - Spills and Leaks), and Section 14.5.2.3 (Spills and Leaks)
Discharges to Sea		
Table A5-2	Identify and estimate any change in discharges to the sea compared to those anticipated for the approved Foundation Project. Where wastewater infrastructure could be used by the Fourth Train Proposal, the incremental change and additional volumes/durations/concentrations, etc. introduced by the Fourth Train Proposal should be compared to the Foundation Project and documented as relevant. Baseline information and technical studies conducted for Foundation Project approvals should be used where available. Monitoring data, audit results and observations from the Foundation Project should be used, where available and relevant, to substantiate construction-phase predictions	Section 4.5.3.4.1 (Reverse Osmosis Facilities), Section 4.5.3.2 (Sanitary Wastewater Systems), Section 5.5.2 (Discharges to Land and Water - Baseline Discharges), and Section 5.5.3 (Discharges to Land and Water - Assessment of Potential Impacts)
6.6	Explain that wastewater volumes generated for injection by the Fourth Train Proposal and the Foundation Project can be accommodated in the subsurface aquifer	Section 5.5.3 (Discharges to Land and Water - Assessment of Potential Impacts)
6.6	Justify that the volumes of fresh water required for the Fourth Train Proposal can be provided by the Foundation Project's reverse osmosis facilities and will not exceed the approved Foundation Project levels or levels that the Foundation Project is seeking approval for, in the case of the permanent reverse osmosis facilities. Reference Foundation Project technical studies to substantiate this.	Section 4.5.3.4.1 (Construction Activities - Onshore Facilities - Reverse Osmosis Facilities), and Section 4.7.2.2.1 (Operational Activities - Onshore Facilities - Reverse Osmosis Facilities).
6.6	Request to extend the duration of use of Foundation Project waste water management infrastructure.	Section 4.5.3.4.2 (Construction Activities - Onshore Facilities - Sanitary Wastewater Systems), and Section 4.7.2.2.2 (Operational Activities - Onshore Facilities - Sanitary Wastewater Systems)
6.6	Justify why no modelling is necessary.	Section 5.5.3 (Discharges to Land and Water - Assessment of Potential Impacts)

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6.6	In the event that discharges are found to change significantly from the Foundation Project, modelling should be used to predict associated water quality and ecological impacts	Section 5.5.3 (Discharges to Land and Water - Assessment of Potential Impacts)
Table A5-2	Review the effectiveness of mitigation and management measures and propose revisions to these where necessary. Examine the feasibility of realistic alternative technologies where relevant and practicable	Section 3.5 (Environmental Monitoring), Table 16-1 (Experience Gained from the Foundation Project relevant to the Fourth Train Proposal), and Table 16-2 (Approved Foundation Project EMPs Relevant to the Fourth Train Proposal).
6.6	Use the results of predictions to examine impacts on coastal and nearshore water quality	Section 10.5.2.1 (Marine Water Quality - Discharges to Sea)
Solid and Liquid Waste		
6.6	Outline the predicted quantities of significant operational solid and liquid waste likely to be generated by the Fourth Train Proposal compared to those assessed and approved for the Foundation Project (e.g. as illustrated in Table 6-1 of the ESD). Describe how they will be managed	Section 5.6 (Solid and Liquid Waste Management)
Impacts on the Terrestrial Environment		
6.7.2	Examine all impacts of the Fourth Train Proposal expected on the terrestrial environment of Barrow Island including those identified against each terrestrial environmental factor in Appendix A5-1 of the Environmental Scoping Document.	Section 9 (Terrestrial Environment - Impacts and Management)
6.7.2 and EPA's PER Guidelines	With the exception of air quality, impacts are expected to be restricted to Barrow Island. Impacts resulting from operational atmospheric emissions of the Fourth Train Proposal may extend to the Pilbara airshed. Define this relevant area of assessment.	Section 5.2.3.3 Atmospheric Modelling Results), Appendix D1 (Gorgon Gas Development Fourth Train Proposal Air Quality Assessment), Section 9.5.2.2 (Vegetation and Flora - Atmospheric Emissions [except dust]), and Section 9.6.2.3 (Terrestrial Fauna - Atmospheric Emissions [except dust]).
EPA's PER Guidelines	Explain the relevance of the physical and biological environment factors to the Fourth Train Proposal, and how they are significant	Section 6 (Environmental and Social Baseline)
EPA's PER Guidelines	Provide a description of all relevant standards / regulations / policies relevant to the physical and biological environment factors	Section 2 (Legislative Framework), Table 9.1 (Key Legislation Relevant to the Terrestrial Environment) Section 9.3.1.2 (Soils and Landforms - Relevant Policies, Plans, and Guidelines), Section 9.4.1.2 (Surface Water and Groundwater - Relevant Policies, Plans, and Guidelines), Section 9.5.1.2 (Vegetation and Flora - Relevant Policies, Plans, and Guidelines), Section 9.6.1.2 (Terrestrial Fauna - Relevant Policies, Plans, and Guidelines), and Section 9.7.1.2 (Subterranean Fauna - Relevant Policies, Plans, and Guidelines).
6.7.2	Revisit the potential impacts and stressors to the terrestrial environment in a risk assessment process, and: - include any additional risks in the assessment - justify the omission from further discussion of any potential impacts or stressors identified in the Environmental Scoping Document	Section 8.2.2 (Identification of Environmental Stressors and Factors that Could Cause Potential Impacts), Section 8.2.3 (Preliminary Identification of Potential Impacts), Section 8.3 (Assessment Phase), and Section 9.1 (Introduction)
6.7.6	Inform predictions by drawing on experience gained from the implementation of the Foundation Project. Available data should include: • audit findings associated with the implementation of mitigation and management measures; • terrestrial environmental monitoring around the HDD site, Feed Gas Pipeline Systems, the Gas Treatment Plant, and Construction Village, and at other sites/areas being monitored by the Foundation Project	Section 3.5.1 (Terrestrial Monitoring), Section 9.3.2 (Soils and Landforms - Assessment and Mitigation of Potential Impacts), Section 9.4.2 (Surface Water and Groundwater - Assessment and Mitigation of Potential Impacts), Section 9.5.2 (Vegetation and Flora - Assessment and Mitigation of Potential Impacts), Section 9.6.2 (Terrestrial Fauna - Assessment and Mitigation of Potential Impacts), Section 9.7.2 (Subterranean Fauna - Assessment and Mitigation of Potential Impacts), and Section 16.2.1 (Experience Gained)
6.7.6	Document relevant uncertainties regarding predicted impacts	Section 9.3.2 (Soils and Landforms - Assessment and Mitigation of Potential Impacts), Section 9.4.2 (Surface Water and Groundwater - Assessment and Mitigation of Potential Impacts), Section 9.5.2 (Vegetation and Flora - Assessment and Mitigation of Potential Impacts), Section 9.6.2 (Terrestrial Fauna - Assessment and Mitigation of Potential Impacts), and Section 9.7.2 (Subterranean Fauna - Assessment and Mitigation of Potential Impacts).
6.7.2	Present the assessment of impacts on the terrestrial environment as both the incremental change introduced by the Fourth Train Proposal alone, and the additional impact of the combined Foundation Project and Fourth Train Proposal when added to the impacts assessed and approved for the Foundation Project	Section 9.3.2 (Soils and Landforms - Assessment and Mitigation of Potential Impacts), Section 9.4.2 (Surface Water and Groundwater - Assessment and Mitigation of Potential Impacts), Section 9.5.2 (Vegetation and Flora - Assessment and Mitigation of Potential Impacts), Section 9.6.2 (Terrestrial Fauna - Assessment and Mitigation of Potential Impacts), and Section 9.7.2 (Subterranean Fauna - Assessment and Mitigation of Potential Impacts).
6.7.2	Examine the incremental and additional change in associated impacts where the Fourth Train Proposal may use utilities or infrastructure already approved under the Foundation Project	Section 4 (Project Description), and Section 9 (Terrestrial Environment - Impacts and Risks).
6.7.2	Use predictions of emissions, discharges, and wastes and associated predicted changes in environmental quality, where relevant, in the assessment of terrestrial impacts	Section 9 (Terrestrial Environment - Impacts and Risks).

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6.7.2	Use the predictions made and monitoring data collected by the Foundation Project to help quantify Fourth Train Proposal impacts, where available	Section 9 (Terrestrial Environment - Impacts and Risks).
6.7.2	Evaluate the mitigation and management strategies, ensuring these strategies reflect the experience gained from the implementation of the Foundation Project and the EPA's Environmental Principles where relevant	Section 9 (Terrestrial Environment - Impacts and Risks).
6.7.2	Complete and include the EPA's Checklist for Documents Submitted for EIA on Marine and Terrestrial Biodiversity, in accordance with the EPA's requirements	Appendix B1 (EPA checklist for Documents Submitted for EIA on Marine and Terrestrial Biodiversity)
Soils and Landforms		
Table A5-1	Examine the following potential impacts in relation to soils and landforms: • exposure and erosion of topsoil during construction; • sedimentation of water courses during construction; • changes in natural drainage patterns during construction; • soil compaction during construction; • soil inversion during construction; • disturbance to geological features during construction; • changes in landform during construction; and • contamination of soil resulting from spills and leaks	Section 9.3 (Soils and Landforms)
6.7.2	If the risk assessment reveals extra or discounts any of these stressors or impacts, justify their inclusion or omission from the PER/Draft EIS	Section 8.2.2 (Identification of Environmental Stressors and Factors that Could Cause Potential Impacts), Section 8.2.3 (Preliminary Identification of Potential Impacts), Section 8.3 (Assessment Phase), and Section 9.1 (Introduction)
Table A5-1	Assess the change in impact of the Fourth Train Proposal compared to the Foundation Project. Use baseline data, monitoring data, audit results and observations from the Foundation Project to substantiate construction-phase predictions where relevant and available	Section 9.3 (Soils and Landforms)
Table A5-1	Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project, including the various applicable EMPs	Section 9.3.3 (Proposed Management)
Surface and Groundwater		
Table A5-1	Examine the following potential impacts: • reduction in the quality of surface and groundwater due to sedimentation and turbidity, discharge of hydrotest water, surface run-off, change in groundwater recharge, and HDD cuttings dewatering during construction; and • potential contamination of water from hydrocarbon leaks and spills	Section 9.4 (Surface Water and Groundwater)
6.7.2	If the risk assessment reveals extra or discounts any of these stressors or impacts, justify their inclusion or omission from the PER/Draft EIS	Section 8.2.2 (Identification of Environmental Stressors and Factors that Could Cause Potential Impacts), Section 8.2.3 (Preliminary Identification of Potential Impacts), Section 8.3 (Assessment Phase), and Section 9.1 (Introduction)
Table A5-1	Assess the change in impact of the Fourth Train Proposal compared to the Foundation Project. Use baseline data, monitoring data, audit results and observations from the Foundation Project to substantiate construction-phase predications where relevant and available	Section 9.4 (Surface Water and Groundwater)
Table A5-1	Review relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project including the various applicable EMPs	Section 9.4.3 (Proposed Management)
Terrestrial flora and vegetation communities, including restricted flora		
Table A5-1	Examine the following potential impacts: • possible clearance of up to 10 ha of vegetation for the purposes of HDD activities and during excavation for the terrestrial component of the Feed Gas Pipeline System; • damage and loss of vegetation due to vehicle and personnel movements during construction and operation; • risk of fire as a result of hot works and vehicle use during construction and operation; and • indirect impacts due to dust generated during construction and due to air emissions during operations	Section 9.5 (Vegetation and Flora)
Table A5-1	Examine the following potential impacts: • potential for non-indigenous species to be introduced or spread during construction and operation	Section 12.3 (Assessment of Quarantine Risk)
6.7.2	If the risk assessment reveals extra or discounts any stressors or impacts, justify their inclusion or omission from the PER/Draft EIS	Section 8.2.2 (Identification of Environmental Stressors and Factors that Could Cause Potential Impacts), Section 8.2.3 (Preliminary Identification of Potential Impacts), Section 8.3 (Assessment Phase), and Section 9.1 (Introduction)

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Table A5-1	Assess the extent to which construction and operation of the Fourth Train Proposal changes the impacts identified for the Foundation Project. Use baseline data, monitoring data, audit results and observations from the Foundation Project to substantiate construction-phase predictions where relevant and available. Also use the results of operational and non-routine atmospheric emissions modelling to evaluate the potential for the Fourth Train Proposal to impact flora and vegetation communities on Barrow Island and in the wider West Pilbara airshed	Section 3.5.1.4 (Terrestrial Monitoring - Vegetation), Section 9.5 (Vegetation and Flora), Section 9.5.2.2 (Atmospheric Emissions), Section 16.2.1 (Experience Gained), and Appendix E1 (Foundation Project Survey, Audit and Environmental Reporting)
Table A5-1	Identify how the Fourth Train Proposal affects the scope of the Terrestrial Disturbance Footprint of the approved Foundation Project. Also review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project	Section 9.2 (Terrestrial Disturbance Footprint), and Section 9.5.3 (Flora and Vegetation - Proposed Management)
Terrestrial fauna including protected species		
Table A5-1	Examine the following potential impacts in relation to terrestrial fauna communities: • direct and indirect disturbance of fauna and/or their habitat during HDD activities, construction of the terrestrial component of the Feed Gas Pipeline System, and as a result of vehicle and personnel movements, dust, noise, creation of heat and shade and light spill around the Gas Treatment Plant • Disturbance to fauna during operations associated with personnel and vehicle movements, noise and light emissions; and • additive impacts on the fauna of Barrow Island, including protected species, associated with multiple stressors	Section 9.6 (Terrestrial Fauna)
Table A5-1	Examine the following potential impacts in relation to terrestrial fauna communities: • introduction or spread of non-indigenous species;	Section 12.3 (Assessment of Quarantine Risk)
6.7.2	If the risk assessment reveals extra or discounts any stressors or impacts, justify their inclusion or omission from the PER/Draft EIS	Section 8.2.2 (Identification of Environmental Stressors and Factors that Could Cause Potential Impacts), Section 8.2.3 (Preliminary Identification of Potential Impacts), Section 8.3 (Assessment Phase), and Section 9.1 (Introduction)
Table A5-1	Assess the change in risk for terrestrial fauna from the Fourth Train Proposal compared to the Foundation Project. Use modelled predictions to evaluate the impacts of operational light, noise and air emissions from the Gas Treatment Plant on sensitive fauna. Use baseline data, monitoring data, audit results and observations from the Foundation Project to substantiate construction-phase predictions where available and relevant	Section 9.6 (Terrestrial Fauna), and Appendix E1 (Foundation Project Survey, Audit and Environmental Reporting)
Table A5-1	Identify how the Fourth Train Proposal affects the scope of the Terrestrial Disturbance Footprint of the approved Foundation Project. Also review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project	Section 9.2 (Terrestrial Disturbance Footprint), and Section 9.6.3 (Terrestrial Fauna - Proposed Management)
Subterranean fauna including protected species		
Table A5-1	Examine the following potential impacts in relation to subterranean fauna communities: • disturbance to the behaviour of subterranean fauna resulting from HDD activities and during excavation for the terrestrial component of the Feed Gas Pipeline System; and • indirect impacts occurring due to changes to organic inputs to groundwater following vegetation clearance and changes to groundwater infiltration rates	Section 9.7 (Subterranean Fauna)
Table A5-1	Examine the following potential impacts in relation to subterranean fauna communities: • introduction or spread of non-indigenous species during construction and operation;	Section 8.2.2 (Identification of Environmental Stressors), and Section 12.3 (Assessment of Quarantine Risk)
6.7.2	If the risk assessment reveals extra or discounts any stressors or impacts, justify their inclusion or omission from the PER/Draft EIS	Section 8.2.2 (Identification of Environmental Stressors and Factors that Could Cause Potential Impacts), Section 8.2.3 (Preliminary Identification of Potential Impacts), Section 8.3 (Assessment Phase), and Section 9.1 (Introduction)
Table A5-1	Assess how the Fourth Train Proposal impacts subterranean fauna. The predictions made and any evidence and baseline data gathered for the Foundation Project should be used	Section 9.7 (Subterranean Fauna)
Table A5-1	Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project	Section 9.7.3 (Subterranean Fauna- Proposed Management)

State (Environmental Scoping Document) Requirements for the Contents of this PER

Scoping Document Section Ref.	Detailed State Requirements for the PER/Draft EIS	Section in the PER/Draft EIS where Requirement is Addressed
Conservation areas		
Table A5-1	Examine the following potential impacts in relation to conservation areas: • Reduction in environmental value in the event of a substantial accidental release of hydrocarbon and/or as a result of operational air emissions	Section 9.8 (Conservation Areas), Section 10.3.2.1 (Foreshore - Spills and Leaks), Section 13.2.2.1 (National Heritage Places - Atmospheric Emissions [except dust]), Section 13.2.2.1 (National Heritage Places - Spills and Leaks), and Section 14.4 (Conservation Areas)
Table A5-1	Assess the change in impact introduced by implementation of the Fourth Train Proposal. Review of the performance to date of the Foundation Project and application of any lessons learnt to the Fourth Train Proposal. Use results of modelling to predict the dispersion of operational air emissions and the spread of accidental hydrocarbon spills occurring in the marine environment.	Section 9.8 (Conservation Areas), and Section 14.4 (Conservation Areas)
EPA's PER Guidelines	Couch potential impacts in the context of the guidance provided in the relevant indicative or final Management Plan for the existing or proposed conservation reserve on the advice of the DEC or another designated management agency	Section 9.8 (Conservation Areas), and Section 14.4 (Conservation Areas)
Table A5-1	Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project	Section 9.8 (Conservation Areas), and Section 14.4 (Conservation Areas)
Assessment of Impacts on the Coastal and Nearshore Environment		
6.7.3	Examine all impacts of the Fourth Train Proposal expected on the State waters surrounding Barrow Island including those identified against each coastal and nearshore environmental factor in Appendix A5-1 of the Environmental Scoping Document	Section 10 (Coastal and Nearshore Environment - Impacts and Management)
6.7.3 and EPA's PER Guidelines	Define the relevant area for the assessment of impacts: impacts are expected to be restricted to State waters surrounding Barrow Island except for non-routine events	Section 10.1 (Introduction)
EPA's PER Guidelines	Explain the relevance of the physical and biological environment factors to the Fourth Train Proposal, and how they are significant	Section 8.2.2 (Identification of Environmental Stressors and Factors that Could Cause Potential Impacts), and Figure 10.2 (Environmental Factors of the Coastal and Nearshore Environment and Identified Stressor Interactions)
EPA's PER Guidelines	Provide a description of all relevant standards / regulations / policies relevant to the physical and biological environment factors	Section 2 (Legislative Framework), Table 10.1 (Key Legislation Relevant to the Coastal and Nearshore Environment) Section 10.3.1.2 (Foreshore - Relevant Policies, Plans, and Guidelines), Section 10.4.1.2 (Seabed [Intertidal and Subtidal] - Relevant Policies, Plans, and Guidelines), Section 10.5.1.2 (Marine Water Quality - Relevant Policies, Plans, and Guidelines), Section 10.6.1.2 (Marine Fauna - Relevant Policies, Plans, and Guidelines), Section 10.7.1.2 (Benthic Primary Producer Habitat - Relevant Policies, Plans, and Guidelines), and 10.8.1.2 (Conservation Areas - Relevant Policies, Plans, and Guidelines).
6.7.3	Revisit the potential impacts and stressors to the coastal and nearshore environment in a risk assessment process, and: - include any additional risks in the assessment - justify the omission from further discussion any potential impacts or stressors identified in the Environmental Scoping Document	Section 8.2.2 (Identification of Environmental Stressors and Factors that Could Cause Potential Impacts) Section 8.2.3 (Preliminary Identification of Potential Impacts) Section 8.3 (Assessment Phase), and Section 10.1 (Introduction)
6.7.6	Inform predictions by drawing on experience gained from the implementation of the Foundation Project. Available data should include: • audit findings associated with the implementation of mitigation and management measures; • marine environmental monitoring for HDD activities including water quality, marine benthic primary producer habitats, and benthic invertebrates; and • marine turtle monitoring as described in the Long-term Marine Turtle Management Plan	Sections 3.5.2 (Marine and Coastal Monitoring), Section 16.2.1 (Experience Gained), and Section 10 (Coastal and Nearshore Environment - Impacts and Management).
6.7.6	Document relevant uncertainties regarding predicted impacts	Section 8.3.4 (Dealing with Uncertainty), Section 10.3.2 (Foreshore - Assessment and Mitigation of Potential Impacts), Section 10.4.2 (Seabed [Intertidal and Subtidal] - Assessment and Mitigation of Potential Impacts), Section 10.5.2 (Marine Water Quality - Assessment and Mitigation of Potential Impacts), Section 10.6.2 (Marine Fauna - Assessment and Mitigation of Potential Impacts), Section 10.7.2 (Benthic Primary Producer Habitat - Assessment and Mitigation of Potential Impacts), and 10.8.2 (Conservation Areas -Assessment and Mitigation of Potential Impacts).

State (Environmental Scoping Document) Requirements for the Contents of this PER

Scoping Document Section Ref.	Detailed State Requirements for the PER/Draft EIS	Section in the PER/Draft EIS where Requirement is Addressed
6.7.3	Present the assessment of impacts on the coastal and nearshore environment as both the incremental change introduced by the Fourth Train Proposal alone, and the additional impact of the Fourth Train Proposal when added to the impacts assessed and approved for the Foundation Project	Section 10.3.2 (Foreshore - Assessment and Mitigation of Potential Impacts), Section 10.4.2 (Seabed [Intertidal and Subtidal] - Assessment and Mitigation of Potential Impacts), Section 10.5.2 (Marine Water Quality - Assessment and Mitigation of Potential Impacts), Section 10.6.2 (Marine Fauna - Assessment and Mitigation of Potential Impacts), Section 10.7.2 (Benthic Primary Producer Habitat - Assessment and Mitigation of Potential Impacts), and 10.8.2 (Conservation Areas -Assessment and Mitigation of Potential Impacts).
6.7.3	Examine the incremental and additional change in associated impacts where the Fourth Train Proposal may use utilities or infrastructure already approved under the Foundation Project	Section 10.3.2 (Foreshore - Assessment and Mitigation of Potential Impacts), Section 10.4.2 (Seabed [Intertidal and Subtidal] - Assessment and Mitigation of Potential Impacts), Section 10.5.2 (Marine Water Quality - Assessment and Mitigation of Potential Impacts), Section 10.6.2 (Marine Fauna - Assessment and Mitigation of Potential Impacts), Section 10.7.2 (Benthic Primary Producer Habitat - Assessment and Mitigation of Potential Impacts), and 10.8.2 (Conservation Areas -Assessment and Mitigation of Potential Impacts).
6.7.3	Use predictions of emissions, discharges, and wastes and associated predicted changes in environmental quality in the assessment of impacts	Section 10 (Coastal and Nearshore Environment - Impacts and Management)
6.7.3	Use the predictions made and monitoring data collected by the Foundation Project to help quantify Fourth Train Proposal impacts, where available	Section 10 (Coastal and Nearshore Environment - Impacts and Management)
6.7.3	Evaluate the mitigation and management strategies, ensuring these strategies reflect the experience gained from the implementation of the Foundation Project and the EPA's Environmental Principles where relevant	Section 10 (Coastal and Nearshore Environment - Impacts and Management)
6.7.3	Complete and include the EPA's Checklist for Documents Submitted for EIA on Marine and Terrestrial Biodiversity, in accordance with the EPA's requirements	Appendix B1 (EPA checklist for Documents Submitted for EIA on Marine and Terrestrial Biodiversity)
Foreshore		
Table A5-1	Assess the following potential impacts • change in landform and deposition of drilling fluid onto the beach in the event of an accidental HDD frac-out • deposition of hydrocarbons onto the beach in the event of a spill occurring offshore • erosion/wash out of the primary dune system due to alteration in drainage at the HDD site and/or onshore Feed Gas Pipeline System route	Section 10.3 (Foreshore), and Section 9.3.2.1 (Vegetation Clearing and Earthworks)
6.7.3	If the risk assessment reveals extra or discounts any stressors or impacts, justify their inclusion or omission from the PER/Draft EIS	Section 8.2.2 (Identification of Environmental Stressors and Factors that Could Cause Potential Impacts) Section 8.2.3 (Preliminary Identification of Potential Impacts) Section 8.3 (Assessment Phase), and Section 10.1 (Introduction)
Table A5-1	Assess the change in impact compared to that predicted for the Foundation Project. Where available, use data and evidence collected by the Foundation Project to substantiate impact predictions	Section 10.3 (Foreshore), and Section 9.3.2.1 (Vegetation Clearing and Earthworks)
Table A5-1	Identify how the Fourth Train Proposal affects the scope of the Marine/Terrestrial Disturbance Footprint approved for the Foundation Project. Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project	Section 10.3 (Foreshore), and Section 9.3.2.1 (Vegetation Clearing and Earthworks)
Seabed (subtidal and intertidal)		
Table A5-1	Examine the following potential impacts: • change in seabed profile and seabed composition due to the physical presence of the Feed Gas Pipeline System as it approaches the shore of Barrow Island • anchor and chain scour to the seabed; • sedimentation and associated changes to sediment profile due to HDD activities and laying of the Feed Gas Pipeline System in nearshore waters • potential contamination of seabed sediment due to a leak or spill	Section 10.4 (Seabed [Intertidal and Subtidal])
Table A5-1	Assess the change in impact compared to that predicted for the Foundation Project. Use monitoring and baseline data collected for the Foundation Project where possible to substantiate impact predictions. Use results of modelling to predict the geographical extent and magnitude of potential impacts reasonably expected from hydrocarbon spills	Section 10.4.2 (Seabed [Intertidal and Subtidal] - Assessment and Mitigation of Potential Impacts), and Section 10.4.2.4 (Seabed [Intertidal and Subtidal] - Spills and Leaks)
Table A5-1	Identify how the Fourth Train Proposal affects the scope of the Marine Disturbance Footprint approved for the Foundation Project. Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project	Section 10.2 (Marine Disturbance Footprint), and Section 10.4 (Seabed [Intertidal and Subtidal])

State (Environmental Scoping Document) Requirements for the Contents of this PER

Scoping Document Section Ref.	Detailed State Requirements for the PER/Draft EIS	Section in the PER/Draft EIS where Requirement is Addressed
Marine water quality		
Table A5-1	Examine the following potential impacts: • change in water quality on the west coast of Barrow Island due to the construction of the Feed Gas Pipeline System and associated HDD activities • Potential change in water quality on the east coast of Barrow Island associated with discharges from additional shipping and in the event that the Fourth Train Proposal affects Foundation Project approved wastewater disposal infrastructure • Potential for spills and leaks during the construction and operational phases to affect water quality	Section 10.5 (Marine Water Quality)
6.7.3	If the risk assessment reveals extra or discounts any stressors or impacts, justify their inclusion or omission from the PER/Draft EIS	Section 8.2.2 (Identification of Environmental Stressors and Factors that Could Cause Potential Impacts), Section 8.2.3 (Preliminary Identification of Potential Impacts), Section 8.3 (Assessment Phase), and Section 10.1 (Introduction)
Table A5-1	Assess the change in impact compared to that predicted for the Foundation Project. Where available use baseline data and monitoring data to validate impact predications. Use modelling results to predict the geographical extent and magnitude of potential impacts reasonably expected from hydrocarbon spills.	Section 10.5 (Marine Water Quality), and Section 10.5.2.3 (Marine Water Quality - Spills and Leaks)
EPA's Checklist for documents submitted for EIA on marine and terrestrial biodiversity	Couch the assessment of impacts in the context of the *Pilbara Coastal Water Quality Project Consultation Outcomes* document (DOE, 2006) and relevant guidance provided in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000).*	Section 10.5 (Marine Water Quality)
Table A5-1	Identify how the Fourth Train Proposal affects the scope of the Marine Disturbance Footprint approved for the Foundation Project. Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project	Section 10.2 (Marine Disturbance Footprint), and Section 10.5 (Marine Water Quality)
Marine fauna including protected species and benthic faunal communities (except benthic primary producers)		
Table A5-1	Examine the following potential impacts: • disturbance to the behaviour of marine fauna from physical interaction, light spill, wastewater discharges, and noise generated during HDD activities and construction of the shore approach of the Feed Gas Pipeline System • potential for any changes in light spill and wastewater discharges from the operational Gas Treatment Plant and Feed Gas Pipeline System to affect marine fauna and/or because of an anticipated increased frequency of LNG and condensate export activities • impacts associated with a hydrocarbon spill	Section 10.6.2.6 (Marine Fauna - Physical Interaction), Section 10.6.2.2 (Marine Fauna - Artificial Light), Section 10.6.2.3 (Marine Fauna - Discharges to Sea), Section 10.6.2.4 (Marine Fauna - Noise and Vibration), and Section 10.6.2.8 (Marine Fauna - Spills and Leaks)
Table A5-1	Examine the following potential impacts: • impacts resulting from the introduction or spread of non-indigenous species	Section 12.3.1 (Assessment of Potential Impacts)
6.7.3	If the risk assessment reveals extra or discounts any stressors or impacts, justify their inclusion or omission from the PER/Draft EIS	Section 8.2.2 (Identification of Environmental Stressors and Factors that Could Cause Potential Impacts) Section 8.2.3 (Preliminary Identification of Potential Impacts) Section 8.3 (Assessment Phase), and Section 10.1 (Introduction)
Table A5-1	Assess the change in impact to marine fauna generated by the construction and operation of the Fourth Train Proposal compared to that assessed for the approved Foundation Project. Where available and relevant, use baseline data, monitoring data audit results and observations from the Foundation Project to substantiate construction-phase predictions. Use modelling to predict the geographical extent and magnitude of potential impacts reasonably expected from hydrocarbon spills and from light spill from the operational Gas Treatment Plant	Section 10.2 (Marine Disturbance Footprint), and Section 10.6 (Marine Fauna)
Table A5-1	Identify how the Fourth Train Proposal affects the scope of the Marine Disturbance Footprint approved for the Foundation Project. Also review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project	Section 10.2 (Marine Disturbance Footprint), and Section 10.6.4 (Marine Fauna - Proposed Management)

State (Environmental Scoping Document) Requirements for the Contents of this PER

Scoping Document Section Ref.	Detailed State Requirements for the PER/Draft EIS	Section in the PER/Draft EIS where Requirement is Addressed
Marine benthic primary producers and their habitats (BPPH)		
Table A5-1	Examine the following potential impacts in relation to marine benthic primary producers: • loss and/or disturbance to coral communities during laying of the Feed Gas Pipeline System, including its shore crossing • loss and/or stress on BPPH in the event of a spill or leak	Section 10.7.2.2 (Benthic Primary Producer Habitat - Seabed Disturbance), and Section 10.7.2.4 (Benthic Primary Producer Habitat - Spills and Leaks)
Table A5-1	Examine the following potential impacts in relation to marine benthic primary producers: loss and/or stress on BPPH through the accidental introduction or spread of a non-indigenous species	Section 12.3.1 (Assessment of Potential Impacts)
6.7.3	If the risk assessment reveals extra or discounts any stressors or impacts, justify their inclusion or omission from the PER/Draft EIS	Section 8.2.2 (Identification of Environmental Stressors and Factors that Could Cause Potential Impacts) Section 8.2.3 (Preliminary Identification of Potential Impacts) Section 8.3 (Assessment Phase), and Section 10.1 (Introduction)
Table A5-1	Assess the change in impact compared to that predicted for the approved Foundation Project. Where available and relevant, use baseline data and monitoring data to validate impact predictions. Use modelling results to predict the geographical extent and magnitude of potential impacts expected from hydrocarbon spills	Section 6.6.1 (Benthic Habitats), Section 10.7.2 (Benthic Primary Producer Habitat - Assessment and Mitigation of Potential Impacts), Section 3.5.2.3 (Horizontal Directional Drilling Marine Monitoring), and Section 3.5.2.5 (Offshore Feed Gas Pipeline Installation Monitoring)
EPA's Checklist for documents submitted for EIA on marine and terrestrial biodiversity	Describe how potential impacts on BPPH have been addressed in the context of the EPA's Environmental Assessment Guideline No. 3 (December 2009) including: - details of the measures taken to address the Overarching Environmental Protection Principles - scale benthic habitat maps showing the current extent and distribution of benthic habitats and the areas of habitat predicted to be lost if the proposal proceeds - descriptions of technical work (e.g. benthic habitat surveys) carried out to underpin the benthic habitat map and - calculations of cumulative loss	Section 6.6.1 (Benthic Habitats), Figure 6-12 (Benthic Primary Producer Habitat Communities Present off the West Coast of Barrow Island in the Vicinity of the Horizontal Directional Drilling Site and the Feed Gas Pipeline System), Figure 6-13 (Benthic Primary Producer Habitat Communities Present off the East Coast of Barrow Island), Table 10.7 (Benthic Primary Producer Habitat), and Appendix E1 (Key Foundation Project Survey, Audit and Environmental Reporting).
Table A5-1	Identify how the Fourth Train Proposal affects the scope of the Marine Disturbance Footprint approved for the Foundation Project. Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project	Section 10.2 (Marine Disturbance Footprint), and Section 10.7 (Benthic Primary Producer Habitats)
Conservation areas		
Table A5-1	Examine the following potential impacts in relation to conservation areas: • Reduction in environmental value in the event of a substantial accidental release of hydrocarbon and/or as a result of operational air emissions	Section 10.8.2 (Assessment and Mitigation of Potential Impacts)
Table A5-1	Assess the change in impact introduced by implementation of the Fourth Train Proposal. Review of the performance to date of the Foundation Project and application of any lessons learnt to the Fourth Train Proposal. Use results of modelling to predict the dispersion of operational air emissions and the spread of accidental hydrocarbon spills occurring in the marine environment	Section 10.8.2 (Assessment and Mitigation of Potential Impacts)
EPA's PER Guidelines	Couch potential impacts in the context of the guidance provided in the relevant indicative or final Management Plan for the existing or proposed marine conservation reserve on the advice of the DEC or another designated management agency	Section 10.8.3 (Proposed Management)
Table A5-1	Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project	Section 10.8.4 (Predicted Environmental Outcome)

State (Environmental Scoping Document) Requirements for the Contents of this PER

Scoping Document Section Ref.	Detailed State Requirements for the PER/Draft EIS	Section in the PER/Draft EIS where Requirement is Addressed
Assessment of Socio-economic Impacts		
6.7.4	Examine all impacts of the Fourth Train Proposal on the society and economy of the State and the Pilbara region including those identified against each social factor in Appendix A5-3 of the Environmental Scoping Document	Section 14.2 (Workforce and Public Health and Safety), Section 14.3 (Cultural Heritage), Section 14.4 (Conservation Areas), Section 14.5 (Land and Sea Use), Section 14.6 (Livelihoods), Section 14.7 (Local Communities), and Section 14.8 (Commonwealth, State and Regional Economy).
EPA's PER Guidelines	Explain the relevance of the socio-economic factors to the Fourth Train Proposal, and how they are significant	Section 14.2 (Workforce and Public Health and Safety), Section 14.3 (Cultural Heritage), Section 14.4 (Conservation Areas), Section 14.5 (Land and Sea Use), Section 14.6 (Livelihoods), Section 14.7 (Local Communities), and Section 14.8 (Commonwealth, State and Regional Economy).
EPA's PER Guidelines	Provide a description of all relevant standards / regulations / policies relevant to the physical and biological environment factors	Section 14.2.1 (Workforce and Public Health and Safety - Assessment Framework), Section 14.3.1 (Cultural Heritage - Assessment Framework), Section 14.4.1 (Conservation Areas - Assessment Framework), Section 14.5.1 (Land and Sea Use - Assessment Framework), Section 14.6.1 (Livelihoods - Assessment Framework), Section 14.7.1 (Local Communities - Assessment Framework), and Section 14.8.1 (Commonwealth, State and Regional Economy - Assessment Framework).
EPA's PER Guidelines	Clearly define the scope of the socio-economic impact assessment	Section 14.1 (Introduction)
6.7.4	Revisit the potential impacts and stressors to the social environment in a risk assessment process, and: - include any additional risks in the assessment - justify the omission from further discussion any potential impacts or stressors identified in the Environmental Scoping Document	Section 8.3 (Assessment Phase), and Section 14 (Social, Cultural and Economic Impacts and Management)
6.7.4	Use predictions of emissions, discharges, and wastes and associated predicted changes in environmental quality for the assessment of impacts, where relevant	Section 14.2.2.1 (Workforce and Public Health and Safety - Atmospheric Emissions [except dust])
Public health and safety		
Table A5-3	Examine the following potential impacts in relation to public health and safety: • pressure on public health and infrastructure in the event of a major industrial accident occurring; • increased health and safety risk on the public due to vessel interactions; and • reduction in environmental health (specifically air quality) reasonably expected from operational air emissions from the Fourth Train Proposal	Section 14.2 (Workforce and Public Health and Safety)
Table A5-3	Assess the impacts on public health reasonably expected from implementation of the Fourth Train proposal compared to the Foundation Project. Any experience gained from the construction of the Foundation Project should also be reviewed and incorporated in the Fourth Train Proposal	Section 14.2 (Workforce and Public Health and Safety)
Cultural heritage		
Table A5-3	Examine how construction may impact sites of cultural and/or archaeological heritage at sea and on Barrow Island	Section 14.3.2.2 (Maritime Heritage)
Table A5-3	Assessment the potential impacts on cultural heritage using baseline information obtained by the Foundation Project and additional secondary data where relevant	Section 14.3 (Cultural Heritage)
Table A5-3	Potential management actions for cultural heritage should include: • avoidance of likely impacts through concept selection; • managing residual impacts through the same mitigation and management measures as implemented for the Foundation Project; • reviewing the need to update the spatial coverage of the Aboriginal Cultural Heritage Management Plan; and • drawing on any lessons and experience gained from implementation of the Foundation Project	Section 14.3.3 (Cultural Heritage - Proposed Management)

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State (Environmental Scoping Document) Requirements for the Contents of this PER

Scoping Document Section Ref.	Detailed State Requirements for the PER/Draft EIS	Section in the PER/Draft EIS where Requirement is Addressed
Land and sea use		
Table A5-3	Examine the following potential impact in relation to land and sea use: • temporary restriction on public use of marine areas due to the establishment of exclusion zones, use of cyclone moorings and vessel movements during the laying of the Feed Gas Pipeline System and its associated HDD activities in nearshore waters, and the approach of LNG and condensate export vessels during operation	Section 14.5 (Land and Sea Use)
Table A5-3	Assess the extent to which impacts on other land and sea users may change with the addition of the Fourth Train Proposal	Section 14.5.2 (Land and Sea Use - Assessment and Mitigation of Potential Impacts)
Table A5-3	Review and draw on lessons learnt and experience gained from the implementation of the Foundation Project where relevant	Section 14.5.3 (Land and Sea Use - Proposed Management), and Table 16.1 (Experience Gained from the Foundation Project relevant to the Fourth Train Proposal)
Livelihoods		
Table A5-3	Examine the following potential impact in relation to livelihoods: • potential benefit associated with labour and service demand during construction and operation	Section 14.6 (Livelihoods)
Table A5-3	Assess the impacts and benefits of implementing the Fourth Train Proposal	Section 14.6.2 (Livelihoods - Assessment and Mitigation of Potential Impacts)
Table A5-3	Review and draw on lessons learnt and experience gained from the implementation of the Foundation Project where relevant	Section 14.6.3 (Livelihoods - Proposed Management)
Local communities		
Table A5-3	Examine the following potential impact in relation to livelihoods: • change in community structures and culture and competition with the local community for the use of social infrastructure as a result of construction activities being extended on Barrow Island (beyond that of the Foundation Project)	Section 14.7 (Local Communities)
Table A5-3	Determine how the implementation of the Fourth Train proposal changes the risk to local communities, compared to that predicted for the Foundation Project	Section 14.7.2 (Local Communities - Assessment and Mitigation of Potential Impacts)
Table A5-3	Review and draw on lessons learnt and experience gained from the implementation of the Foundation Project where relevant	Section 14.7.3 (Local Communities - Proposed Management)
Local and regional economy		
Table A5-3	Examine the following potential impact in relation to the local and regional economy: • positive benefits due to an extended demand for labour, equipment, supplies, and services during construction of the Fourth Train Proposal	Section 14.8 (Commonwealth, State, and Regional Economy)
Table A5-3	Assess how the Fourth Train Proposal changes the impacts and benefits anticipated for the Foundation Project. Use and update (using secondary sources) baseline data available from the Foundation Project. Where available, use data collected for the Foundation Project to substantiate predictions	Section 14.8.2 (Commonwealth, State, and Regional Economy - Assessment and Mitigation of Potential Impacts)
Table A5-3	Review and draw on lessons learnt and experience gained from the implementation of the Foundation Project where relevant	Section 14.8.3 (Commonwealth, State, and Regional Economy - Predicted Socioeconomic Outcome)
Assessment of Cumulative Impacts		
6.7.5	Evaluate the environmental impacts reasonably expected from the implementation of the Fourth Train Proposal in combination with the as-built and operational Foundation Project	Section 9 (Terrestrial Environment - Risks and Management), Section 10 (Coastal and Nearshore Environment - Impacts and Risks), Section 11 (Greenhouse Gas Emissions and Energy Management), Section 12 (Quarantine Management), Section 13 (Matters of NES - Impacts and Management), and Section 15 (Cumulative Impacts).
6.7.5	Examine the following cumulative impacts:	
6.7.5	• impacts that are additive on one environmental factor of Barrow Island's terrestrial, nearshore, and coastal flora and fauna. For relevant sensitive receptors, the additional impact introduced by the Fourth Train Proposal when added to those assessed and approved for the Foundation Project will be examined. Additive impacts on an environmental or social factor should be assessed as part of the predicted environmental outcome for the factor	Section 9 (Terrestrial Environment - Risks and Management), Section 10 (Coastal and Nearshore Environment - Impacts and Risks), Section 11 (Greenhouse Gas Emissions and Energy Management), Section 12 (Quarantine Management), Section 13 (Matters of NES - Impacts and Management), and Section 15 (Cumulative Impacts).
6.7.5	• impacts of the Fourth Train Proposal (and Foundation Project) in addition to those of other developments on the terrestrial flora and fauna of Barrow Island and on local and regional air quality	Section 9.5.2 (Flora and Vegetation - Assessment and Mitigation of Potential Impacts), Section 9.6.2 (Terrestrial Fauna - Assessment and Mitigation of Potential Impacts), Section 5.2 (Atmospheric Emissions), Section 15.3 (Considered Actions in the Cumulative Impact Assessment), Section 15.5.1.1 (Flora and Vegetation) including 15.5.1.1.1 (Atmospheric Emissions), and Section 15.5.1.2 (Terrestrial Fauna) including 15.5.1.2.1 (Atmospheric Emissions),

State (Environmental Scoping Document) Requirements for the Contents of this PER

Scoping Document Section Ref.	Detailed State Requirements for the PER/Draft EIS	Section in the PER/Draft EIS where Requirement is Addressed
Proposed Environmental Management		
6.8	Where relevant to the design of the Fourth Train Proposal, apply the same environmental mitigation and management measures as for the Foundation Project. This includes an overall environmental management system supported by a series of EMPs	Section 16.2 (Environmental Management Framework for the Fourth Train Proposal)
6.8	Where impacts identified for the Fourth Train Proposal can be managed and monitored on the same basis as the EMPs that have been approved for the Foundation Project, apply these same EMPs to the Fourth Train Proposal by way of minor amendments (e.g. to expand their scope and address any incremental or additional impacts)	Section 16.2 (Environmental Management Framework for the Fourth Train Proposal), and Table 16-2 (Approved Foundation Project EMPs Relevant to the Fourth Train Proposal)
6.8	Describe the environmental management framework proposed for the Fourth Train Proposal, including the overall management system as well as any required changes to reflect the Fourth Train Proposal in the relevant EMPs	Section 16 (Environmental Management Framework)
6.8	Include hyperlinks to the Foundation Project EMPs for reference	Table 3-1 (Foundation Project Environmental Management and Monitoring Plans, Programs, Systems, Procedures, and Reports as required under the Ministerial Conditions as relevant to the Fourth Train Proposal)
6.8	Reflect all experience gained in implementing relevant EMPs during the Foundation Project construction in future revised EMPs	Section 16.2.1 (Experience Gained), and Table 16-1 (Experience Gained from the Foundation Project relevant to the Fourth Train Proposal
6.8	Consider Chevron Australia's need for providing and reviewing offsets for any residual environmental impacts associated with the Fourth Train Proposal, in accordance with EPA Guidance Statement No. 19 and the Western Australian Government's Environmental Offsets Policy 2011. The Environmental Offsets Reporting Form (as provided in EPA 2008) will be included for any specific offsets	Section 16.3 (Environmental Offsets)
Conclusion		
EPA's PER Guidelines	Indicate Chevron Australia's view of the environmental costs and benefits of the proposal. This should aim to show how the proposal would achieve an overall net environmental benefit	'Conclusion' of Executive Summary
EPA's PER Guidelines	Mention the implications of the adoption of the Fourth Train Proposal design and operation of best practicable measures to minimise environmental impacts. Chevron Australia should also note how the proposal addresses the object and principles set out in S4A of the EP Act	Conclusion' of Executive Summary
EPA's PER Guidelines	Outline the basis upon which Chevron Australia believes the Fourth Train Proposal is environmentally acceptable	'Conclusion' of Executive Summary

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Appendix B3: Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
General	Assessment of relevant impacts on matters protected under the EPBC Act must be presented in a stand-alone report or section that fully addresses the issues relevant to the controlling provisions under the EPBC Act. To reduce overlap, cross referencing to other parts of the EIS may be used where required.	Section 13 (Matters of NES) presents an assessment on each matter of NES, supported by other sections of the PER/Draft EIS, as shown in the remainder of this spreadsheet
1. Executive Summary		
1. Executive Summary	Provide an Executive Summary that outlines the key findings of the EIS including:	
	· The background and need for the proposal	'Introduction' of the Executive Summary
	· A discussion of the alternatives to the proposal and reasons for selecting the preferred option	'Development Alternatives' of the Executive Summary
	· The pre-operational, operational and post-operational activities associated with the proposal	'Fourth Train Proposal Description' of the Executive Summary
	· The proposed schedule for key activities and expected duration of the proposed action	'Development Timeline' of the Executive Summary
	· An overview of the existing regional and local environments, summarising the features of the physical, biological, social and economic environment relating to the proposed action and associated activities	'Existing Environment' of the Executive Summary
	· A description of relevant impacts on matters protected by the controlling provisions under the EPBC Act	'Controlling Provisions' and Table ES-9 of the Executive Summary
	· A summary of the environmental protection measures and safeguards, monitoring and decommissioning procedures to be implemented	Environmental Impacts and their Management', 'Greenhouse Gas Emissions and Energy Management', 'Quarantine Management', 'Controlling Provisions' and Tables ES-6, ES-7 and ES-8, ES-9 of the Executive Summary
	· An outline of the environmental record of Chevron	'Environmental and Social Commitment and Responsibility' of the Executive Summary
2. General Information		
2. General Information	Provide background information, including:	
	· Title of the proposed action	Section 1.3.1 (Proposal Title)
	· The full name and postal address of the designated proponent	Section 1.3.7 (Proponent Details)
	· Clear outline of the objectives of the proposed action, including the need	Section 1.3.2 (Proposal Background), Section 1.3.5 (Fourth Train Proposal Objectives), and Section 4.2.2 (Defer or not Develop Alternative)
	· The legislative background including the matters of NES protected under Part 3 of the EPBC Act	Section 1.6.1 (Commonwealth Environmental Impact Assessment Process), Section 2 (Legislative Framework), and Section 13 (Matters of National Environmental Significance - Impacts and Management)
	.... and any other requirements and approvals needed under the EPBC Act	Section 1.6.1 (Commonwealth Environmental Impact Assessment Process), Section 2 (Legislative Framework), and Section 13 (Matters of National Environmental Significance - Impacts and Management)
	· Location of the proposed action	Section 1.3.4 (Location), and Figure 1-1 (Fourth Train Proposal Location)
	.... (including maps of the locations of all proposed activities and infrastructure)	Figure 1-1(Fourth Train Proposal Location), Figure 4-1 (Location of the Gas Fields to be Developed for the Fourth Train Proposal), Figure 4-2 (Overview of the Key Fourth Train Proposal Components on or near Barrow Island in Relation to the Approved Foundation Project), Figure 4-3 (Proposed Feed Gas Pipeline System Route Options Included in the Fourth Train Proposal), Figure 4-4 (Location of the Shore Crossing at Barrow Island and an Indicative Layout of the Shore Crossing Area), Figure 4-5 (Onshore Route of the Feed Gas Pipeline System for the Fourth Train Proposal), Figure 4-7 (Indicative Layout of the Fourth Train Proposal Components of the Gas Treatment Plant), Figure 4-10 (Outline of Horizontal Directional Drilling Procedure), Figure 4-11 (Location of Reverse Osmosis Facilities including Intake and Outfall Structures), Figure 13-1 (The Commonwealth Marine Area in Relation to the Fourth Train Proposal), and Figure 13-2 (Oil Spill Modelling Locations).
	· The background to the development of the proposed action	Section 1.3.2 (Proposal Background), and Section 3 (Foundation Project Overview)

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	· How the proposed action relates to any other actions that have been, or are being, taken or that have been approved in the region affected by the proposed action	Section 1.6 (Relationship with Other Actions in the Region), Section 8 (Assessment Method), and Section 15 (Cumulative Impact)
	· The current status of the proposed action	Section 1.4 (Approach to Preparing this PER/draft EIS)
	· The consequences of not proceeding with the proposed action	Development Alternatives' of the Executive Summary, and Section 4.2.2 (Defer or not Develop Alternative)
	· A description of government planning policies and statutory controls which will influence the proposed action. All applicable jurisdictions and areas of responsible authorities within the area must be listed and shown on maps at appropriate scales	Sections 2.2.2 (Commonwealth, State, and Local Policies and Plans), Section 13.2 (Introduction), and Section 16.2.4.1 (Other Approval Documentation)
3. Consultation		
3. Consultation	Provide details of any consultation about the Proposal, including:	Section 7 (Stakeholder Engagement), Section 14.7 (Local Communities), and Appendix C (Key Stakeholder List)
	· Consultation that has already taken place	Table 7-1 (Summary of Stakeholder Engagement from February 2011 to Present for the Fourth Train Proposal)
	· If there has been any consultation about the Proposal, any documented response to, or result of, the consultation	Table 7-2 (Key Issues Raised by Stakeholders)
	· Any further proposed consultation about relevant impacts of the proposed action	Section 7.6 (Ongoing Stakeholder Engagement),
	· Identification of affected parties, including a statement mentioning any communities that may be affected and a description of their views	Section 7.3 (Key Stakeholders), Table 7-2 (Key Issues Raised by Stakeholders), and Appendix C (Key Stakeholder List).
4. Alternatives to the Proposed Action		
4. Alternatives to the Proposed Action	Describe, to the extent possible, any prudent and feasible alternatives to the proposed action, including:	Development Alternatives' of the Executive Summary, and Section 4.2 (Alternatives to the Proposed Development)
	· If relevant, the alternative of taking no action	Section 4.2.2 (Defer or not Develop Alternative)
	· A comparative description of the adverse and beneficial relevant impacts of each alternative on the matters protected by the controlling provisions of the Proposal	Section 4.2.3 (Comparison of Alternatives in Relation to the Controlling Provisions)
	· Sufficient detail to make clear why any alternative is preferred to another.	Section 4.2.4 (Preferred Alternative)
	Describe the short, medium and long-term advantages and disadvantages of the options.	Section 4.2 (Alternatives to the Proposed Development)
5. Description of the Action		
5. Description of the Action	Describe aspects of the Proposal that may have relevant impacts on matters protected by the controlling provisions of the Proposal including:	Section 3 (Foundation Project Overview), Section 4 (Proposal Description and Alternatives), Section 5 (Emissions, Discharges and Wastes), and Section 8 (Assessment Method)
	· All components of the proposed action, including site selection, site preparation (including any action that may result in the modification of the natural surface of the sea-bed), development options, construction, commissioning, operation and decommissioning	Section 4.3 (Offshore Components), Section 4.4 (Onshore Components), Section 4.5 (Construction Activities), Section 4.6 (Simultaneous Operations), Section 4.7 (Operational Activities), and Section 4.8 (Decommissioning Activities)

Public

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	· Location of any works to be undertaken, structures to be built or elements of the Proposal, including illustrations and maps, including the location of:	Section 1.3.4 (Location), Figure 1-1 (Fourth Train Proposal Location), Figure 4-1 (Location of the Gas Fields to be Developed for the Fourth Train Proposal), Figure 4-2 (Overview of the Key Fourth Train Proposal Components on or near Barrow Island in Relation to the Approved Foundation Project), Figure 4-3 (Proposed Feed Gas Pipleline System Route Options Included in the Fourth Train Proposal), Figure 4-4 (Location of the Shore Crossing at Barrow Island and an Indicative Layout of the Shore Crossing Area), Figure 4-5 (Onshore Route of the Feed Gas Pipeline System for the Fourth Train Proposal), Figure 4-6 (Indicative Cross Section of the Fourth Train Proposal Onshore Feed Gas Pipeline System Installed within the Approved Foundation Project Feed Gas Pipeline Systems Footprint), Figure 4-7 (Indicative Layout of the Fourth Train Proposal Components of the Gas Treatment Plant), Figure 4-11 (Location of Reverse Osmosis Facilities including Intake and Outfall Structures)
	§ Production wells and any water or gas disposal wells	Section 4.3.2 (Wells and Subsea Infrastructure)
	§ Sub-sea well-head completions and sub-sea pipelines	Section 4.3.2 (Wells and Subsea Infrastructure), Section 4.3.3 (Intrafield Flowlines), Section 4.3.4 (Offshore Feed Gas Pipeline System), Section 4.5.1 (Construction Phase - Offshore Facilities), Section 4.7.1 (Operational Activities - Offshore Facilities), Section 4.8 (Decommissioning Activities), Figure 4-1 (Location of the Gas Fields to be Developed for the Fourth Train Proposal), Figure 4-2 (Overview of the Key Fourth Train Proposal Components on or near Barrow Island in Relation to the Approved Foundation Project), and Figure 4-3 (Proposed Feed Gas Pipleline System Route Options Included in the Fourth Train Proposal),
	§ Processing platforms and facilities	Section 4.4.3 (Gas Treatment Plant), and Figure 4-7 (Indicative Layout of the Fourth Train Proposal Components of the Gas Treatment Plant)
	§ Sub-sea gathering systems	Figure 4-1 (Location of the Gas Fields to be Developed for the Fourth Train Proposal), Figure 4-2 (Overview of the Key Fourth Train Proposal Components on or near Barrow Island in Relation to the Approved Foundation Project), Figure 4-3 (Proposed Feed Gas Pipleline System Route Options Included in the Fourth Train Proposal), Figure 4-4 (Location of the Shore Crossing at Barrow Island and an Indicative Layout of the Shore Crossing Area), Figure 4-5 (Onshore Route of the Feed Gas Pipeline System for the Fourth Train Proposal), Figure 4-6 (Indicative Cross Section of the Fourth Train Proposal Onshore Feed Gas Pipeline System Installed within the Approved Foundation Project Feed Gas Pipeline Systems Footprint), Figure 4-7 (Indicative Layout of the Fourth Train Proposal Components of the Gas Treatment Plant), Figure 4-11 (Location of Reverse Osmosis Facilities including Intake and Outfall Structures)
	§ Any facility for vessel based supply of offshore facilities, and offloading facilities	Section 4.4.3.7 (LNG and Condensate Storage and Offloading)
	§ Any other infrastructure associated with the proposed action, including terrestrial infrastructure	Section 4 (Project Description), Section 4.3 (Offshore Components), and Section 4.4 (Onshore Components)
	· How the works are to be undertaken and design parameters for those aspects of the structures or elements of the proposed action relevant to a consideration of relevant impacts on the controlling provisions, including	Section 4.5 (Construction Activities), Section 4.6 (Simultaneous Operations), Section 4.7 (Operational Activities), and Section 4.8 (Decommissioning Activities)
	§ An explanation of the anticipated timetable for construction, commissioning, operation and decommissioning	Section 1.3.6 (Development Timeline)

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	§ Details of construction, commissioning, operational and decommissioning equipment to be used	Section 4.5 (Construction Activities), Section 4.7 (Operational Activities), and Section 4.8 (Decommissioning Activities)
	§ Details of the operations of the proposed action throughout its lifespan	Section 4.7 (Operational Activities)
	· As far as predictable, proposed for waste reduction, treatment, reuse and disposal	Section 5.6.3 (Solid and Liquid Waste Management - Proposed Management Actions)
	· Information on potentially hazardous materials to be used throughout the proposal life, including methods of transport, storage and disposal	Section 4 (Project Description and Alternatives), Section 4.4.3.1 (Inlet Facilities), Section 4.4.3.7 (LNG and Condensate Storage and Offloading), and
	· The number and source of staff and training for staff involved for all phases of the proposed action	Section 6.8.2 (Workforce Health and Safety), Section 6.8.5 (Local Communities), Section 12.4 (Implementation and Management of the Quarantine Management System), and Section 14.6 (Livelihoods)
6. Description of the Environment		
6. Description of the Environment *Listed Species, Communities and National Heritage*	Identify all threatened species, ecological communities, migratory species and National Heritage places listed under the EPBC Act that are likely to be impacted by the Fourth Train Proposal, including those likely to be impacted in the event of a hydrocarbon spill (such as those listed species occurring within the range of hydrocarbon spill modelling). For each of the matters identified, provide the following information as a minimum:	Section 6.5 (Terrestrial Ecology), Section 6.6 (Marine Ecology), Section 6.7 (Protected Areas), and Appendix E2 (Conservation Significant Species Considered for Assessment)
	a. Information on the abundance, distribution, ecology and habitat preferences of listed species and communities	Section 3.5 (Environmental Monitoring), Table 3-1 (Foundation Project Environmental Management and Monitoring Plans, Programs, Systems, Procedures, and Reports as required under the Ministerial Conditions as Relevant to the Fourth TRain Proposal), Section 6.5.2 (Terrestrial Fauna Habitat), Section 6.6.1 (Benthic Habitats), Section 6.5.3 (Terrestrial Fauna Species), Section 6.6.2 (Marine Fauna), Section 13.3 (Listed Threatened and Migratory Species and Communities – Terrestrial Environment), Section 13.4 (Listed Threatened and Migratory Species and Communities –Marine Species, and Their Habitats), Table 16.2 (Approved Foundation Project EMPs Relevant to the Fourth Train Proposal), Appendix E1 (Key Foundation Project Survey, Audit and Environmental Reporting), and Appendix E2 (Conservation Significant Species Considered for Assessment)
	b. Information on the conservation value of each habitat type from a local and regional perspective, including the percentage representation of each habitat type on site in relation to its local and regional extent	Table 3-1 (Foundation Project Environmental Management and Monitoring Plans, Programs, Systems, Procedures, and Reports as required under the Ministerial Conditions as Relevant to the Fourth Train Proposal), Table 6-2 (Vegetation Associations at the Fourth Train Proposal Horizontal Directional Drilling Site), Section 6.5.2 (Terrestrial Fauna Habitat), Section 6.6.1 (Benthic Habitats), Section 6.5.3 (Terrestrial Fauna Species), Section 6.6.2 (Marine Fauna), Section 13.3 (Listed Threatened and Migratory Species and Communities – Terrestrial Environment), Section 13.4 (Listed Threatened and Migratory Species and Communities –Marine Species, and Their Habitats), Section 13.5 (Commonwealth Marine Environment), Table 16.2 (Approved Foundation Project EMPs Relevant to the Fourth Train Proposal), and Appendix E1 (Key Foundation Project Survey, Audit and Environmental Reporting

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	c. If a population of a listed species is present on the site, its size and the important of that population from a local and regional perspective	Section 3.5.2.1.9 (Status of Marine Turtle Populations on Barrow Island), Section 6.5.3 (Terrestrial Fauna Species), Section 6.6.2 (Marine Fauna), Section 10.6.2.2.3 (Marine Avifauna), Section 10.6.2.2.4 (Marine Reptiles), and Appendix E2 (Conservation Significant Species Considered for Assessment)
	d. Discussion of known existing threats to the species, whether or not attributable to the proposed action, with reference to relevant impacts from the proposed action (including taking into consideration any relevant guidelines, policies, plans and statutory provisions)	Section 3.5 (Environmental Monitoring), Table 3-1 (Foundation Project Environmental Management and Monitoring Plans, Programs, Systems, Procedures, and Reports as required under the Ministerial Conditions as Relevant to the Fourth TRain Proposal), Table 8-2 (Stressors Relevant to the Fourth Train Proposal), Table 8-3 (Environmental Factors Potentially Impacted by the Fourth Train Proposal), Section 9 (Terrestrial Environment - Impacts and Management), Section 10 (Marine Environment - Impacts and Risks), Section 12 (Quarantine Management), Section 13.3 (Listed Threatened and Migratory Species and Communities – Terrestrial Environment), Section 13.4 (Listed Threatened and Migratory Species and Communities – Marine Species, and Their Habitats), Section 15 (Cumulative Impacts), Appendix D (Technical Studies), and Appendix E4 (Detected Non-Indigenous Terrestrial Species Currently on Barrow Island)
	e. Details of the geology and geomorphology of the area	Section 6.4. (Physical Environment), Section 6.4.2 (Bathymetry), Section 6.4.4.3 (Bedform and Sediment Quality), Section 6.4.5 (Landforms and Topography), Section 6.4.6 (Geology and Soils), Section 9.3 (Soils and Landforms), and Section 9.4 (Surface Water and Groundwater).
	f. Baseline information and maps identifying at both the site and regional levels:	
	i. Known occurrences of the protected matters	Figure 6-27 (Marine Protected Areas in the Vicinity of the Fourth Train Proposal Area), Section 6.5 (Terrestrial Ecology), Section 6.5.3 (Terrestrial Fauna Species), Section 6.6 (Marine Ecology), Section 6.6.2 (Marine Fauna), Section 6.7.1.1 (Montebello Commonwealth Marine Reserve), Section 6.7.2 (Ningaloo Marine Park and Muiron Islands Marine Management Area), Section 6.7.3 (Ningaloo), Section 9.5.2.5 (Conservation-significant Vegetation and Flora), Section 9.6.2.8 (Conservation-significant Species and Habitat), Section 9.7.2.6 (Conservation-significant Species), Section 10.6.3 (Conservation-significant Species), Section 13 (Matters of National Environmental Significance - Impacts and Management), Appendix E1 (Key Foundation Project Survey, Audit and Environmental Reporting), and Appendix E2 (Conservation Significant Species Considered for Assessment)

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	ii. Potential habitat for species or communities (differentiating where relevant on the basis of use e.g. breeding habitat, migration pathways, feeding habitat)	Table 3-1 (Foundation Project Environmental Management and Monitoring Plans, Programs, Systems, Procedures, and Reports as required under the Ministerial Conditions as Relevant to the Fourth Train Proposal), Table 6-2 (Vegetation Associations at the Fourth Train Proposal Horizontal Directional Drilling Site), Section 6.5.2 (Terrestrial Fauna Habitat), Section 6.5.3 (Terrestrial Fauna Species), Section 6.6.1 (Benthic Habitats), Section 6.6.2 (Marine Fauna), Figure 6-9 (Vegetation Associations in the Vicinity of the Fourth Train Proposal Horizontal Directional Drilling Site Area), Figure 6-10 (Locations of Conservation-significant Flora Individuals Identified in the Vicinity of the Fourth Train Proposal Horizontal Directional Drilling Site Area), Figure 6-11 (Locations of Significant Fauna Habitats on Barrow Island), Figure 6-12 (Benthic Primary Producer Habitat Communities Present off the West Coast of Barrow Island in the Vicinity of the Horizontal Directional Drilling Site and the Feed Gas Pipeline System), Figure 6-13 (Benthic Primary Producer Habitat Communities Present off the East Coast of Barrow Island), Figure 6-14 (Biologically Important Areas in the North-west Marine Region for Whale Sharks), Figure 6-15 (Biologically Important Areas in the North-west Marine Region for Humpback Whales), Figure 6-16 (Humpback Whale Main Migration Route), Figure 6-17 (Biologically Important Areas for Green Turtles), Figure 6-18 (Biologically Important Areas for Flatback Turtles), Figure 6-19 (Biologically Important Areas for Hawksbill Turtles), Figure 6-20 (Biologically Important Areas for Loggerhead Turtles), Figure 6-21 (Marine Turtle Beach Usage), Figure 6-23 (Biologically Important Areas for Wedge-tailed Shearwaters), Figure 6-24 (Biologically Important Areas for Fairy Terns), Figure 6-25 (Biologically Important Areas for Lesser Crested Terns), Figure 6-26 (Biologically Important Areas for Roseate Terns), Figure 6-27 (Marine Protected Areas in the Vicinity of the Fourth Train Proposal Area), Section 13.3 (Listed Threatened and Migratory Species and Communities – Terrestrial Environment), Section 13.4 (Listed Threatened and Migratory Species and Communities –Marine Species, and Their Habitats) and figures therein, Section 13.5 (Commonwealth Marine Environment), Table 16.2 (Approved Foundation Project EMPs Relevant to the Fourth Train Proposal), and Appendix E1 (Key Foundation Project Survey, Audit and Environmental Reporting)
	iii. Regional migration pathways for species or communities	Section 6.6.2 (Marine Fauna), Figure 6-16 (Humpback Whale Main Migration Route)
	g. For all listed threatened, migratory or marine species, including but not limited to those listed in Attachment 1, that are believed not likely to be impacted by the proposed action, but for which suitable habitat is present and could be impacted by the Fourth Train Proposal, detailed information must be included to demonstrate that a relevant impact on the species will not occur.	Section 13.3 (Listed Threatened and Migratory Species and Communities – Terrestrial Environment), Section 13.4 (Listed Threatened and Migratory Species and Communities –Marine Species, and Their Habitats), and Appendix E2 (Conservation Significant Species Considered for Assessment)
	Consideration of each species, community or site must have regard to any policy documents prepared, endorsed or otherwise made publically available by the Department of SEWPaC in relation to it.	Table 13-2 (Summary of Environmental and Heritage Values of the Ningaloo Coast), Tables 13-5 (Policies, Plans, and Guidelines Relevant to Impacts on Listed Terrestrial Species), Section 13.8 (Policies, Plans, and Guidelines Relevant to EPBC Act-Listed Marine Species Potentially Impacted by the Fourth Train Proposal), and Table 13.20 (Policies, Plans, and Guidelines Relevant to the Fourth Train Proposal's Commonwealth Marine Area).
6. Description of the Environment	Describe the following elements of the marine environment:	
	a. Climate and atmospheric characteristics (e.g. air quality, seasonal temperatures, humidity, wind, evaporation and rainfall)	Section 6.4.1 (Climate)

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
Commonwealth Marine Environment	b. Oceanographic conditions, especially those which may have a bearing on the proposed action. Information on seasonal variation, waves, tides, currents, water salinity, clarity, temperature and depths must be included as a minimum. Discuss frequency and severity of extreme weather conditions, such as storms and cyclones for the 2, 10 and 100 year conditions.	Sections 6.4.2 (Bathymetry), Section 6.4.3 (Oceanography), and Section 6.4.4 (Water and Sediment Quality), Section 6.4.10.3 (Sea Level Rise and Storm Surge), Section 6.4.10.4 (Sea Surface Temperature Change), Section 6.4.10.5 (High Intensity Rainfall Events and Cyclones), and Section 13.5.7 (Commonwealth Marine Environment [Seabed Disturbance])
	c. Bathymetric and geotechnical information, including within any proposed flowline routes and any other affected areas. Discuss the geomorphic and topographic features and seismic stability of these areas	Section 6.4.2 (Bathymetry), Section 6.4.4.3 (Bedform and Sediment Quality), and Section 13.5.7 (Commonwealth Marine Environment [Seabed Disturbance])
	d. Known flora and fauna, including baseline information and maps on communities and individual species types, and where known, population genetics and stock structure in the immediate and surrounding areas that may be subject to relevant impacts, as determined by literature search and survey and sampling programs, if required	Section 6.6.1 (Benthic Habitats), and Section 6.6.2 (Marine Fauna) and figures therein
	Provide an evaluation of the flora and fauna communities identified with reference to:	
	a. Habitat values in a local, regional and national context	Section 6.6.1 (Benthic Habitats), Section 6.6.1.1 (Benthic Habitats [Regional]), Section 6.6.1.2. (Benthic Habitats [Fourth Train Proposal Area]), Section 6.6.2 (Marine Fauna), Section 13.4 (Listed Threatened and Migratory Species and Communities –Marine Species, and Their Habitats), and Section 13.5 (Commonwealth Marine Environment)
	b. Presence of endemic species	Section 6.6.1 (Benthic Habitats), Section 6.6.2 (Marine Fauna), Section 13.4 (Listed Threatened and Migratory Species and Communities –Marine Species, and Their Habitats), Section 13.5 (Commonwealth Marine Environment), and Appendix E2 (Conservation Significant Species Considered for Assessment)
	c. Local and regional representation	Section 6.6.1 (Benthic Habitats), 6.6.1.1 (Benthic Habitats [Regional]) 6.6.1.2. (Benthic Habitats [Fourth Train Proposal Area]), Section 6.6.2 (Marine Fauna), Section 13 (Matters of National Environmental Significance - Impacts and Management), and Appendix E2 (Conservation Significant Species Considered for Assessment)
	d. Conservation and biodiversity values	Section 6.6.1 (Benthic Habitats), Section 6.6.2 (Marine Fauna), Section 6.7 (Protected Areas), Section 13 (Matters of National Environmental Significance - Impacts and Management), Section 13.2 (National Heritage Places), and Appendix E2 (Conservation Significant Species Considered for Assessment)
	e. Economic and cultural value of species	Sections 6.8.4.2.2 (Fisheries), Section 6.8.4.2.4 (Marine Tourism), and Section 6.8.4.2.5 (Recreational Fishing)

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	f. Migratory species	Section 6.6.2 (Marine Fauna), Figure 6-14 (Biologically Important Areas in the North-west Marine Region for Whale Sharks), Figure 6-15 (Biologically Important Areas in the North-west Marine Region for Humpback Whales), Figure 6-16 (Humpback Whale Main Migration Route), Figure 6-17 (Biologically Important Areas for Green Turtles), Figure 6-18 (Biologically Important Areas for Flatback Turtles), Figure 6-19 (Biologically Important Areas for Hawksbill Turtles), Figure 6-20 (Biologically Important Areas for Loggerhead Turtles), Figure 6-23 (Biologically Important Areas for Wedge-tailed Shearwaters), Figure 6-24 (Biologically Important Areas for Fairy Terns), Figure 6-25 (Biologically Important Areas for Lesser Crested Terns), Figure 6-26 (Biologically Important Areas for Roseate Terns),and Section 13.4 (Listed Threatened and Migratory Species and Communities – Marine Species and their Habitats).
	g. Unique habitats	Section 6.6.1 (Benthic Habitats), Section 6.6.2 (Marine Fauna), Section 6.7 (Protected Areas), Figure 6-12 (Benthic Primary Producer Habitat Communities Present off the West Coast of Barrow Island in the Vicinity of the Horizontal Directional Drilling Site and the Feed Gas Pipeline System), and Figure 6-13 (Benthic Primary Producer Habitat Communities Present off the East Coast of Barrow Island)
	Discuss the likely presence of any unique, rare, threatened, endangered or vulnerable flora and fauna species and communities or listed migratory species, as well as whales and other cetaceans in the marine environment relevant to the proposed action, including the marine environment, that may be impacted by the Fourth Train Proposal. Include an evaluation of the significance of their occurrence (including conservation status, distribution, population viability and habitat requirements).	Section 6.6.2 (Marine Fauna), Figure 6-14 (Biologically Important Areas in the North-west Marine Region for Whale Sharks), Figure 6-15 (Biologically Important Areas in the North-west Marine Region for Humpback Whales), Figure 6-16 (Humpback Whale Main Migration Route), Figure 6-17 (Biologically Important Areas for Green Turtles), Figure 6-18 (Biologically Important Areas for Flatback Turtles), Figure 6-19 (Biologically Important Areas for Hawksbill Turtles), Figure 6-20 (Biologically Important Areas for Loggerhead Turtles), Figure 6-21 (Marine Turtle Beach Usage), Figure 6-23 (Biologically Important Areas for Wedge-tailed Shearwaters), Figure 6-24 (Biologically Important Areas for Fairy Terns), Figure 6-25 (Biologically Important Areas for Lesser Crested Terns), Figure 6-26 (Biologically Important Areas for Roseate Terns), Figure 6-27 (Marine Protected Areas in the Vicinity of the Fourth Train Proposal Area), Section 13.3 (Listed Threatened and Migratory Species and Communities – Terrestrial Environment), Section 13.4 (Listed Threatened and Migratory Species and Communities –Marine Species, and Their Habitats) and figures therein, Section 13.4 (Listed Threatened and Migratory Species and Communities –Marine Species, and Their Habitats), Section 13.5 (Commonwealth Marine Environment) and Appendix E2 (Conservation Significant Species Considered for Assessment)
	Include a broader description of the biodiversity and biogeography of the receiving environment. Identify sensitive environments along with key ecological relationships and interdependencies (e.g.. coral spawning, fish spawning aggregations, flora and fauna relationships etc.).	Section 6.6 (Marine Ecology)
	Discuss the existing disturbance to flora and fauna, and the incidence of introduced pest species	Sections 6.6.2 (Marine Fauna) Section 3.5.3 (Terrestrial and Marine Quarantine Management), and Section 12 (Quarantine Management).
	Describe the heritage values of any National or World Heritage places, including the Ningaloo National and World Heritage place	Section 6.7.2 (Ningaloo Marine Park and Muiron Islands Marine Management Area), Section 6.7.3 (Ningaloo Coast), and Table 13-2 (Summary of Environmental and Heritage Values of the Ningaloo Coast)

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	Identify any existing or proposed reserves in, or neighbouring, the Fourth Train Proposal or within proximity to the area that is likely to be impacted in the event of a hydrocarbon spill and their status. Include the reserve characteristics, status, IUCN category and values and relevant management strategies.	Section 6.7 (Protected Areas) and figures therein, Section 13.5 (Commonwealth Marine Environment), and Table 13-20 (Policies, Plans, and Guidelines Relevant to the Fourth Train Proposal's Commonwealth Marine Area)
7. Impacts on Matters of National Environmental Significance		
7. Impacts on Matters of NES	**Provide a description of the relevant impacts of the Fourth Train Proposal on the matters protected by the controlling provisions for the Proposal, including but not limited to relevant impacts:**	Table 3-1 (Foundation Project Environmental Management and Monitoring Plans, Programs, Systems, Procedures, and Reports as required under the Ministerial Conditions as Relevant to the Fourth TRain Proposal), Section 6 (Environmental and Social Baseline), Section 9 (Terrestrial Environment - Impacts and Management), Section 10 (Marine Environment - Impacts and Management), Section 12 (Quarantine Management), Section 13 (Matters of National Environmental Significance - Impacts and Management), Section 15 (Cumulative Impacts), Section 16 (Environmental Management Framework), Table 16-1 (Experience Gained from the Foundation Project relevant to the Fourth Train Proposal), and Table 16-2 (Approved Foundation Project EMPs relevant to the Fourth Train Proposal).
	a. On species arising from vegetation and habitat clearance or degradation	Section 9.6.2.1 (Vegetation Clearing and Earthworks), Section 13.3 (Listed Threatened and Migratory Species and Communities – Terrestrial Environment), Appendix E1 (Key Foundation Project Survey, Audit and Environmental Reporting), and Appendix E2 (Conservation Significant Species Considered for Assessment
	b. As a result of construction, increased noise and vibration (including acoustic volume, noise frequency and noise propagation) and site excavation	Section 3.5.6 (Vibration Monitoring [Construction] - Marine Turtles), Section 3.5.5 (Noise Monitoring [Construction] - Mammals and White-winged Fairy Wrens [Barrow Island]), Section 5.4 (Noise and Vibration Emissions), Section 9.6.2.6 (Noise and Vibration), Section 9.7.2.6 (Noise and Vibration), Section 10.6.2.4 (Noise and Vibration), Section 13.3.2 (Listed Threatened and Migratory Species and Communities – Terrestrial Environment [Assessment and Mitigation of Potential Impacts]), Section 13.4.2 (Listed Threatened and Migratory Species and Communities – Marine Species, and Their Habitats [Assessment and Mitigation of Potential Impacts]), and Section 13.5.6 (Commonwealth Marine Environment [Noise and Vibration]) Appendix D4 (Cumulative Noise Impact Study for the Gorgon Expansion Project Barrow Island LNG Plant)
	c. From drill cuttings, including drill cuttings modelling where there is a relevant impact on a controlling provision	Table 3-1 (Foundation Project Environmental Management and Monitoring Plans, Programs, Systems, Procedures, and Reports as required under the Ministerial Conditions as Relevant to the Fourth TRain Proposal), Section 3.5.2.3 (Horizontal Directional Drilling Marine Monitoring), Section 3.5.2.5 (Offshore Feed Gas Pipeline Installation Monitoring), Section 13.5.5.1 (Discharges from Offshore Drilling and Completion Activities), Table 16-1 (Experience Gained from the Foundation Project relevant to the Fourth Train Proposal), and Table 16-2 (Approved Foundation Project EMPs relevant to the Fourth Train Proposal).
	d. From operational light emissions, including light spill modelling	Section 3.5.2.1.5 (Light Monitoring Program), Section 3.5.2.1.6 (Congregation in Offshore Lights), Section 13.4 (Listed Threatened and Migratory Species and Communities – Marine Species), Section 13.5.4 (Commonwealth Marine Environment [Artificial Light]), and Appendix D3 (Gorgon Light Emissions Study - Fourth Train Proposal)

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	e. From other solid, liquid and gaseous waste produced during the construction, commissioning, operation and decommissioning phases	Section 5 (Emissions, Discharges and Wastes), Section 3.5.1.4.3 (Dust Impact Vegetation Monitoring Program), Section 3.5.7 (Ambient Air Quality Monitoring), Section 13.2.2.1 (National Heritage Places [Atmospheric Emissions (except dust)]), Section 13.4 (Listed Threatened and Migratory Species and Communities – Marine Species), Section 13.5.3 (Commonwealth Marine Environment [Atmospheric Emissions (except dust)]), and Section 13.5.5 (Commonwealth Marine Environment [Discharges to Sea]) Appendix D1 (Gorgon Gas Development Fourth Train Proposal Air Quality Assessment)D2 (Gorgon Expansion Project Phase 2 Acid Gas Vent Dispersion Modelling), and Appendix D5 (Assessment of Environmental Risk - Hydrocarbon Spill).
	f. Arising from the introduction and/or spread of exotic and invasive pest species	Section 3.5.3 (Terrestrial and Marine Quarantine Management), and Section 12 (Quarantine Management)
	g. As a result of increased vessel and vehicle movement and increased noise during construction, operation and decommissioning	Section 4.3 (Offshore Components), Section 4.4 (Onshore Components), Section 4.5 (Construction Activities), Section 4.6 (Simultaneous Operations), Section 4.7 (Operational Activities), Section 4.8 (Decommissioning Activities), Section 13.3 (Listed Threatened and Migratory Species and Communities – Terrestrial Environment), Section 13.4 (Listed Threatened and Migratory Species and Communities – Marine Species), Section Section 13.5.6 (Commonwealth Marine Environment [Noise and Vibrations]), and Section 13.5.8 (Commonwealth Marine Environment [Physical Presence of Infrastructure and Physical Interaction])
	h. Arising from the timing of construction works, e.g. on species during migratory and breeding seasons	Table 3-1 (Foundation Project Environmental Management and Monitoring Plans, Programs, Systems, Procedures, and Reports as required under the Ministerial Conditions as Relevant to the Fourth TRain Proposal), Section 3.5 (Environmental Monitoring), Section 4.5 (Construction Activities), Section 10.6.2.6. (Physical Interaction), Section 13.4 (Listed Threatened and Migratory Species and Communities – Marine Species), and Section 13.4.2.2.3 (Whales: Humpback Whale, Bryde's Whale, Blue Whale and Sperm Whale)
	i. On Ningaloo National Heritage Place	Section 6.7 (Protected Areas), and Section 13.2 (National Heritage Places)
7. Impacts on Matters of NES *Hydrocarbon Spill Modelling*	**Include an analysis of the likelihood of a range of spill scenarios, including but not limited to a well blowout / uncontrolled leak occurring from the proposed wells at both subsea and sea level, and spills/leaks from infrastructure and/or equipment (such as pipeline rupture). The analysis must consider:**	Table 5-26 (Results of the Worst-case Outcomes from the Hydrocarbon Spill Modelling at Sensitive Shoreline Receptor Locations), Section 5.7 (Accidental Releases (Spills and Leaks) to the Marine Environment), Section 10.4.2.4 (Seabed [Intertidal and Subtidal] - Assessment and Mitigation of Potential Impacts [Spills and Leaks]), Section 10.5.2.3 Marine Water Quality - Assessment and Mitigation of Potential Impacts [Spills and Leaks]), Section 10.6.2.8 (Marine Fauna - Assessment and Mitigation of Potential Impacts [Spills and Leaks]), Section 10.6.3 (Conservation-significant Species), Sections 13.2.2.2 (National Heritage Places [Spills and Leaks]), Section 13.4 (Listed Threatened and Migratory Species and Communities –Marine Species) Section 13.5.9 (Commonwealth Marine Environment [Spills and Leaks]), and Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Section 5 therein.

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Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	a. The complexity of the drilling proposal, including water depth, duration and number of wells	Section 4.3.1 (Gas Fields), Table 4-3 (Gas Fields Proposed to be Developed as Part of the Phased Development of the Combined Gorgon Gas Development, and Future Developments), Section 4.3.2 (Wells and Subsea Facilities), and Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill)
	b. The level of understanding of the geophysical and geochemical properties over the drilled depth	Section 6.4.4.3 (Bedform and Sediment Quality), Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill)
	c. Prevention measures	Section 5.7.3 (Accidental Releases [Spills and Leaks] to the Marine Environment [Proposed Management]), Section 5.7.3.1 (Accidental Releases [Spills and Leaks] to the Marine Environment [Control Measures])
	d. The historical context (i.e. frequencies of blowouts and well control incidents for operations in similar offshore environments).	Section 13.5.9 (Spills and Leaks), and Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill)
	Include hydrocarbon spill trajectory modelling for a range of spill scenarios, including a 'worst case' scenario spill. The modelling must:	Section 5.7.3.1 (Accidental Releases (Spills and Leaks) to the Marine Environment [Control Measures]), and Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill)
	a. Model a subsea and sea-level blowout, if appropriate, of at least 11 weeks duration	Section 13.5.9 (Spills and Leaks), Table 13-32 (Potential Impacts to Key Ecological Features of the North-west Marine Region Following an 11-week Subsea Well Blowout in the Chandon Gas Field), and Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Section 3.2.1 therein
	b. Address all times of the year for which approval is sought	Section 13.5.9 (Spills and Leaks), Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Section 3 therein, and Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Appendix 1 Section 2.2 therein
	c. Provide a description of, and justify the modelling of, the hydrocarbon type, including toxicity, weathering characteristics and release volume	Section 5.7.2.1 (Fate and Transport of Spilled Hydrocarbons (Oil Spill Modelling)) Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Section 2.1 therein, and Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Appendix 1 Section 2.2.7 therein
	d. Model any other more likely scenarios such as spills or leaks from infrastructure and equipment	Section 5.7.2.1 (Fate and Transport of Spilled Hydrocarbons [Oil Spill Modeliing]), Table 5-24 (Hydrocarbon spill Modelling Scenarios Relevant to the Fourth Train Proposal) Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Appendix 1 Section 3 therein
	Include a description of the relevant impacts and consequences for all protected matters likely to be impacted should a blowout or other spill occur. The description of relevant impacts must:	Section 13.5.9 (Spills and Leaks), Section 13.2.2.2 (National Heritage Places [Spills and Leaks]), Section 13.4 (Listed Threatened and Migratory Species and Communities – Marine Species), and Section 13.5.9 (Commonwealth Marine Environment [Spills and Leaks])
	a. Be specific to the characteristics of the hydrocarbons released, including toxicity and weathering characteristic sand be specific to the modelling results	Section 5.7 (Accidental Releases (Spills and Leaks) to the Marine Environment) Section 13.2.2.2 (National Heritage Places [Spills and Leaks]) Section 13.4.2 (Listed Threatened and Migratory Species and Communities –Marine Species -Assessment and Mitigation of Potential Impacts) (Various Subsections therein), Section 13.5.9 (Commonwealth Marine Environment [Spills and Leaks]) Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Section 2.1 therein Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Section 2.2 therein Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Section 6 therein Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Appendix 1 Section 2.2.7 therein, and Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Appendix 1 Section 3 therein

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	b. Address both physical and toxicity impacts	Section 13.2.2.2 (National Heritage Places [Spills and Leaks]) Section 13.4.2 (Listed Threatened and Migratory Species and Communities –Marine Species -Assessment and Mitigation of Potential Impacts) (Various Subsections therein), Section 13.5.9 (Commonwealth Marine Environment [Spills and Leaks]) Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Section 2.1 therein Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Section 2.2 therein Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Section 6 therein Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Appendix 1 Section 2.2.7 therein, and Appendix D5 (Assessment of Environmental Risk – Hydrocarbon Spill) - Appendix 1 Section 3 therein
	c. Address impacts on habitats for listed species	Table 5-26 (Results of the Worst-case Outcomes from the Hydrocarbon Spill Modelling at Sensitive Shoreline Receptor Locations), Section 10.4.2.4 (Seabed [Intertidal and Subtidal] - Assessment and Mitigation of Potential Impacts [Spills and Leaks]), Section 10.5.2.3 Marine Water Quality - Assessment and Mitigation of Potential Impacts [Spills and Leaks]), Section 10.6.2.8 (Marine Fauna - Assessment and Mitigation of Potential Impacts [Spills and Leaks]), Section 10.6.3 (Conservation-significant Species), Sections 13.2.2.2 (National Heritage Places [Spills and Leaks]), Section 13.4 (Listed Threatened and Migratory Species and Communities – Marine Species), Section 13.5.9 (Spills and Leaks), Section 13.5.9 (Commonwealth Marine Environment [Spills and Leaks]), and Table 13-32 (Potential Impacts to Key Ecological Features of the North-west Marine Region Following an 11-week Subsea Well Blowout in the Chandon Gas Field)
	d. Address impacts on heritage places and the Commonwealth Marine Area	Sections 13.2.2.2 (National Heritage Places [Spills and Leaks]), and Section 13.5.9 (Commonwealth Marine Environment [Spills and Leaks])
	Provide response measures that would be undertaken in the event of a blowout from the proposed wells or other leaks/spills. The response measures must:	Section 5.7.3.2 (Accidental Releases (Spills and Leaks) to the Marine Environment [Response Measures])
	a. Include a description of Chevron's preparedness for an incident, particularly the capability of implementing a 'first strike' response; that is, the response within the first 24 to 48 hours of an incident before other resources can be accessed and mobilised, including under the National Plan	Section 5.7.3.2 (Accidental Releases (Spills and Leaks) to the Marine Environment [Response Measures])
	b. Detail the availability of equipment and mobilisation time	Section 5.7.3.2 (Accidental Releases (Spills and Leaks) to the Marine Environment [Response Measures])
	c. Address prioritisation of sensitive environments and habitats for protected matters and focus on minimising relevant impacts	Section 5.7.3.2.2 (Response Measures [Response Prioritisation])
	d. Articulate methods by which the identified sensitive environments will be protected or relevant impacts minimised	Section 5.7.3.2 (Accidental Releases (Spills and Leaks) to the Marine Environment [Response Measures])
7. Impacts on Matters of NES	**Specifically relating to the <u>Commonwealth Marine Environment</u>, provide a description of the relevant impacts of the proposed action:**	

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
Impacts on the Commonwealth Marine Environment	a. On the functioning of the marine environment, taking into consideration the 'whole of environment' including consideration of other users of the Commonwealth marine area	Section 3.5.2 (Marine and Coastal Monitoring), Section 3.5.3 (Terrestrial and Marine Quarantine Management), Section 3.5.5 (Noise Monitoring [Construction] - Mammals and White-winged Fairy Wrens [Barrow Island]), Section 3.5.6 (Vibration Monitoring [Construction] - Marine Turtles), Section 6.6 (Marine Ecology), Section 10.4 (Seabed [Subtidal and Intertidal]), Section 10.5 (Marine Water Quality), Section 10.6 (Marine Fauna), Section 10.7 (Benthic Primary Producer Habitat), Section 10.8 (Conservation Areas), Section 10.9 (Potential Impacts During Decommissioning), Section 11.2.3 (Greenhouse Gas Emissions in Commonwealth Marine Area), Section 13.5 (Commonwealth Marine Environment), and Section 15.5.2 (Coastal and Nearshore Environment, and Commonwealth Marine Environment).
	b. Regarding the incidence of extreme environmental events, whether or not attributable to the Fourth Train Proposal (e.g.. cyclones etc.) and any related safety response that may impact on the environment	Section 4.3.4.6 (Offshore Feed Gas Pipeline System Stabilisation and Protection), Section 4.9.2 (Extreme Weather Events), Section 5.5.3.7 (Drainage Systems), Section 5.7.3.1.5 (Cyclone Contingency), Section 6.4.10.3 (Sea Level Rise and Storm Surge), Section 6.4.10.4 (Sea Surface Temperature Change), Section 6.4.10.5 (High Intensity Rainfall Events and Cyclones), and Section 13.5.9 (Spills and Leaks).
	c. To the sea floor through anchoring and direct placement, sediment disturbance as well as relevant impacts of removal. The zone of likely seabed disturbance must be identified	Section 4.3.4.1 (Pipeline Route Options), Figure 6-12 (Benthic Primary Producer Habitat Communities Present off the West Coast of Barrow Island in the Vicinity of the Horizontal Directional Drilling Site and the Feed Gas Pipeline System), and Section 13.5.7 (Seabed Disturbance)
	d. To fauna and flora species (composition and population densities), considering changes to overall communities, community types, propagation of species and potential barriers	Section 13.4 (Listed Threatened and Migratory Species and Communities –Marine Species, and Their Habitats), Section 13.5 (Commonwealth Marine Environment), and Appendix E2 (Conservation Significant Species Considered for Assessment)
	e. To macrobenthic species, fish and larger marine fauna species (composition and population densities), including changes to communities, breeding success, habitat, potential barriers or disturbances to migration or migratory patterns and other wildlife movements	Section 13.4 (Listed Threatened and Migratory Species and Communities –Marine Species, and Their Habitats), Section 13.5 (Commonwealth Marine Environment), and Appendix E2 (Conservation Significant Species Considered for Assessment)
	f. On rare, threatened, or otherwise valuable flora and fauna, communities (including threatened species and communities, listed marine species including whales and other cetaceans and listed migratory species) and habitat, conservation areas and protected areas	Section 13.4 (Listed Threatened and Migratory Species and Communities –Marine Species, and Their Habitats), Section 13.5 (Commonwealth Marine Environment), and Appendix E2 (Conservation Significant Species Considered for Assessment)
	g. From solid, liquid and gaseous waste produced during the construction, commissioning, operation and decommissioning phases, including:	Section 5 (Emissions, Discharges and Wastes), and Section 13.5 (Commonwealth Marine Environment)
	i. Volumes of all solid, liquid and gaseous waste projected to be produced including produced formation water and atmospheric emissions of pollutants, such as oxides of nitrogen, sulphur dioxide and volatile organic compounds throughout the lifecycle of the Fourth Train Proposal. The proponent must quantify all projected emissions throughout the lifecycle of the Fourth Train Proposal. All emissions sources (combustion, process, fugitive etc.) must be discussed)	Section 5.2 (Atmospheric Emissions), Section 5.5 (Discharges to Land and Water), and Section 5.6 (Solid and Liquid Waste Management)
	ii. Atmospheric emissions modelling and greenhouse emissions assessment including but not limited to:	Section 5.2 (Atmospheric Emissions), and Section 11 (Greenhouse Gas Emissions and Energy Management)
	a) Data on maximum annual emissions of carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) throughout the lifecycle of the project, from construction and operation to decommissioning. The inventory must include:	Section 11 (Greenhouse Gas Emissions and Energy Management)

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	· An estimate of emissions on a gas by gas basis and by source including whether the source is within, or external to, the Commonwealth marine environment	Section 11.2 (Greenhouse Gas Emissions), and Section 11.2.3 (Greenhouse Gas Emissions in Commonwealth Marine Areas)
	· A summary table of emissions on a gas by gas basis	Section 11.2 (Greenhouse Gas Emissions), and Table 11-2 (Greenhouse Gas Emissions Produced in the Commonwealth Marine Area during Construction of the Fourth Train Proposal)
	· A summary table listing emissions on a carbon dioxide equivalent basis	Table 11-1 (Estimated Annual Greenhouse Gas Emissions from the Operation of the Fourth Train Proposal), and Table 11-2 (Greenhouse Gas Emissions Produced in the Commonwealth Marine Area during Construction of the Fourth Train Proposal)
	· A summary of gross emissions, emission reduction due to both offsets and mitigation and net emissions	Section 11.3.7 (Emissions Reduction from Proposed Management), and Section 11.3.8 (Greenhouse Gas Emissions Offsets)
	b) Cumulative emissions as far as is practicable (with regards to known potential future expansions or developments by Chevron and other proponents in the vicinity of the development)	Section 11.2.4 (Impact on Global Greenhouse Gas Emissions)
	c) The methodology used in making the estimates and a justification for using that methodology	Section 11.2.2.1 (Methodology and Assumptions)
	d) The estimated greenhouse gas emissions from the Fourth Train Proposal in a national and global context (both as a result of the entire project, and from emissions emitted within the Commonwealth marine environment)	Section 11.2.4 (Impact on Global Greenhouse Gas Emissions)
	e) A description of methods by which greenhouse gas emissions could be mitigated	Section 11.3 (Proposed Greenhouse Gas Emissions and Energy Efficiency Management Measures)
	f) Information on the range of offsets that may be pursued for emissions to be emitted directly to the Commonwealth marine environment	Section 11.3.8 (Greenhouse Gas Offsets)
	g) A program which includes ongoing monitoring, investigation, review and reporting of greenhouse gas emissions and abatement measures	Section 11.1.2 (Commonwealth Legislation and Policy)
	h. Relating to potential socio-economic and cultural impacts **(in the Commonwealth Marine Environment)** including a description and discussion of relevant impacts (both positive and negative):	
	i. Caused by any short, medium and long-term changes, interruption, alteration or curtailment of activities and uses of the area due to the Fourth Train Proposal, including changes to uses or users	Section 14.5 (Land and Sea use)
	ii. On sites of historical or cultural significance, including places entered in the Commonwealth Heritage List or Register of the National Estate and other significant sites and unknown or unsurveyed sites	Section 14.3 (Cultural Heritage)
	iii. On existing industry and commerce affected by the proposed action	Section 14.5 (Land and Sea use)
	iv. To employees in terms of workplace safety	Section 14.2 (Workforce and Public Health and Safety)
	v. On shipping and any potential traffic hazards	Section 14.5 (Land and Sea use), and Section 14.7 (Local Communities)
	vi. On visual and aesthetic values, impacts to tourism and access for conservation purposes	Section 14.4 (Conservation Areas)
	vii. To historic shipwrecks in the area, including where relevant on, as yet, unknown shipwrecks or those in unsurveyed areas	Section 14.3 (Cultural Heritage)
	i. On places with known heritage, social or cultural values, such that they have been recognised with listing or recording under relevant State or Commonwealth legislation or are nominated to be listed under such legislation	Section 13.2 (National Heritage Places), Section 13.5 (Commonwealth Marine Environment), and Section 14.3 (Cultural Heritage)
	j. On water clarity, salinity and temperature with specific reference to stratification of the water column.	Section 13.5.5.1 (Discharges from Offshore Drilling and Completion activities), Section 13.5.5.2 (Discharges from the Fourth Train Proposal Offshore Feed Gas Pipeline System), Section 13.5.5.3 (Discharges from Marine Vessels), Section 13.5.7.1 (Installation of the Fourth Train Proposal Offshore Feed Gas Pipeline System), and Section 13.5.7.2 (Installation of the Fourth Train Proposal Intrafield Flowlines)
7. Impacts on	**Include in the EIS:**	

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Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
Matters of NES *General*	a. A detailed assessment of the nature and extent of the relevant long-term and short-term impacts on the matters protected by the controlling provisions for the Fourth Train Proposal, including a summary table detailing the extent of impact for each controlling provision	Table ES-8 (Key Potential Impacts, Mitigation and Management Measures, and Predicted Outcomes for Fourth Train Proposal Controlling Provisions), Section 13 (Matters of NES), Table 13-1 (Summary of Controlling Provisions for the Fourth Train Proposal), Table 13-7 (Stressors to Listed Terrestrial Species from the Implementation of the Fourth Train Proposa), Table 13-10 (Stressors and Potential Impacts to Listed Marine Species from the Implementation of the Fourth Train Proposal), and Table 13-22 (Stressors and Potential Impacts to the Commonwealth Marine Environment from the Implementation of the Fourth Train Proposal)
	b. A statement whether any relevant impacts are likely to be unknown, unpredictable or irreversible	Section 13.7 (Matters of NES [Conclusion])
	c. Information on the scientific reliability of investigations and conclusions drawn, including degree of certainty or statistical confidence where appropriate. This must include any assumptions or limitations of any models used to make predictions and the qualifications of any experts consulted	Section 3.4.2.2 (Ministerial Conditions), Section 3.5 (Environmental Monitoring), Section 5.1 (Emissions, Discharges and Wastes [Introduction]), Section 8 (Assessment Method), Section 13.1.1 (Matters of NES [Approach]), Section 13.1.2 (Matters of NES [Scope of the Assessment]), Section 13.2.4 (National Heritage Places [Predicted Environmental Outcome]), Section 13.3.4 (Listed Threatened and Migratory Species and Communities – Terrestrial Environment [Predicted Environmental Outcome]), Section 13.4.4 (Listed Threatened and Migratory Species and Communities –Marine Species, and Their Habitats [Predicted Environmental Outcome]), Section 13.5.11 (Commonwealth Marine Environment [Predicted Environmental Outcome]), Section 13.7 (Matters of NES [Conclusion]), Section 16 (Environmental Management Framework), Appendix E1 (Key Foundation Project Survey, Audit and Environmental Reporting), and Appendix F (Environmental Risk Assessment)
	d. Information on the survey methodology used, including any limitations of the methodology and data collected for each protected matter, as well as a justification for the survey methodology and survey sites employed	Section 3.4.2.2 (Ministerial Conditions), Section 3.5 (Environmental Monitoring), Section 5.1 (Emissions, Discharges and Wastes [Introduction]), Section 8 (Assessment Method), Section 13.1.1 (Matters of NES [Approach]), Section 13.1.2 (Matters of NES [Scope of the Assessment]), Section 13.2.4 (National Heritage Places [Predicted Environmental Outcome]), Section 13.3.4 (Listed Threatened and Migratory Species and Communities – Terrestrial Environment [Predicted Environmental Outcome]), Section 13.4.4 (Listed Threatened and Migratory Species and Communities –Marine Species, and Their Habitats [Predicted Environmental Outcome]), Section 13.5.11 (Commonwealth Marine Environment [Predicted Environmental Outcome]), Section 13.7 (Matters of NES [Conclusion]), Section 16 (Environmental Management Framework), Appendix E1 (Key Foundation Project Survey, Audit and Environmental Reporting), and Appendix F (Environmental Risk Assessment)

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	e. Evidence to demonstrate that survey methodology follows all relevant state and Commonwealth survey guidelines and how this has been achieved	Appendix E (Environmental Baseline), and Appendix D (Technical Studies)
	f. Any technical data, any sources of authority, and other information used or needed to make an assessment of the relevant impacts. Reliability of forecasts and predictions, confidence limits and margins of error must be indicated as appropriate. References included must clearly state whether peer review has taken place or not.	Section 5 (Emissions, Discharges and Wastes), Section 6 (Environmental Baseline), Section 9 (Terrestrial Environment - Impacts and Management), Section 10 (Coastal and Nearshore Environment - Potential Impacts and Management), Section 12 (Quarantine Management), Section 13 (Matters of National Environmental Siognificance - Impacts and Management), Section 15 (Cumulative Impacts), Section 16 (Environmental Management Framework), Appendix E (Environmental Baseline), and Appendix D (Technical Studies)
	Consideration of relevant impacts must encompass direct, indirect, cumulative and facilitated impacts where:	Section 5 (Emissions, Discharges and Wastes), Section 6 (Environmental Baseline), Section 13 (Matters of NES),Section 8 (Assessment Method), Table 8-1 (Definitions of Impact Assessment Terms used in this PER/Draft EIS), and Figure 8-1 (Impact Terms Diagram), Section 9 (Terrestrial Environment - Impacts and Management), Section 10 (Coastal and Nearshore Environment - Potential Impacts and Management), Section 12 (Quarantine Management), Section 13 (Matters of National Environmental Siognificance - Impacts and Management), Section 15 (Cumulative Impacts), and Section 16 (Environmental Management Framework)
	Indirect impacts include those which are not a direct result of the proposed action, and may include off-site or downstream impacts, such as impacts on migratory species from changes to the hydrology of estuarine areas located off-site	
	Facilitated impacts include those resulting from actions of third parties that are facilitated by the Fourth Train Proposal, such as increased shipping or road traffic facilitated through the construction of a port or expansion of a facility	
	Cumulative impacts include the incremental impacts of the Fourth Train Proposal when combined with other past, present and reasonably foreseeable future actions (both related and unrelated), such as cumulative impacts associated with clearing and habitat modification for past and future foreseeable developments on Barrow Island.	Section 13 (Matters of National Environmental Significance - Impacts and Management), and Section 15 (Cumulative Impacts)
8. Economic and Social Matters		

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Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
8. Economic and Social Matters	Include:	
	a. A description of employment opportunities expected to be generated by the proposed action (including construction and operational phases)	Section 14.6 (Livelihoods), Section 14.8 (Commonwealth, State, and Regional Economy), and Section 13.7 ((Matters of NES [Conclusion])
	b. A description of the projected economic value of the proposed action at the regional, state and national levels	Section 14.8 (Commonwealth, State, and Regional Economy), and 13.7 ((Matters of NES [Conclusion])
	c. A description of the economic and social impacts of any proposed construction camps.	Section 14.2 (Workforce and Public Health and Safety), 14.6 (Livelihoods), and Section 14.8 (Commonwealth, State, and Regional Economy)
9. Environmental Management System		
9. Environmental Management System	Explain the overall environmental management philosophy that will be applied to areas impacted by the Fourth Train Proposal	Section 16 (Environmental Management Framework), and Section 13.6 (Management Framework Relevant to the Controlling Provisions)
	Outline the proposed environmental management system that will be applied to the Fourth Train Proposal, including summary details of audit protocols and reporting procedures. Reference must be made to consultation, relevant legislation, standards adopted, safeguards planned, management practices, monitoring programs and emergency contingency plans, ...	Section 16 (Environmental Management Framework), and Section 13.6 (Management Framework Relevant to the Controlling Provisions)
	...... including the management of facilities in the event of cyclones and other severe weather events.	Section 4.7.2.1 (Gas Treatment Plant), Section 5.2.3.2.3 (Non-routine Operations), Section 5.7.3.1.3 (Vessel Collision), and Section 5.7.3.1.5 (Cyclone Contingency)
10. Safeguards, Mitigation Measures and Monitoring		
10. Safeguards, Mitigation Measures and Monitoring	Describe the proposed safeguards, mitigation measures and monitoring programs to address relevant impacts of the Fourth Train Proposal, with a focus on matters of NES. This must include:	Section 13.2.3 (National Heritage Places [Proposed Management]), Section 13.3.3 (Listed Threatened and Migratory Species and Communities – Terrestrial Environment [Proposed Management]), Section 13.4.3 (Listed Threatened and Migratory Species and Communities –Marine Species, and Their Habitats [Proposed Management]), Section 13.5.10 (Commonwealth Marine Environment [Proposed Management]), Section 13.6 (Management Framework Relevant to the Controlling Provisions), and Section 13 "Illustrative mitigation and management tables" .
	· a consolidated list and outline of the environmental mitigation measures, monitoring programs and/or management plans to prevent, reduce or compensate for the relevant impacts of the action, including measures proposed that are to be undertaken by state or local government, or by the proponent	Table 12-23 (Illustrative Mitigation and Management Measures for Atmospheric Emissions in the Commonwealth Marine Area), Table 13-24 (Illustrative Mitigation and Management Measures for Artificial Light in the Commonwealth Marine Area),T Table 13-26 (Illustrative Mitigation and Management Measures for Planned Discharges to Sea in the Commonwealth Marine Area), Table 13-27 (Illustrative Mitigation and Management Measures for Anthropogenic Marine Noise in the Commonwealth Marine Area), Table 13-30 (Illustrative Mitigation and Management Measures for Seabed Disturbance in the Commonwealth Marine Area),and Table 13-31 (Illustrative Mitigation and Management Measures for Physical Presence and Physical Interaction in the Commonwealth Marine Area)
	· a description and an assessment of the expected or predicted effectiveness of the mitigation measures, monitoring program and/or management plan	Section 16.2.1 (Experience Gained), and Table 16-1 (Experience Gained from the Foundation Project relevant to the Fourth Train Proposal)
	· the cost of the proposed measures	Section 13.6 (Management Framework Relevant to the Controlling Provisions)
	· the name of the agencies responsible for endorsing or approving each monitoring program or management plan that will be submitted to meet regulatory requirements	Section 16.2.3.3 (Statutory EMPs)

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	· any provisions for independent auditing	Section 3.4.2.3 (Statutory EMPs), Section 3.4.2.3.1 (Adaptive Management), Section 3.5.3 (Terrestrial and Marine Quarantine Management), Section 16.2.1 (Experience Gained), and Table 16-1 (Experience Gained from the Foundation Project relevant to the Fourth Train Proposal)
	Environmental Management Plans (EMPs) must include estimates of relevant impacts from the Fourth Train Proposal and detail appropriate measures that will be taken to avoid or reduce impacts on matters of NES. The methodology of estimates must be explained and justified. EMPs must allow for the collection of baseline environmental data and ongoing monitoring for the duration of the Fourth Train Proposal and subsequent rehabilitation, so impacts on matters of NES can be adequately measured. Proposed methods for baseline measurement and subsequent monitoring must be demonstrably scientific and statistically sound. Details of requirements for the preparation of EMPs under other relevant legislation must be provided. In an effort to avoid duplication, areas of consistency between separate requirements must be identified.	Section 3.4 (Environmental Management Framework for the Foundation Project), Table 3-1 (Foundation Project Environmental Management and Monitoring Plans, Programs, Systems, Procedures, and Reports as required under the Ministerial Conditions as relevant to the Fourth Train Proposal), Section 16 (Environmental Management Framework), and Table 16-2 (Approved Foundation Project EMPs Relevant to the Fourth Train Proposal)

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	In outlining proposed monitoring programs, clearly identify what is to be monitored and why. Design monitoring programs to provide objective evidence regarding activities associated with the Fourth Train Proposal and whether these activities are adversely impacting on the environment in the short, medium and long term. Monitoring programs must demonstrate consideration of:	Section 3.4 (Environmental Management Framework for the Foundation Project), Section 3.4.2.3 (Statutory EMPs), Section 3.4.2.3.1 (Adaptive Management), Table 3-1 (Foundation Project Environmental Management and Monitoring Plans, Programs, Systems, Procedures, and Reports as required under the Ministerial Conditions as relevant to the Fourth Train Proposal), Section 16 (Environmental Management Framework), and Table 16-2 (Approved Foundation Project EMPs Relevant to the Fourth Train Proposal)
	· the effectiveness of mitigation measures (including any rehabilitation measures)	Section 3.5 (Environmental Monitoring), Section 16.2.1 (Experience Gained), and Table 16-1 (Experience Gained from the Foundation Project relevant to the Fourth Train Proposal)
	· relevant impacts on the controlling provisions as a result of management and operation of the Fourth Train Proposal	Section 13.6 (Management Framework relevant to the Controlling Provisions), and Section 13.7 (Conclusion)
	· the difference between predicted and actual impacts	Section 13.6 (Management Framework relevant to the Controlling Provisions), and Section 13.7 (Conclusion)
	· methods for identification or non-predicted impacts and appropriate reporting and remedial measures	Section 3.4 (Environmental Management Framework for the Foundation Project), Section 3.4.2.3 (Statutory EMPs), Section 3.4.2.3.1 (Adaptive Management), Section 13.6 (Management Framework relevant to the Controlling Provisions), Section 16 (Environmental Management Framework), and Table 16-2 (Approved Foundation Project EMPs Relevant to the Fourth Train Proposal)
	· application and effectiveness of emergency and contingency plans	Section 3.4.2.3.1 (Adaptive Management), , and Section 5.7.3.2 (Response Measures)
	· review of consultation and management arrangements with regulatory authorities, commercial users, indigenous and traditional users and the wider community	Section 7.3 (Key Stakeholders), Section 7.4 (Methods of Stakeholder Engagement), Section 7.6 (Ongoing Stakeholder Engagement
	· identification of any negative impacts upon the effectiveness of community infrastructure and services.	Section 14.7 (Local Communities)
11. Proposed Offset Measures		
11. Proposed Offset Measures	Where relevant impacts cannot be avoided or mitigated, describe any strategies proposed to offset (compensate for) those impacts. These strategies should reflect any relevant publically available guidance issued by SEWPaC in relation to offsets and in particular, must:	Section 16.3 (Environmental Offsets), and Section 13.6.1 (Environmental Offsets)
	· Demonstrate how the offset will achieve long-term conservation outcomes	Section 16.4 (Net Conservation Benefits)
	· Reflect the scale and intensity of impacts from the proposed action on the site	Section 16.3 (Environmental Offsets), and Section 13.6.1 (Environmental Offsets)
	· Consider the consequences of unavoidable impacts on individual matters protected by the controlling provisions for the Fourth Train Proposal in the context of their conservation status	Section 16.3 (Environmental Offsets), and Section 13.6.1 (Environmental Offsets)
	· Consider approaches to offsets by the State	Section 16.3 (Environmental Offsets), and Section 13.6.1 (Environmental Offsets)
12. Other Approvals and Conditions		
12. Other Approvals and Conditions	Provide information on other requirements for approval or conditions that apply, or that the proponent reasonably believes are likely to apply, where relevant to the controlling provisions for the proposed action. This must include:	Section 13.6 (Management Framework Relevant to the Controlling Provisions), Section 16 (Environmental Management Framework), Section 16.2.3.2 (Ministerial Conditions), Section 16.2.4 (Tier 3 – Subsidiary Documents), Table 16-2 (Approved Foundation Project EMPs Relevant to the Fourth Train Proposal), and Table 16-3 (Key Subsequent Approvals that may be required for the Fourth Train Proposal)
	· Details of any local or state government planning scheme, or plan or policy under any local or State government planning system that deals with the proposed action, including:	Section 16 (Environmental Management Framework), and Section 16.2.4.2 (Development Proposals)
	§ What environmental assessment of the proposed action has been, or is being, carried out under the scheme, plan or policy	Section 13.6 (Management Framework Relevant to the Controlling Provisions),, Section 16 (Environmental Management Framework), and Section 16.2.4.3 (Environment Plans)
	§ How the scheme provides for the prevention, minimisation and management of any relevant impacts.	Section 13.6 (Management Framework Relevant to the Controlling Provisions),, and Section 16 (Environmental Management Framework)

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
	· A description of any approval that has been obtained from a State, Territory or Commonwealth agency or authority (other than an approval under the EPBC Act), including any conditions that apply to the proposed action	Section 13.6 (Management Framework Relevant to the Controlling Provisions),, Section 16 (Environmental Management Framework), Section 16.2.3.2 (Ministerial Conditions), and Table 16-2 (Approved Foundation Project EMPs Relevant to the Fourth Train Proposal)
	· A statement identifying any additional approval that is required	Table 16-3 (Key Subsequent Approvals that may be required for the Fourth Train Proposal)
	· A description of the monitoring, enforcement and review procedures that apply, or are proposed to apply to the proposed action	Section 16.2 (Environmental Management Framework for the Fourth Train Proposal), and Table 16-2 (Approved Foundation Project EMPs Relevant to the Fourth Train Proposal)
13. Environmental Record		
13. Environmental Record	Provide:	
	· Details of any proceedings under Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources against the person proposing to take the action	Section 1.7.3 (Environmental Record)
	· Details of the corporation's environmental policy and planning framework	Section 1.7.2 (Chevron Corporation's Operational Excellence Management System)
	· Details of any non-compliance with Cth environmental requirements.	Section 1.7.3 (Environmental Record), and Section 13.7 (Matters of NES [Conclusion])

Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS		
Tailored Guidelines Section Ref.	**Detailed Commonwealth Requirement for the PER/Draft EIS**	**Section in the PER/Draft EIS where Requirement is Addressed**
14. Conclusion		
14. Conclusion	Provide an overall conclusion on the environmental acceptability of the Fourth Train Proposal including a discussion on compliance with objectives and requirements of the EPBC Act including the principles of ecological sustainable development. Reasons justifying undertaking the proposed action, in the manner proposed must be outlined. The conclusion must summarise measures proposed or required by way of mitigating or offsetting any unavoidable impacts on matters protected by the controlling provisions.	Conclusion' of Executive Summary , and Section 13.7 (Matters of NES [Conclusion])
15. Information Sources		
15. Information Sources	With respect to any information presented, state:	All sections:
	· The source of information	- All information sources are referenced. Lists of references are then provided at the end of each section
	· How recent the information is	- All information sources are referenced and monitoring and experience gained data are dated
	· How the reliability of the information was tested (specifically whether the information has been peer reviewed)	- Much of the data used has already been presented and approved as part of Foundation Project environmental approvals / EMPs / Subsidiary documents. This is clearly stated where relevant
	· What uncertainties (if any) are in the information	Any uncertainties in information have been identified and assumptions made clearly explained and justified.
	· The qualifications and experience of the study team and any specialist consultants	Section 1.4 (Approach to preparing this PER/draft EIS)
	· The names of the subject matter experts involved in the development of the environmental impact statement and their areas of expertise	Section 1.4 (Approach to preparing this PER/draft EIS)
	Any further or ongoing consultations or studies must be outlined	Section 7.6 (Ongoing Stakeholder Engagement)
16. Reference List and Bibliography		
16. Reference List and Bibliography	Include a reference list and bibliography that is accurate and concise and includes the address of any internet pages used as data sources	List of References are provided at the end of each section
17. Appendices and Glossary		
17. Appendices and Glossary	Detailed technical information studies or investigations necessary to support the main text of the EIS, but not suitable for inclusion in the main text, must be included as appendices (e.g. detailed technical or statistical information, maps, risk assessment, baseline data, supplementary reports).	Appendices
	Include a glossary defining technical terms and abbreviations used in the text to assist the general reader.	Terms and Acronyms List

Appendix B4: Public Environmental Review – Environmental Scoping Document

Gorgon Gas Development Fourth Train Proposal:

Public Environmental Review – Environmental Scoping Document

Document No:	G4-NT-REPX0000005	Revision:	1
Revision Date:	21 May 2012	Copy No:	
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Public Environmental Review – Environmental Scoping Document

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Revision Approvals

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Checked:	Daley Welch		
Approved:	David Lee		
Document Control QC:			

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☐ General Manager Greater Gorgon	Colin Beckett		

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1.0 Introduction

Chevron Australia Pty Ltd (Chevron Australia) seeks approval to enable production from the Gorgon Gas Development Foundation Project (Foundation Project) to be expanded from the approved 15 million tonnes per annum (MTPA) to 20 MTPA through the development of the Gorgon Gas Development Fourth Train Expansion Proposal (Fourth Train Proposal).

The Foundation Project, which incorporates three Liquefied Natural Gas (LNG) processing trains on Barrow Island using gas gathered from the Gorgon and Jansz–Io fields in the Greater Gorgon Area, is currently under construction. Since receiving approval for the Foundation Project, the opportunity for progressing a fourth LNG train was identified after additional hydrocarbon resources in the Greater Gorgon Area were discovered.

The Fourth Train Proposal involves the installation of facilities for gathering gas from these new offshore fields in the Greater Gorgon Area, transporting the gathered gas to, and processing it through a fourth LNG train on Barrow Island. Figure 1-1 shows the location of the various components of this Fourth Train Proposal and defines the geographical extent of the Fourth Train Proposal Area (Proposal Area). The regional context of the Fourth Train Proposal is described in Section 4.1.

1.1 Purpose of this Document

The Fourth Train Proposal was referred to the Western Australian (WA) Environmental Protection Authority (EPA) under section 38 of the *Environmental Protection Act 1986* (WA) (EP Act) on 27 April 2011 (Chevron Australia 2011). It was also referred to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) on the same date, as required under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Chevron Australia 2011a).

On 23 May 2011, the WA EPA determined that the Fourth Train Proposal requires assessment and set the level of assessment at a Public Environmental Review (PER) with an eight-week public review period (EPA Assessment No: 1889). The EPA requested that Chevron Australia prepare this Environmental Scoping Document.

On 3 June 2011, SEWPaC deemed that the Fourth Train Proposal was a Controlled Action requiring assessment and approval under the EPBC Act and set the level of assessment as an Environmental Impact Statement (EIS) (SEWPaC reference EPBC 2011/5942). SEWPaC have provided Chevron Australia with Tailored Guidelines describing the required scope of the Draft EIS (provided in Appendix 3 for information).

Chevron Australia intends to present a combined PER/Draft EIS document for public review, addressing both EPBC Act and EP Act requirements. This combined document approach has been endorsed by both the EPA and by SEWPaC.

This Environmental Scoping Document specifically describes the scope of works required to satisfy Schedule 2 of the EPA's Environmental Impact Assessment Administrative Procedures 2010 (EPA 2010). It has been prepared in accordance with the Guide to Preparing an Environmental Scoping Document (EPA 2010a). The purpose of this Environmental Scoping Document is to:

- develop specific guidelines on the key environmental issues in State jurisdiction relevant to the Fourth Train Proposal that will be addressed in the PER/Draft EIS
- identify the necessary impact predictions for the Fourth Train Proposal, and the information on the environmental setting required to carry out the assessment.

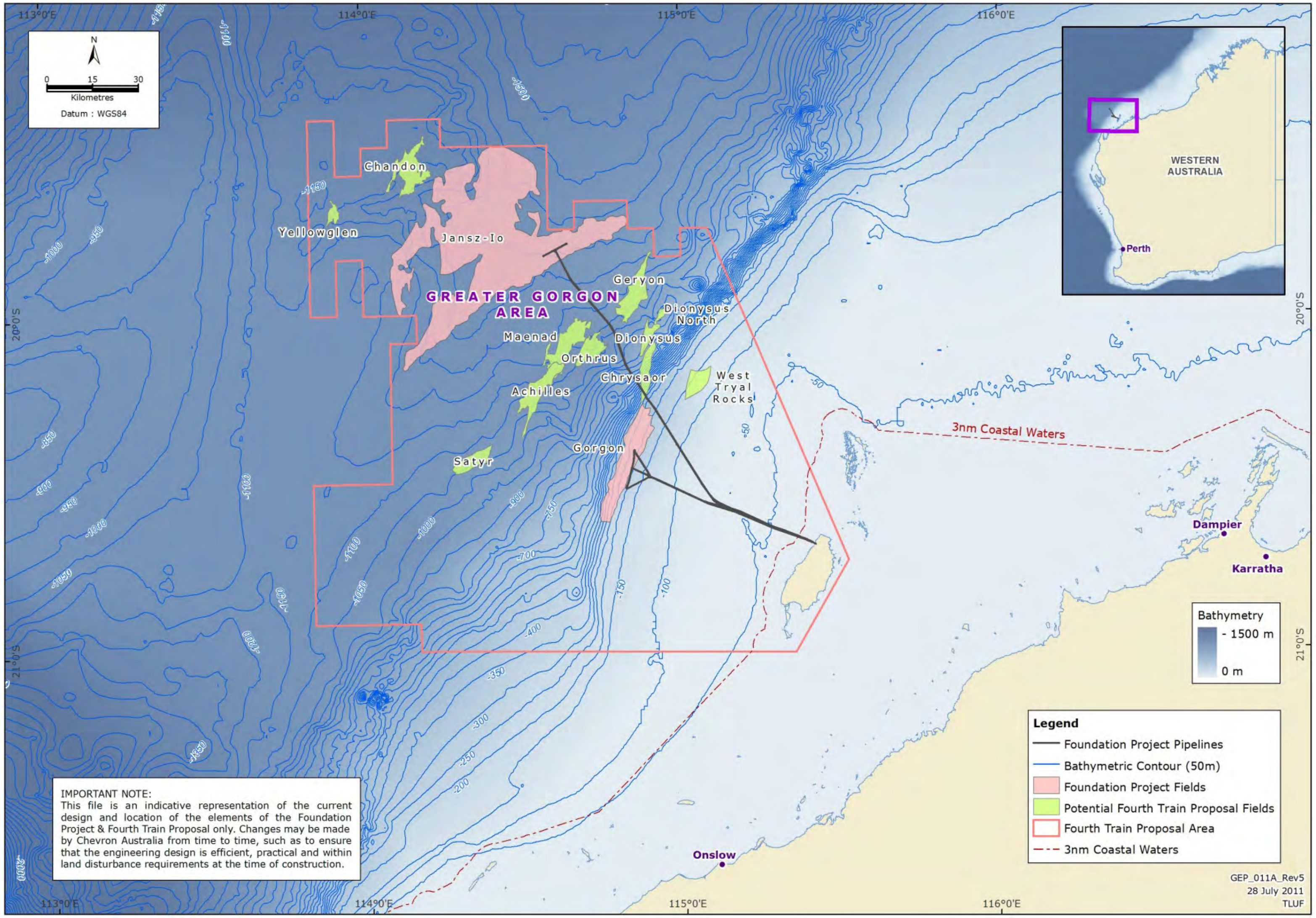

Figure 1-1 Fourth Train Proposal Area

1.2 Proponent Details

Chevron Australia is the proponent for the Fourth Train Proposal on behalf of the following companies, collectively known as the Gorgon Joint Venturers (GJVs):

- Chevron Australia Pty Ltd
- Chevron (TAPL) Pty Ltd
- Shell Development (Australia) Pty Ltd
- Mobil Australia Resources Company Pty Limited
- Osaka Gas Gorgon Pty Ltd
- Tokyo Gas Gorgon Pty Ltd
- Chubu Electric Power Gorgon Pty Ltd.

Proponent postal address	GPO Box S1580 Perth WA 6000
Key proponent contact for the proposal	Mr David Lee Government Approvals Manager, Gorgon Expansion Project 250 St Georges Terrace Perth WA 6000 Phone: (08) 9216 4144 Email: DavidLee@chevron.com

1.3 Project History

1.3.1 Overview

The Fourth Train Proposal is related to the following Chevron Australia projects, which are together referred to as the Foundation Project:

- the 10 MTPA initial Gorgon Gas Development
- the Revised and Expanded Gorgon Gas Development
- the Jansz Feed Gas Pipeline.

Section 1.3.2 details the approvals history of these projects.

The Foundation Project comprises a range of offshore and terrestrial components to recover gas from the Gorgon and Jansz–Io gas fields; transport the recovered gas by a Feed Gas Pipeline System to Barrow Island; and process the recovered gas at, and ship it from, a Gas Treatment Plant currently under construction on Barrow Island (see Figure 1-1 and Figure 2-1).

1.3.2 Approvals History

1.3.2.1 Strategic Evaluation

In late 2001, the Government of Western Australia determined that a strategic level evaluation of the proposed (now approved) Gorgon Gas Development was required to allow it to make an informed decision on whether to provide in-principle approval for the restricted use of Barrow Island for a Gas Treatment Plant and associated infrastructure.

This evaluation consisted of an Environmental, Social and Economic (ESE) Review, which was submitted for Government consideration in February 2003. The WA Government sought advice on environmental matters from the WA EPA, and social, economic and strategic aspects of the plan from the WA Department of Industry and Resources (DoIR). Advice was also sought from the Conservation Commission of WA, in which the Barrow Island Nature Reserve is vested.

In-principle support for the Gorgon Gas Development was granted by the WA Government in August 2003, as expressed in the Gorgon Gas Processing and Infrastructure Project Agreement (the State Agreement) and its ratifying Act, the *Barrow Island Act 2003* (WA) (Barrow Island Act) (see Section 3.2).

The State Agreement and the Barrow Island Act document the undertakings between the GJVs and the WA Government resulting from the ESE Review process and the granting of in-principle access to Barrow Island. A wide range of conditions and obligations are stipulated in the State Agreement.

1.3.2.2 Environmental Approvals

The initial Gorgon Gas Development was assessed through an Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP) assessment process (Chevron Australia 2005, 2006). It was approved by the WA State Minister for Environment on 6 September 2007 by way of Ministerial Implementation Statement No. 748 (Statement No. 748) and the Commonwealth Minister for the Environment and Water Resources on 3 October 2007 (EPBC Reference: 2003/1294).

In September 2008, Chevron Australia sought both State and Commonwealth approval through a Public Environmental Review (PER) assessment process (Chevron Australia 2008) for the Revised and Expanded Gorgon Gas Development to make some changes to 'Key Proposal Characteristics' of the initial Gorgon Gas Development, as outlined below:

- addition of a five MTPA LNG train, increasing the number of LNG trains from two to three
- expansion of the CO_2 Injection System, increasing the number of injection wells and surface drill locations
- extension of the causeway and the Materials Offloading Facility (MOF) into deeper water.

The WA State Minister for Environment approved the Revised and Expanded Gorgon Gas Development on 10 August 2009 by way of Ministerial Implementation Statement No. 800 (Statement No. 800). Statement No. 800 also superseded Statement No. 748 as the approval for the initial Gorgon Gas Development. Statement No. 800 therefore provides approval for both the initial Gorgon Gas Development and the Revised and Expanded Gorgon Gas Development. A subsequent amendment to Statement No. 800 was issued to the GJVs by the WA State Minister for Environment on 7 June 2011 under Ministerial Implementation Statement No. 865 (Statement No. 865). Statement No. 865 specifically amends certain conditions in Statement No. 800 relating to dredging and dredged spoil disposal. Other conditions in Statement No. 800 remain unaffected by Statement No. 865.

On 26 August 2009, the Commonwealth Minister for the Environment, Heritage and the Arts issued approval for the Revised and Expanded Gorgon Gas Development (EPBC Reference: 2008/4178), and varied the conditions for the initial Gorgon Gas Development (EPBC Reference: 2003/1294).

The Jansz Feed Gas Pipeline was assessed via Environmental Impact Statement/Assessment on Referral Information (ARI) and EPBC Referral assessment processes (Mobil Australia 2005, 2006). It was approved by the WA State Minister for Environment on 28 May 2008 by way of Ministerial Implementation Statement No. 769 (Statement No. 769) and the Commonwealth Minister for the Environment and Water Resources on 22 March 2006 (EPBC Reference: 2005/2184). Proponentship of the Jansz Feed Gas Pipeline was transferred from Mobil Australia to Chevron in 2009.

Since the Foundation Project was approved, further minor changes that are not expected to have a significant impact on the environment in addition or different to that approved by the Ministers for Environment, have been made and approved. Further changes to the Foundation Project may also be made in the future and where relevant, subsequent approvals sought.

1.4 Structure of this Document

Table 1-1 summarises where the requirements under the WA EP Act are addressed in this document.

Table 1-1 Adherence to EPA's Environmental Scoping Document Requirements

EPA Requirement [1]	Section Reference in this Document
Describe the purpose of this document	Section 1.1
Identify the proponent including Joint Venture partnership arrangements and proponent's name, address and nominated contact	Section 1.2
Provide a summary description of the proposal including maps at regional and local scales	Section 2.0 Figure 1-1 illustrates the location of the proposal
Present the project and assessment target timeline	Section 8.1
Provide the basis for justifying proposal and selecting preferred option	Section 2.5
Describe the regional setting of the proposal in a regional biophysical and social context	Section 4.0
Describe the tenure of land to be used in the proposal	Section 2.3
Summarise the potential environmental impacts, their significance and management responses	Section 5.0 and Appendix 5 Note that an environmental risk assessment to determine the level of risk will be undertaken for and documented in the PER/Draft EIS
Describe the proposed studies and investigations	Section 6.0
Identify the key environmental factors and principles for this proposal	Section 5.0, Appendix 5 and Appendix 6
Describe the applicable legislation	Section 3.0
Describe the community and other stakeholder consultation programmes including list of stakeholders that have been identified for inclusion	Section 7.0
Define how the PER document will undergo peer review	Section 8.3
Present the PER study team	Section 8.2
List the references used to prepare the Environmental Scoping Document	Appendix 1
Provide a table relating environmental factors and principles to the scope of investigations	Appendix 5 and Appendix 6

[1] *Requirements as defined in EPA 2010a.*

2.0 Summary Description of the Proposal

2.1 Proposal Overview

The Fourth Train Proposal comprises additions to several elements of the Foundation Project. Additional subsea wells and gas gathering systems, a new Feed Gas Pipeline System, and a fourth LNG train will be constructed. Existing LNG and condensate export facilities (constructed as part of the Foundation Project) will be used where practicable to export products generated by this Fourth Train Proposal from Barrow Island. Table 2-1 summarises the scope of the Fourth Train Proposal as compared to the scope examined in the environmental assessment documentation of the Foundation Project.

Table 2-1 Scope of Foundation Project and Fourth Train Proposal

Scope of the Foundation Project – as covered in:		Fourth Train Proposal
EIS/ERMP and Jansz–Io ARI	**Revised and Expanded PER**	
Construction, commissioning and operation of: • Subsea gas wells in the Gorgon and Jansz–Io gas fields • Two Feed Gas Pipeline Systems from the Gorgon and Jansz–Io gas fields to and across Barrow Island, using Horizontal Directional Drilling (HDD) as the method to cross the Barrow Island shore at North Whites Beach • A 10 MTPA, two LNG train Gas Treatment Plant on the east coast of Barrow Island • Marine offloading facilities and a 3.1 km jetty from the east coast of Barrow Island to export the processed LNG and condensate • Dredging of access channels to the jetty • A Domestic Gas Treatment Plant on Barrow Island and associated Domestic Gas pipeline system from Barrow Island to the mainland to connect to the Dampier to Bunbury Natural Gas Pipeline • Onshore wells into the Dupuy Formation under Barrow Island for the reinjection of reservoir	Construction, commissioning and operation of: • One additional 5 MTPA LNG train at the Gas Treatment Plant on Barrow Island bringing the total processing capacity of the plant to 15 MTPA using three LNG trains • Changes to the reservoir Carbon Dioxide Injection System to allow for an increased injection rate associated with the addition of one LNG train, increasing the number of injection wells and surface drill centre locations on Barrow Island • Revision of the causeway and the Materials Offloading Facility (MOF) designed to access deeper water to avoid hard rock material and the need for an extensive drilling and blasting program.	Construction, commissioning and operation of: • Subsea wells in new gas fields in the Greater Gorgon Area (other than Gorgon and Jansz–Io) – see Figure 1-1 • A new Feed Gas Pipeline System from the new gas fields to the Gas Treatment Plant on Barrow Island. To the extent practicable, this will follow the route of the approved Foundation Project's Feed Gas Pipeline Systems as it approaches Barrow Island. Similar to the approved Foundation Project, the shore crossing is to be constructed using HDD techniques. An area of approximately 10 ha of uncleared land may be required for the purpose of the HDD site and the exit of the Feed Gas Pipeline System from this site. The remainder of the onshore section of the Feed Gas Pipeline System will be constructed within the same corridor approved for the Foundation Project's Feed Gas Pipeline Systems and

Scope of the Foundation Project – as covered in:		Fourth Train Proposal
EIS/ERMP and Jansz–Io ARI	Revised and Expanded PER	
CO_2 removed from the Gorgon feed gas • Ancillary facilities and utilities to support the construction and operational phases including construction village, operations workforce accommodation, road upgrades, airport modifications, water supply, waste water systems etc.		will be approximately 14 km long (see Figure 2-1) • One additional 5 MTPA LNG train and associated facilities within the existing approved Foundation Project Footprint (see Figure 2-1) bringing the total design processing capacity of the plant to 20 MTPA using four LNG trains • Use of, and possible modification to, ancillary facilities and utilities provided by the Foundation Project to support the construction and operational phases, including construction village, operations workforce accommodation, road upgrades, airport modifications, water supply, waste water systems etc.

The new elements of the Fourth Train Proposal are described in Sections 2.2.1 to 2.2.3. Wherever practicable, the new elements will use the design and the existing infrastructure and facilities of the Foundation Project. In addition, some supporting infrastructure and facilities built and operated as part of the Foundation Project may be shared and may require modification and/or addition to accommodate the requirements of the Fourth Train Proposal (see Section 2.2.3).

2.2 Key Characteristics of the Fourth Train Proposal

2.2.1 Subsea Gathering System

Upstream facilities will be installed to access the Feed Gas and gas condensate reserves in gas fields located in the Greater Gorgon Area and to supply these reserves to the new Feed Gas Pipeline System. These upstream facilities will be located in the Commonwealth waters, in water depths ranging from approximately 140 m to 1500 m (Figure 1-1).

The final design of the field development program will determine the total number of subsea production wells required for the Fourth Train Proposal, which is currently estimated to be between approximately 38 and 63 wells. Initially, gas and gas condensate will be produced from between approximately 10 and 16 production wells located in fields shown in Figure 1-1 (not including the Gorgon or Jansz–Io fields). Additional gas reserves will be developed over the life of the Fourth Train Proposal to supply the required quantity of Feed Gas for the four

LNG trains, requiring between approximately 28 and 47 further production wells in the fields shown in Figure 1-1 (not including Gorgon and Jansz–Io).

Several activities will be undertaken, including:

- drilling and completion of production wells and installation of subsea wellhead trees
- installation and operation of a subsea gathering system, injection lines, and control/power umbilical lines
- remote operation of the wells and subsea facilities from the Gas Treatment Plant on Barrow Island
- provision of offshore support, including the provision of construction materials and maintenance, from existing mainland support facilities where practicable.

It is anticipated that offshore compression may be needed during the latter stages of the Fourth Train Proposal field lives. Future offshore compression facilities are not in scope for the Fourth Train Proposal.

2.2.2 Feed Gas Pipeline System

A Feed Gas Pipeline System will be constructed as part of the Fourth Train Proposal to transport gas, gas condensate, and produced water from the gas fields to the gas processing facilities on Barrow Island (see Figure 1-1). The Feed Gas Pipeline System will traverse Commonwealth and State waters to Barrow Island, then traverse approximately 14 km across Barrow Island to the Gas Treatment Plant.

The proposed route of the marine component of the Feed Gas Pipeline System will be finalised following the completion of technical, environmental, safety, and economic performance evaluations, but it will be located within the Fourth Train Proposal Area shown in Figure 1-1. The terrestrial component of the Feed Gas Pipeline System will be located within the approved Foundation Project's Feed Gas Pipeline System corridor (see Figure 2-1).

The marine component of the Feed Gas Pipeline System will be installed on the seabed. Rock armouring or alternative support material may be used for pipeline stabilisation, where required.

The Feed Gas Pipeline System will cross the shore onto Barrow Island adjacent to the existing Foundation Project's Feed Gas Pipeline Systems shore crossings at North Whites Beach. Like the Foundation Project, the shore crossing will be constructed using horizontal directional drilling (HDD) to reduce disturbance.

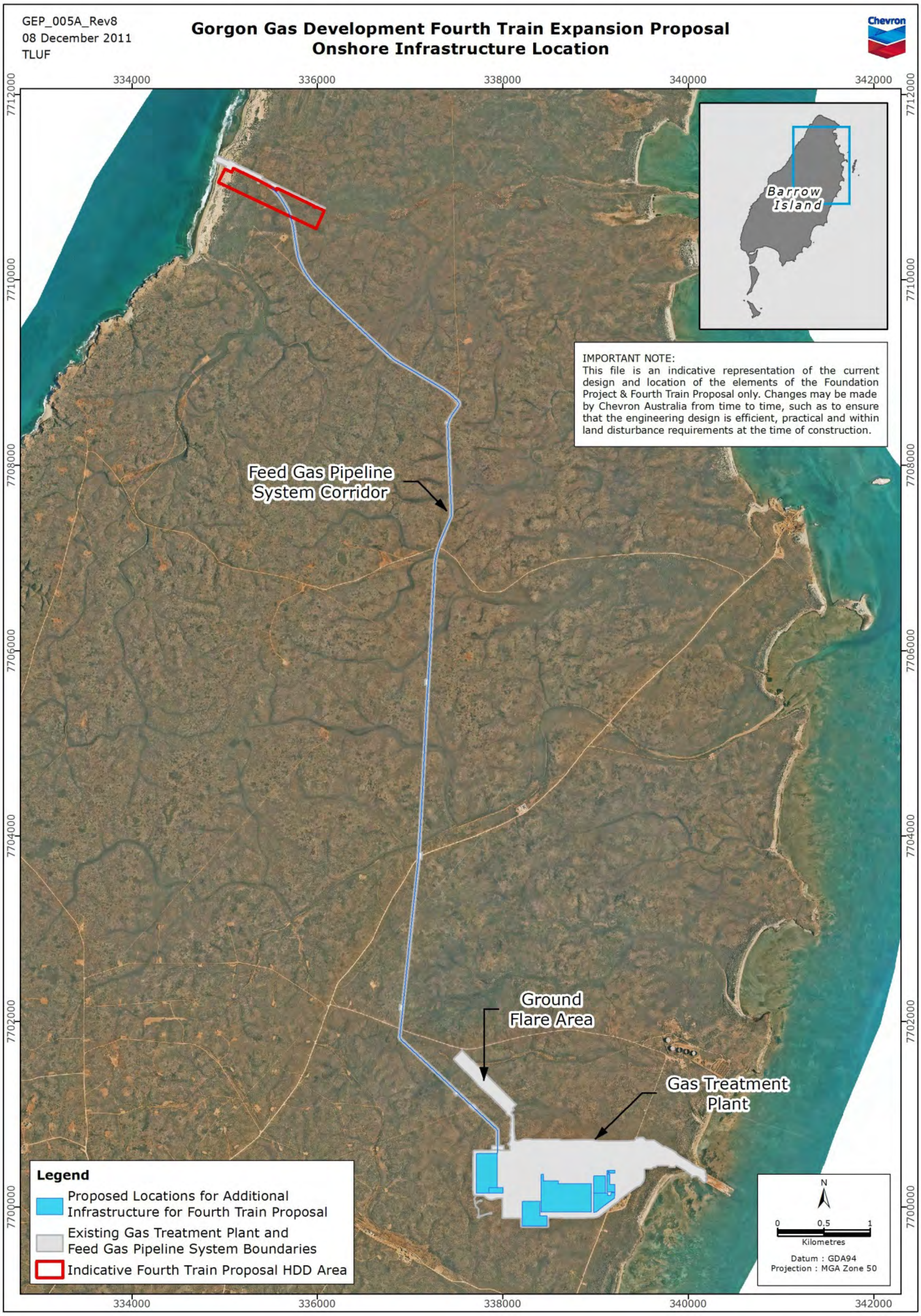

Figure 2-1 Location of Terrestrial Infrastructure on Barrow Island

2.2.3 Gas Treatment Plant

Downstream facilities will process the Feed Gas gathered from the subsea wells (see Section 2.2.1). A nominal five MTPA LNG train will be constructed, supported by the Foundation Project's infrastructure and facilities, where practicable. The construction of additional facilities for the Fourth Train Proposal may include:

- one LNG train with associated facilities
- monoethylene glycol (MEG) processing/regeneration equipment
- inlet receiving facilities
- condensate stabilisation capabilities
- acid gas removal unit
- LNG storage facilities
- additional pipe racks
- underground services
- Boil-off Gas (BOG) System
- utilities (either additional or extension of existing)
- power generation facilities.

Chevron Australia anticipates that all new Gas Treatment Plant facilities required for this Fourth Train Proposal will be located within the approved Foundation Project Gas Treatment Plant area (see Figure 2-1).

It is envisaged that the fourth LNG train will process gas from any of the fields supplying the Gas Treatment Plant, including gas from the Gorgon and Jansz–Io fields.

2.2.4 Marine Facilities and Operations

LNG and condensate produced through the addition of the fourth LNG train will be exported via existing facilities already approved under the Foundation Project, where practicable. Depending on fleet configuration, the Fourth Train Proposal may increase the number of ship loadings from the LNG Jetty at Town Point from approximately 290 to 300 shipments per year (under the Foundation Project) to approximately 350 to 360 per year once the Fourth Train Proposal is operational.

2.2.5 Supporting Infrastructure

A number of facilities on Barrow Island may be required to support the construction and operation of the Fourth Train Proposal, including:

- airport
- access roads
- supply bases
- Construction Village
- Operations Workforce Accommodation
- Administration and Operations Complex
- communication facilities
- flare system
- solid waste management facilities

- waste water disposal facilities
- carbon dioxide injection system
- off-plot utilities, such as seawater intake, reverse osmosis (RO) plant, brine disposal equipment
- Materials Offloading Facility (MOF)
- LNG Jetty
- Barge Landing
- warehousing facilities
- quarantine facilities
- condensate and LNG storage and loading facilities.

These facilities have been assessed and approved as part of the Foundation Project; a number of these facilities are illustrated in Figure 2-2.

In addition, some facilities that have been assessed and approved as part of the Foundation Project may require modification and/or addition for the purposes of this Fourth Train Proposal. These facilities may include:

- storage facilities for chemicals, fuel, and materials etc.
- in-plant roads
- temporary lay-down areas for construction.

The PER/Draft EIS will describe the supporting Foundation Project infrastructure that is expected to be used during both the construction and operation of the Fourth Train Proposal (see Section 6.6 for further details).

Figure 2-2 Gorgon Gas Development Foundation Project Infrastructure on and adjacent to Barrow Island

2.3 Fourth Train Proposal Footprint on Barrow Island

The Fourth Train Proposal Footprint refers to the areas of cleared and uncleared terrestrial land that will be required for the construction and operation of the Fourth Train Proposal.

Barrow Island is reserved under the Western Australian *Conservation and Land Management Act 1984* (WA) (CALM Act) as a Class A nature reserve for the purposes of 'Conservation of Flora and Fauna'. However, the Barrow Island Act makes provision for land on Barrow Island to be used for gas processing purposes. The Barrow Island Act limits to 300 ha the amount of uncleared land on Barrow Island that may be the subject of leases, licences, and easements for gas processing purposes.

Approximately 73 ha of land is anticipated to be required for the Fourth Train Proposal facilities, which are all located on Barrow Island. This area is described as follows:

- Up to 50 ha of land, which has already been cleared under the Foundation Project's Gas Treatment Plant, will be occupied by the fourth LNG train and associated construction activities (Figure 2-1).
- The proposed terrestrial component of the Feed Gas Pipeline System will require approximately 13 ha of land for which clearing has already been approved for the Foundation Project. This is approximately one-third of the Foundation Project's Feed Gas Pipeline System easement (Figure 2-1).
- The Fourth Train Proposal may require an easement over an additional approximately 10 ha of uncleared land for HDD purposes and the terrestrial component of the Feed Gas Pipeline System.

The approximately 73 ha of land anticipated to be required for the Fourth Train Proposal is encompassed within the 300 ha area of uncleared land available for gas processing purposes under the Barrow Island Act.

2.4 Construction Schedule and Workforce

Subject to the outcome of current feasibility studies and approvals, the indicative start date for construction of the Fourth Train Proposal is 2014. Meanwhile, the Foundation Project is expected to start operation of its first LNG train in 2014 with trains 2 and 3 subsequently becoming operational in 2015. Therefore, construction of the Fourth Train Proposal may overlap with both construction and operational phases of the Foundation Project.

Chevron Australia does not anticipate the workforce needed to construct and commission the Fourth Train Proposal infrastructure will exceed the peak workforce approved for construction of the Foundation Project. The construction workforce for the Fourth Train Proposal will be accommodated in the same Construction Village on Barrow Island that has been assessed and approved for the Foundation Project.

2.5 Justification for Selected Option and Alternative Options Considered

Chevron Australia also considered these alternatives to taking the proposed action:

- processing the gas in an alternative location, such as existing or proposed gas processing facilities in the Pilbara area
- deferring the development of the newly discovered gas reserves until capacity in the Foundation Project's Gas Treatment Plant becomes available (i.e. when hydrocarbon reserves in the Foundation Project's Gorgon and Jansz–Io fields decline).

The Barrow Island option has been selected for processing the gas because it uses the infrastructure and facilities that are already being constructed on Barrow Island for the Foundation Project. This offers synergies that reduce the overall physical footprint of the Fourth Train Proposal compared to a newly developed site.

The primary impact of not developing the Fourth Train Proposal is ultimately a loss of the associated economic benefits to the nation, state, and region that are expected to contribute to general economic growth and sustain regional development. The economic benefits include those derived by the Government (e.g. direct payment of taxes by the GJVs and by the workers and businesses associated with the Proposal) and from employment and business/service income generated by the Proposal.

3.0 Key Legislation

Table 3-1 lists the key environmental and activity-specific primary legislation applicable to the assessment of Fourth Train Proposal impacts. The PER/Draft EIS will also reference associated secondary legislation, where relevant. While this Environmental Scoping Document focuses on the State environmental approvals process, the Fourth Train Proposal will also be required to comply with Commonwealth legislative requirements. Therefore, both State and Commonwealth legislation relevant to the Proposal are listed.

Table 3-1 Primary Legislation Relevant to the Assessment of Fourth Train Proposal Impacts

State	Commonwealth
• *Aboriginal Heritage Act 1972* • *Barrow Island Act 2003* • *Bushfires Act 1954* • *Conservation and Land Management Act 1984* • *Contaminated Sites Act 2003* • *Dangerous Goods Safety Act 2004*[Note 1] • *Environmental Protection Act 1986* • *Fish Resources Management Act 1994* • *Heritage of Western Australia Act 1990* • *Land Administration Act 1997* • *Litter Act 1979* • *Local Government Act 1995* • *Marine and Harbours Act 1981* • *Maritime Archaeology Act 1973* • *Petroleum (Submerged Lands) Act 1982* • *Petroleum Act 1967* • *Petroleum Pipelines Act 1969* • *Planning and Development Act 2005* • *Pollution of Waters by Oil and Noxious Substances Act 1987* • *Shipping and Pilotage Act 1967* • *Soil and Land Conservation Act 1941* • *Western Australian Marine (Sea Dumping) Act 1981* • *Wildlife Conservation Act 1950*	• *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* • *Australian Heritage Council Act 2003* • *Clean Energy Act 2011* • *Energy Efficiency Opportunities Act 2006* • *Environment Protection and Biodiversity Conservation Act 1999* • *Environment Protection (Sea Dumping) Act 1981* • *Historic Shipwrecks Act 1976* • *National Greenhouse and Energy Reporting Act 2007* • *Navigation Act 1912* • Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 • Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011 • *Offshore Petroleum and Greenhouse Gas Storage Act 2006* • *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* • *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* • *Quarantine Act 1908*

Note 1: A preliminary Quantitative Risk Assessment will be submitted to the Department of Mines and Petroleum (DMP), as required under subsidiary regulations of this Act, prior to the end of the third quarter of 2013.

3.1 Environmental Protection Act (WA)

The *Environmental Protection Act 1986* (EP Act) is the principal statute that provides for environmental protection in Western Australia. It sets out to 'prevent, control and abate pollution and environmental harm, for the conservation, preservation, protection enhancement and management of the environment'.

Part IV of the EP Act governs the assessment of development proposals. Part V provides for the control and licensing of potentially polluting activities.

3.2 Barrow Island Act (WA)

In-principle support for the Gorgon Gas Development was granted by the WA Government in August 2003 and expressed in the State Agreement and the Barrow Island Act. The Barrow Island Act and the State Agreement set out the rights and obligations of both the GJVs and the State Government in regard to the development of gas processing facilities on Barrow Island. In particular, these regulatory instruments:

- allow for the authorisation of proposals to undertake offshore production of natural gas and petroleum, and for processing this gas on Barrow Island
- make provision for land on Barrow Island to be used for gas processing purposes
- allow for the authorisation of underground disposal of carbon dioxide recovered during gas processing on Barrow Island
- have regard for the need to minimise environmental disturbance on Barrow Island and provide support for conservation programs.

3.3 Environment Protection and Biodiversity Conservation Act (Commonwealth)

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the principal statute for the protection of environmental matters of National Environmental Significance (matters of NES). The key objectives of the EPBC Act are to:

- provide for the protection of the environment, especially those aspects of the environment that are matters of NES
- promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources
- conserve Australian biodiversity
- enhance the protection and management of important natural and cultural places
- promote a cooperative approach to the protection and management of the environment involving governments, the community, landholders, and indigenous peoples
- assist in the cooperative implementation of Australia's international environmental responsibilities
- provide a streamlined national environmental assessment and approvals process.

While not addressed in this Environmental Scoping Document, the Fourth Train Proposal will be required to meet the requirements of the EPBC Act. The Commonwealth Department of Sustainability, Environment, Water, People and Communities (SEWPaC) has provided Chevron Australia with separate guidelines to meet the environmental approvals under the EPBC Act (these guidelines are reproduced in Appendix 3 for information).

Chevron Australia intends to present a combined PER/Draft EIS document to address the requirements of both the EP Act and the EPBC Act.

3.4 Policies and Guidelines

A number of international treaties and conventions, Commonwealth and State policies, position statements, guidance statements, environmental guidelines, and codes of practice may relate to the assessment of impacts associated with this Fourth Train Proposal, including those listed below.

International:

- Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment (commonly referred to as the China–Australia Migratory Bird Agreement or CAMBA) (CAMBA 1986)
- Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (commonly referred to as the Japan–Australia Migratory Bird Agreement or JAMBA) (JAMBA 1974)
- Agreement between the Government of Australia and the Government of Republic of Korea for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (commonly referred to as the Republic of Korea–Australia Migratory Bird Agreement or ROKAMBA) (ROKAMBA 2006)
- Convention on Biological Diversity 1992 (ratified by Australia in 1993)
- Convention on the Conservation of Migratory Species of Wild Animals 1979 (known as the Bonn Convention)
- International Convention on Oil Pollution Preparedness, Response and Co-operation 1990
- International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL 73/78)
- United Nations Convention on the Law of the Sea, 1982 (UNCLOS)

Commonwealth:

- National Strategy for Ecologically Sustainable Development 1992
- Intergovernmental Agreement on the Environment 1992
- National Strategy for Conservation of Australia's Biological Diversity 1996
- National Environment Protection (Ambient Air) Measure (as varied) 2003
- National Environment Protection (Air Toxics) Measure 2004
- National Environment Protection (National Pollutant Inventory) Measure 1998
- National Environment Protection (Movement of Controlled Waste between States and Territories) Measure (as varied) 2010
- National Waste Policy: Less Waste, More Resources 2009
- National Water Quality Management Strategy: Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2). Stormwater harvesting and reuse 2009
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000.

State (Western Australia):

- Western Australia State Sustainability Strategy 2003
- The 100-Year Biodiversity Conservation Strategy for Western Australia (Draft) 2006
- State Environmental (Ambient Air) Policy 2009 (Draft)

- Western Australian Environmental Offsets Policy 2011
- Environmental Assessment Guidelines No. 3 – Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment 2009
- Environmental Assessment Guidelines No. 4 – Towards Outcome-based Conditions (Draft) 2009
- Environmental Assessment Guidelines No. 5 – Environmental Assessment Guidelines for Protecting Marine Turtles from Light Impacts 2010
- Guidance Statement No. 12 – Minimising Greenhouse Gas Emissions 2002
- Guidance Statement No. 19. – Environmental Offsets – Biodiversity 2008
- Guidance Statement No. 20 – Sampling of Short Range Invertebrate Fauna for Environmental Impact Assessment in Western Australia 2009
- Guidance Statement No. 33 – Environmental Guidance for Planning and Development 2008
- Guidance Statement No. 41 – Assessment of Aboriginal Heritage 2004
- Guidance Statement No. 51 – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia
- Guidance Statement No. 54 – Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia 2003
- Guidance Statement No. 54a – Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia 2007
- Guidance Statement No. 55 – Implementing Best Practice in Proposals submitted to the Environmental Impact Assessment Process 2003
- Guidance Statement No. 56 – Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia 2004
- Pilbara Coastal Waters Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives
- State Water Quality Management Strategy No. 6
- Cultural Heritage Due Diligence Guidelines, Parts 1 and 2, 2011.

4.0 Environmental Setting

A considerable amount of baseline information is available from the approvals and compliance assurance process for the Foundation Project. This information will be relied upon for the Fourth Train Proposal environmental approvals, where relevant. As such, only highlights of the environmental setting are provided here. Further details are available in Chevron Australia documents (Chevron Australia 2006, 2008, 2009, 2009a, 2009b, 2010, 2010a, 2010b and 2010c).

4.1 Regional Setting

The Fourth Train Proposal will be developed in Commonwealth and State waters and on Barrow Island within the geographical Proposal Area illustrated in Figure 1-1.

The gas fields to be developed are in the Greater Gorgon Area, located in the Carnarvon Basin on the North West Shelf of Australia, more than 130 km off the north-west coast of Western Australia in water depths up to 1500 m. This area falls under Commonwealth jurisdiction.

Barrow Island is located off the Pilbara coast 85 km north-north-east of the town of Onslow and 140 km west of Karratha. It is approximately 25 km long and 10 km wide and covers 23 567 ha. Barrow Island is the largest of a group of islands, which include the Montebello and Lowendal Islands. It has been the site of a large terrestrial oilfield since 1967 and is a Class A Nature Reserve gazetted under the *Land Administration Act 1997* (WA) and the CALM Act.

4.2 Physical Environment

4.2.1 Climate

The southern portion of the North West Shelf (NWS), including Barrow Island, is characterised by an arid, subtropical climate. The summer season occurs from October to March, with mean daily maximum temperatures reaching 34 °C, and mean daily minimum temperatures averaging 20 °C. During winter (June–August), mean daily maximum temperatures reach 26 °C, with mean daily minimum temperatures of 17 °C. The months of April, May and September are considered a transition season (Chevron Australia 2005).

The mean wind speed around Barrow Island under prevailing non-cyclonic conditions during the summer period is 6.6 m/s, with a maximum of 16.2 m/s (Kellogg Joint Venture Gorgon [KJVG] 2008). The dominant directions during summer are from the south-west and west. During winter, winds approach from the east, south, and south-west, with a mean speed of 5.8 m/s and a maximum speed of 19.4 m/s (Asia Pacific Applied Science Associates [APASA] 2009).

Barrow Island is in a region of high tropical cyclone frequency, with an average of four cyclones passing within 400 nautical miles (nm) of the Island each year. Under extreme cyclone conditions, winds can reach more than 250 km/h (APASA 2009).

4.2.2 Terrestrial Environment

4.2.2.1 Landforms and Topography

Barrow Island has relatively low elevation (up to 60 m above sea level) and is characterised by gentle undulations, eroded ridges, valley floor flood plains, and some incised creek channels. The Fourth Train Proposal terrestrial components are located in an area protected from wave action and with a slight land gradient to the ocean. The coastline is characterised by vegetated sand dunes and expansive tidal flats.

4.2.2.2 Geology and Soils

Barrow Island is a geological extension of the Cape Range Peninsula, which became separated from mainland Australia between 6000 and 8000 years ago as a result of rising sea levels. Barrow Island is composed of coastal deposits overlying tectonically folded limestone.

The soils of Barrow Island vary from duplex to coarse textural uniform depending upon their topographic position and geological parent rock (Lewis and Grierson 1990). On the western side, soil texture is typically silty clay with alluvial watersheds dominated by silty clays and clayey loam textures (Lewis and Grierson 1990). On the eastern slopes, the soils are much coarser with coarse clayey sands, sandy loams, and sandy clays dominating. In the lower-lying areas, duplex soils are present (Lewis and Grierson 1990). The location of the Feed Gas Pipeline System shore crossing (North Whites Beach) comprises coastal sands overlaying shoreline limestone platforms. An outcrop of limestone forms an extensive rock platform between the water and the sand, and runs parallel to the sandy beach. The primary dunes are steep and comprise coastal sand.

4.2.2.3 Surface Hydrology

There are no permanent creeks on Barrow Island. The surface hydrology on Barrow Island is characterised by:

- unpredictable, but sometimes very intense rainfall resulting in substantial run-off in some areas and short-term ponding
- consistently high rates of evaporation resulting in extremely low soil moisture content
- high infiltration capacities of the surface sands and limestones, which is conducive to the recharge of relatively deep groundwater aquifers.

The hydrological regime of Barrow Island is split by a water divide running north to south along a central, elevated ridge (Chevron Australia 2008).

Permanent surface water sources occur in freshwater seeps, which are located more than 5 km from the terrestrial component of the Feed Gas Pipeline System. The nearest ephemeral freshwater seep is situated approximately 500 m south of the North Whites Beach Feed Gas Pipeline System shore crossing (Chevron Australia 2008).

4.2.2.4 Groundwater

There are two aquifers below Barrow Island – a deep, brackish aquifer found at depths below 900 m, and a shallow unconfined aquifer containing a fresher water lens at depths typically between 9 m and 53 m, floating upon denser, saline groundwater (Chevron Australia 2008).

4.2.2.5 Air Quality

Sources of atmospheric emissions on Barrow Island are the existing WA Oil operations (Sinclair Knight Merz [SKM] 2005) and emissions associated with the construction and future operation of the Foundation Project. Key emissions include oxides of sulphur (SO_x), oxides of nitrogen (NO_x), volatile organic compounds (VOCs), carbon monoxide (CO), greenhouse gases, and particulate matter (PM).

At a regional level (i.e. the west Pilbara airshed) air quality is likely to be influenced by major industrial sources in the Karratha, Dampier, Onslow, and Cape Lambert regions. Relevant major industrial sources in this area are listed in Appendix 7.

4.2.3 Marine Environment

4.2.3.1 Oceanography

The shallow, coastal waters off Barrow Island are well mixed with little evidence of stratification (Chevron Australia 2010). Surface water temperatures off Barrow Island vary between 22 °C and 31 °C.

The prevailing oceanic conditions in the Barrow Island region are governed by a combination of sea and swell waves (Chevron Australia 2005). Sea waves are shorter-period waves generated by local winds, whereas swell waves are generated by distant storms. Local wind-generated seas have variable wave heights, typically ranging from 0 to 4 m under non-tropical cyclone conditions (APASA 2009). Typically, wave heights at Barrow Island are within the range 0.2 to 0.5 m, with peak periods of two to four seconds (RPS MetOcean 2008). Maximum wave heights are mostly a result of tropical cyclones, which can generate waves in a radial direction out from the storm centre and may therefore generate swell from any direction, with wave heights ranging from 0.5 to 9.0 m (APASA 2009).

4.2.3.2 Water Quality

In the shallow, nearshore waters off the west coast of Barrow Island, turbidity and concentrations of suspended sediments are generally low (<5 mg/L) and indicative of clear water environments (Chevron Australia 2005).

However, wave activity is important in contributing to local resuspension of sediments, resulting in elevated turbidity and suspended sediment concentrations. Therefore, extreme weather events, such as tropical cyclones, have a strong influence on water quality (Chevron Australia 2010).

4.2.3.3 Coastal Processes

The Barrow Island coast has predominantly been developed by the effects of wind and water. Coastal erosion of the rocky headlands and weathering of the intertidal shore platform provides a source of sediment for the beach faces. Tropical cyclones potentially create the most dramatic changes to beach profiles as storm surges raise water levels and expose wave influence to higher parts of the beach not normally vulnerable to waves (Chevron Australia 2006).

4.2.3.4 Bathymetry and Seabed Features

The State waters around Barrow Island lay over an area of the continental shelf. The bathymetry of the continental shelf is characterised as a broad, flat to gently undulating sea floor with areas of moderate relief in water depths of less than about 175 m (Gorgon Upstream Facilities Team [GUFT] 2009).

4.2.3.5 Marine Surficial Sediments

Surficial sediments in State waters off the west coast of Barrow Island are unconsolidated, overlaying a cemented calcarenite substrate. These sediments are mostly calcareous, dominated by sand, and contain shells and shell fragments (Chevron Australia 2005). Off North Whites Beach, outcropping cemented sediments and prominent sand ripples are present (Chevron Australia 2010).

4.3 Biological Environment

4.3.1 Terrestrial Ecology

4.3.1.1 Flora and Vegetation

A total of 226 plant taxa have been confirmed on Barrow Island (Chevron Australia 2009). None of these are Declared Rare Flora species under subsection (2) of section 23F of the *Wildlife Conservation Act 1950* (WA) (Wildlife Conservation Act) and as listed by the Western Australian Department of Environment and Conservation (DEC) (Chevron Australia 2009). Nineteen weed species are documented as currently occurring on Barrow Island (Chevron Australia 2009).

Three Priority Flora species have been collected on Barrow Island (*Helichrysum oligochaetum, Corchorus congener* and *Mukia* sp. Barrow Island (D.W. Goodall 1264)[1] (Chevron Australia 2009). Priority Flora is a non-legislative category aimed at managing those plant taxa listed by the DEC on the basis that they are known from only a few collections, or a few sites, but which have not been adequately surveyed. Such flora may be rare or threatened, but cannot be considered for declaration as rare flora until further survey work has been undertaken.

Mattiske (1993) mapped and described 34 vegetation formations on Barrow Island that are grouped into eight habitats. To date, more detailed mapping of the vegetation has included descriptions of 263 vegetation associations (excluding 16 disturbed units) over 11% of Barrow Island. None of these associations occur entirely within the areas identified as Foundation Project or Fourth Train Proposal locations (Chevron Australia 2009).

4.3.1.2 Terrestrial Mammals

Fifteen species of terrestrial mammals have been recorded on Barrow Island (Chevron Australia 2009). Six species are protected under the Wildlife Conservation Act (see Appendix 3); these are:

- Black-flanked Rock-wallaby (*Petrogale lateralis lateralis*)
- Barrow Island Euro (*Macropus robustus isabellinus*)
- Spectacled Hare-wallaby (*Lagorchestes conspicillatus conspicillatus*)
- Barrow Island Golden Bandicoot (*Isoodon auratus barrowensis*)
- Boodie (*Bettongia lesueur*)
- Water rat (*Hydromys chrysogaster*).

With the exception of the Black-flanked Rock-wallaby, which inhabits the west coast of Barrow Island, all are likely to occur in or near the terrestrial component of the Fourth Train Proposal.

There are no fauna habitats unique to the combined Foundation Project and Fourth Train Proposal Footprints (Chevron Australia 2005).

4.3.1.3 Terrestrial Reptiles and Amphibians

Forty-five terrestrial reptile species have been recorded on Barrow Island (Chevron Australia 2009). One amphibian species – a single species of burrowing frog (*Cyclorana maini*) – has been recorded on Barrow Island.

None of the terrestrial reptile species on Barrow Island are listed as Threatened Species under the Wildlife Conservation Act.

4.3.1.4 Avifauna

Of the 119 bird species recorded on Barrow Island, two are protected under the Wildlife Conservation Act (the Australian Bustard and the White-winged Fairy-wren [Barrow Island]) (see Appendix 3). The White-winged Fairy-wren (Barrow Island) is known to be present in the area likely to be affected by the Fourth Train Proposal (see Appendix 3).

4.3.1.5 Terrestrial Invertebrates

At least 1261 terrestrial invertebrate species have been identified to date on Barrow Island, none of which are listed as requiring special protection under the Wildlife Conservation Act, or listed as priority species by the DEC (Chevron Australia 2009). Most terrestrial invertebrate species appear to be more abundant on Barrow Island during the wet season when there is a flush of growth in dominant plant forms.

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[1] *Mukia* sp. Barrow Island has since been renamed *Cucumis* sp. Barrow Island (D.W. Goodall 1264).

Several species of terrestrial invertebrates have been identified as short-range endemics (SREs) on Barrow Island (Chevron Australia 2009a) but surveys have shown that most of these species are widespread on Barrow Island.

4.3.1.6 Subterranean Fauna

A total of 13 troglobitic and 43 stygofauna taxa have been recorded on Barrow Island (Chevron Australia 2009b). Subterranean fauna taxa, along with their conservation status, are listed in Appendix 3. The Subterranean Blind Snake (*Ramphotyphlops longissimus*) is listed by the DEC as a Priority 2 species and is likely to be endemic and restricted to Barrow Island since it is known from only one specimen collected on Barrow Island (see Appendix 3) (Chevron Australia 2009).

4.3.1.7 Ecological Communities

No Threatened Ecological Communities (TECs), as listed in the DEC's TEC Database (DEC 2010), have been recorded or are known to occur on Barrow Island. However, the DEC has listed three Priority 1 Ecological Communities (PECs) on Barrow Island as:

- Barrow Island Subterranean Fauna
- Barrow Island Creekline Vegetation
- Coastal dune soft spinifex grassland.

By definition, this means that the DEC considers these communities are:

> '*poorly-known with apparently few, small occurrences, all or most of which are not actively managed for conservation (e.g. active mineral leases) and for which current threats exist; or if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, appear to be under immediate threat from known threatening processes across their range*' (DEC 2010).

4.3.2 Marine Ecology

4.3.2.1 Marine Habitats (in State Waters)

Nearshore benthic habitats are characterised by limestone platform covered with a veneer of unvegetated sand. Macroalgal assemblages dominate off the west coast of Barrow Island, with macroalgal taxa common within the local area and region. Small, sparse patches of seagrass occur on sand veneers at a few locations and at low levels of percentage cover (Chevron Australia 2010b). Corals are present in low abundances and as sparsely scattered colonies of species (e.g. the hard coral *Turbinaria* spp.) (Chevron Australia 2010b).

Further offshore, benthic habitats are characterised by unvegetated or bare sand. Macroalgal assemblages represent the dominant ecological element, with seagrass and coral colonies rarely present (Chevron Australia 2010b).

4.3.2.2 Marine Reptiles

Of the six marine turtle species known to occur in north-western Australian waters, Green (*Chelonia mydas*), Flatback (*Natator depressus*) and, to a lesser extent, Hawksbill (*Eretmochelys imbricate*) Turtles are commonly found at Barrow Island. All three turtle species are protected under State legislation (see Appendix 3). Barrow Island is a regionally important nesting area for Green and Flatback Turtles, whilst Hawksbill Turtles nest at low densities on Barrow Island (Chevron Australia 2005).

4.3.2.3 Marine Mammals

Three whale species that are listed as specially protected under the provisions of the Wildlife Conservation Act may be present in State waters off the coast of Barrow Island (see Appendix 3). The Humpback Whale is the most common whale species in the region, migrating annually between their feeding grounds in Antarctic waters and their calving grounds in Pilbara/Kimberley waters from June to October (Chevron Australia 2005). Northbound Humpback Whales tend to remain on or within 200 m water depth, while southbound whales tend to come closer to Barrow Island and generally occur between 50 m and 200 m water depth (Jenner *et al.* 2001).

Dugongs (*Dugong dugon*) are Specially Protected under Schedule 4 of the Wildlife Conservation Act (see Appendix 3). Dugongs are not expected to frequent the locations where Fourth Train Proposal activities will occur, owing to the absence of well-developed seagrass habitats on which they feed (Chevron Australia 2005). However, dugongs may travel through the shallow coastal waters to other areas in the region (Chevron Australia 2010).

4.3.2.4 Fish

Populations of demersal fish species are present in the Proposal Area. These populations are not protected under the Wildlife Conservation Act, but may include commercially important species such as snapper, emperor, and grouper (Chevron Australia 2010b).

Whale Sharks, the world's largest species of fish, may pass through the deeper waters off Barrow Island occasionally; however, they do not aggregate there given the apparent absence of upwelling or other habitats thought to encourage aggregations (Chevron Australia 2005).

4.3.3 Protected/Conservation Areas

Barrow Island is reserved under the Western Australian *Conservation and Land Management Act 1984* (CALM Act) as a Class A nature reserve. The Boodie, Double and Middle Islands Nature Reserve was gazetted in 1984 (Reserve 38728, other than Class A) and covers an area of 586.7 ha. Both reserves extend to the low water mark and are set aside for the purpose of 'conservation of flora and fauna'. They are collectively known as the Barrow Group, and are zoned 'Conservation, Recreation and Nature Land' under the Shire of Ashburton Town Planning Scheme No. 7.

Adjoining Barrow Island are the Barrow Island Marine Park – a significant breeding and nesting area for marine turtles and coral reefs – and the Barrow Island Marine Management Area (Figure 4-1). The Barrow Island Marine Management Area is unzoned, with the exception of the Bandicoot Bay Conservation Area. The Bandicoot Bay Conservation Area, established for benthic fauna and seabird protection, is located on the south coast of Barrow Island. The Barrow Island Marine Park and the Barrow Island Marine Management Area are reserved under the CALM Act. The Barrow Island Marine Management Area is listed on the Western Australian Register of Heritage Places.

Further afield, the Ningaloo Marine Park and Muiron Islands Marine Management Area have also been established as reserves under the CALM Act. The Ningaloo Marine Park, a 'Class A' reserve and listed as a World Heritage Site in 2011, is located off the North West Cape of Western Australia, as shown in Figure 4-1. The boundaries of the Ningaloo Marine Park are approximately 80 km south-west of the Proposal Area and 130 km south-west of Barrow Island at their closest points. The Ningaloo Marine Park extends for about 300 km and covers an area of approximately 263 300 ha. It is located within a 40 m strip above the high water mark in State waters, and includes Ningaloo Reef, the largest fringing reef in Australia (Department of Conservation and Land Management [CALM] 2005).

The Muiron Islands Marine Management Area, located adjacent to the north-east boundary of the Ningaloo Marine Park, covers an area of approximately 28 600 ha. Three conservation areas for flora and fauna protection have been established in the Muiron Islands Marine Management Area. These conservation areas cover a total area of approximately 7% of the Marine Management Area; the remaining 93% of the total area is unclassified (CALM 2005).

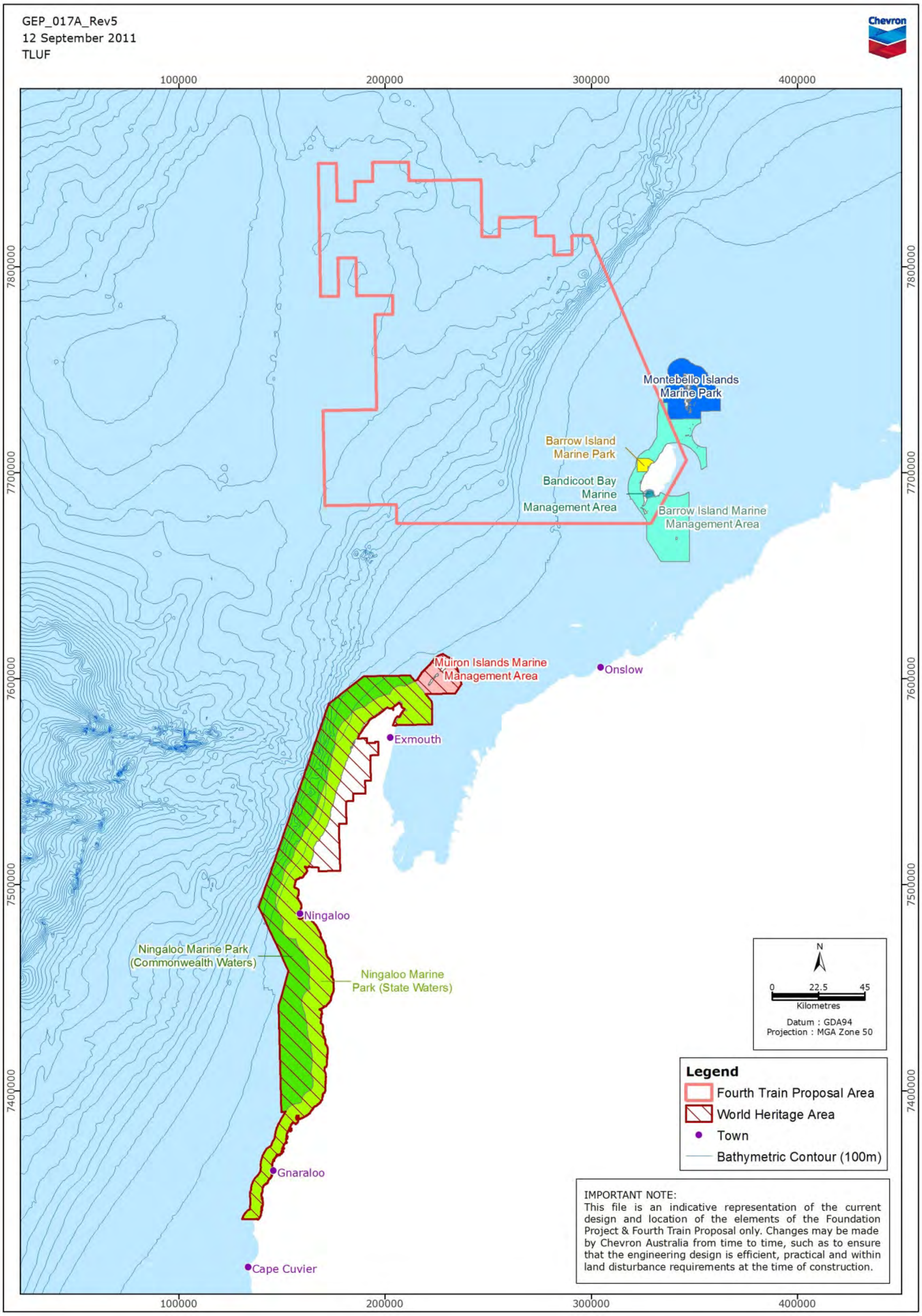

Figure 4-1 Marine Protected Areas in the Vicinity of the Proposal Area

4.4 Human Environment

4.4.1 Land and Sea Use

Barrow Island is vested in the Conservation Commission of Western Australia and is managed on its behalf by the DEC. The nature reserve is also listed on the Commonwealth Register of the National Estate.

Petroleum lease L1H, which has been actively used for petroleum exploration and production purposes since 1964, extends over the land mass of Barrow Island. The Barrow Island Act provides that no more than 300 ha in total of uncleared land is to be leased, or is to be the subject of licences or easements, for gas processing projects.

A number of Western Australian and Commonwealth commercial fisheries operate in the Montebello/Lowendal/Barrow Island region.

4.4.2 Local and Regional Economy

4.4.2.1 State Economy

The value of Western Australia's mineral and petroleum industry reached a record AU$91.6 billion in 2010. Iron ore remained the State's most valuable resource in 2010, accounting for AU$48.5 billion or 53% of all mineral and petroleum sales (Department of Mines and Petroleum [DMP] 2010).

Petroleum, which includes crude oil, condensate, LNG, natural gas, liquefied petroleum gas (LPG), butane, and propane, is Western Australia's second largest sector, accounting for AU$22.9 billion or 25% of total mineral and petroleum sales (DMP 2010).

In 2010, LNG production increased by 8% to 16.5 million tonnes with the value of sales increasing by 39% to AU$8.8 billion. This elevated LNG to become the second most valuable commodity in the State (DMP 2010).

Mineral and petroleum resources dominate the State's exports, contributing a substantial 91% towards the State's total merchandise exports in 2010. Western Australia maintained its status as Australia's leading exporter in 2010, contributing a record 44% towards Australia's merchandise export earnings (DMP 2010).

4.4.2.2 Regional Economy of the Pilbara

The Pilbara economy is dominated by the mining and petroleum industries, with iron ore, oil and condensate, LPG, LNG, and natural gas among WA's largest export revenue earners. Commercial activities in the Pilbara exist primarily to service the resources sector. Such activities include engineering, surveying, personnel, and equipment hiring services (Pilbara Development Commission 2006). The Pilbara's rapid economic growth is predicted to continue over an extended period as major new resource projects and expansions are commissioned. In particular, the iron ore and oil and gas production sectors will continue to develop and expand to meet the increasing demand from China and the rest of Asia. As a result, the Pilbara is expected to remain an area of strategic significance to both the State and national economies for some time into the future (Pilbara Development Commission 2010).

During the 2006 Census, the mining and construction sectors employed 29.4% and 10.7% of the Pilbara's workforce, respectively. The manufacturing sector, comprising mainly small businesses supplying the regional market, had an estimated sales income of AU$309 million during the period 2004 to 2005 and employed up to 4.3% of the region's workforce (Pilbara Development Commission 2006). The population has increased by 15% over the past seven years, primarily due to development within the resources sector (Pilbara Development Commission 2010).

4.4.3 Local Community

There is no resident population on Barrow Island. Barrow Island has been actively used for petroleum exploration and production purposes since 1957 and access to the Island is restricted to personnel associated with oilfield operations, construction of the Foundation Project, and the DEC's activities.

Barrow Island and its surrounds are located within the Shire of Ashburton in the Pilbara region of Western Australia. The Shire of Ashburton covers an area of approximately 105 650 km^2 (predominantly mainland) and includes the towns of Onslow, Tom Price, Paraburdoo, and Pannawonica. Tom Price is the Shire's largest town and its administration centre. The mainland resident population of the Shire was estimated to be approximately 6730 in 2010 with an estimated growth rate of 0.8% per annum since 2005 (Australian Bureau of Statistics [ABS] 2011). The primary employer in the Shire in the 2006 census was mining, employing more than 50% of residents over 15 years old (ABS 2008). The Shire is home to a large indigenous population, some of whom reside in or near Onslow.

4.4.4 Culture and Heritage

Archival sources suggest that a number of important vessels have been lost in the Onslow/Barrow Island region, and there is potential for lugger shipwreck sites to occur near Barrow Island (Chevron Australia 2005). The earliest known shipwreck of European origin within Australian waters (The Trial) is located approximately 45 km north of Barrow Island.

The existence of any residual wreckage (which would constitute an archaeological site) can only be determined if it is discovered. The Foundation Project's Feed Gas Pipeline System shore approaches, the MOF, and the shore areas around the Gas Treatment Plant area were examined by a marine heritage expert and no shipwreck sites were discovered (Chevron Australia 2008).

The Department of Indigenous Affairs (DIA) Register of Aboriginal Sites lists 13 archaeological but no ethnographic sites for Barrow Island. Archaeologists, anthropologists, and indigenous stakeholders examined areas associated with the Foundation Project in 2006 and 2007; no new indigenous cultural sites or materials were discovered in areas likely to be disturbed by the Foundation Project (Chevron Australia 2008).

5.0 Preliminary Environmental Analysis of the Fourth Train Proposal

5.1 Introduction and Purpose

An environmental risk assessment will be conducted for the PER/Draft EIS, which will consider environmental receptors (or 'environmental factors') that the Fourth Train Proposal may impact. A preliminary environmental analysis of the Fourth Train Proposal was completed by Chevron Australia for the purpose of this Environmental Scoping Document. The objectives of this preliminary analysis were to:

- identify *environmental stressors* (hazards/threats to the environment, such as the release of air emissions to the atmosphere) and *environmental factors* (receptors such as flora and fauna) likely to be of relevance for the Fourth Train Proposal
- identify *environmental factors* that require additional baseline data collection to support the assessment of impacts in State jurisdiction
- identify *environmental stressors* that require additional study to predict potential impacts on environmental factors.

5.2 Methodology

As the design and execution of the Fourth Train Proposal is expected to be very similar to that of the Foundation Project, the methodology adopted for this preliminary environmental analysis has drawn extensively on the results of the environmental risk assessments conducted for the Foundation Project (see Section 1.3.2). These environmental risk assessments identified the environmental stressors and factors of relevance for the Foundation Project (see Section 5.3.1).

The methodology used for the preliminary environmental analysis was:

- Compare the scope of activities associated with the Fourth Train Proposal to those examined for the Foundation Project.
- Make preliminary identification of the likely stressors, environmental factors, and associated potential impacts relevant to the construction and operation of the Fourth Train Proposal. This process used the results of the environmental risk assessments completed for the Foundation Project. It also reflected the consultations that Chevron Australia has held with government stakeholders about the Fourth Train Proposal.
- Review the available baseline information to support an assessment of identified environmental impacts and the identification of information gaps for which additional baseline data collection or additional studies need to be undertaken to support the assessment of impacts in State jurisdiction.

Environmental stressors and factors relevant to the Fourth Train Proposal were determined on the basis that they may:

- pose additional or different adverse impacts from those of the approved Foundation Project and therefore will need to be avoided, reduced, and/or managed
- be of high community/public interest
- lead to, or be affected by, cumulative impacts in the local or regional area.

5.3 Results

5.3.1 Comparison with the Foundation Project

The key environmental issues identified and examined in detail in the environmental risk assessments for the Foundation Project (Chevron Australia 2005, 2008) were:

- biodiversity and conservation values of Barrow Island and its surrounding waters, with a particular focus on:
  - clearance of native vegetation and associated fauna habitats
  - damage to sensitive coastal and nearshore habitats, including beaches, dune systems, and coral communities
  - protected terrestrial fauna, including short-range endemics, subterranean fauna, protected mammals, avifauna, and reptiles
  - protected marine fauna, including marine turtles and marine mammals
- quarantine management given the need for considerable transfers of people, equipment, and materials to Barrow Island
- disposal of reservoir CO_2 by injection into the Dupuy Formation beneath Barrow Island.

To the extent practicable, the Fourth Train Proposal will mirror the activities and designs used for the Foundation Project. It will also use land, infrastructure and facilities already approved for the Foundation Project (see Table 2-1 for a summary comparison of the scope of activities for the Fourth Train Proposal and the Foundation Project). As such, the scope of activities that could lead to potential environmental impacts is anticipated to be considerably less for the Fourth Train Proposal when compared with the Foundation Project. In particular, the following activities, considered as key activities for the Foundation Project from an environmental perspective, are **not in scope** for this Fourth Train Proposal:

- Construction of marine facilities on the east coast of Barrow Island (e.g. Marine Offloading Facility and LNG Jetty), and associated dredging and dredged spoil disposal. This activity was an important focus of the environmental risk assessment studies conducted for the Foundation Project given the potential for dredging and dredged spoil disposal to impact coastal processes, coastal morphology, water quality, and marine flora and fauna (including corals) around Barrow Island. Other than upstream subsea gathering systems and a Feed Gas Pipeline System, additional marine facilities and dredging are not anticipated for the Fourth Train Proposal.
- Clearance of native vegetation at the Gas Treatment Plant and along the onshore section of the Feed Gas Pipeline System. The majority of land required for the Fourth Train Proposal infrastructure has already been approved for clearance under the Foundation Project (see Section 2.3). The Fourth Train Proposal may only require clearance of approximately 10 ha of land at the HDD site (consideration of which will be included in the environmental risk assessment of the PER/Draft EIS).
- Development of further onshore sites for the injection of reservoir CO_2. The Foundation Project included a pipeline (approximately 10 km long) and injection wells, plus additional pressure management wells drilled into the Dupuy Formation beneath Barrow Island. Key direct impacts associated with this included vegetation clearance, habitat loss, and fauna disturbance (including protected species). No significant change to the CO_2 injection system is anticipated for the Fourth Train Proposal regardless of the reservoir CO_2 management option selected.
- Changes to the Domestic Gas system infrastructure. This system included a Domestic Gas processing facility at the Gas Treatment Plant on Barrow Island and a pipeline system of approximately 91 km from Barrow Island across to the mainland and interconnection into the

existing Dampier to Bunbury Natural Gas Pipeline. This activity was identified in the environmental risk assessments conducted for the Foundation Project as resulting in physical disturbance to the seabed and requiring clearing of 75 ha of terrestrial and intertidal vegetation communities on the Pilbara mainland. No change to the infrastructure of this approved Domestic Gas system is anticipated for the Fourth Train Proposal.

- Construction of ancillary facilities and utilities to support construction and operational phases. Construction of facilities such as the Construction Village, Operations Workforce Accommodation, road upgrades, airport modifications, water supply, waste water systems etc. contributed to the total area of land cleared of native vegetation under the Foundation Project. The Fourth Train Proposal intends to use these existing facilities to the extent practicable, thereby reducing its overall Footprint.

While noting that the scope of activities associated with the Fourth Train Proposal is smaller than that already assessed and approved for the Foundation Project, the Fourth Train Proposal will still introduce additional stressors (hazards or threats) to the environment. These stressors may impact environmental factors (receptors) in the same or in different geographical areas, and/or may extend the time period over which stressors already examined by the Foundation Project will be experienced. Table 5-1 summarises the environmental stressors and factors that were examined in the EIS/ERMP and PER for the Foundation Project and comments on their likely relevance to the Fourth Train Proposal.

Table 5-1 Stressors and Environmental Factors Identified and Examined for the Foundation Project

Foundation Project (EIS/ERMP and PER)[1]		Relevance to the Fourth Train Proposal
Project Stressors	**Associated Environmental Factors**	
Site disturbance/ excavation (onshore)	• Soil and landforms • Air quality • Surface water and groundwater quality • Flora and vegetation communities • Terrestrial fauna • Subterranean fauna	Development of the Fourth Train Proposal may require up to approximately 10 ha of land to be cleared of vegetation on Barrow Island at the HDD site. This is considerably less than the land approved for clearance under the Foundation Project. In addition, earthworks will be required at the Gas Treatment Plant over an area of ~42 ha (already approved for clearance under the Foundation Project). This compares to the substantially greater area of earthworks for the Foundation Project. Impacts are restricted to Barrow Island.
Physical presence (of infrastructure)	• Air quality • Surface water and groundwater quality • Terrestrial fauna • Subterranean fauna • Seabed • Foreshore • Benthic primary producers (marine flora and corals) and habitats • Marine fauna • Livelihoods and	New infrastructure will be added to the seabed and on Barrow Island by the Fourth Train Proposal. The duration of likely construction impacts on identified environmental factors associated with the Foundation Project may be extended to cater for construction of the Fourth Train Proposal infrastructure on Barrow Island. Foundation Project impacts on the foreshore were related to the construction and presence of the Domestic Gas system, the MOF, and the LNG jetty. As the Fourth Train Proposal will not be altering this infrastructure, this factor is not considered relevant to the Fourth Train Proposal.

Foundation Project (EIS/ERMP and PER)[1]		Relevance to the Fourth Train Proposal
Project Stressors	**Associated Environmental Factors**	
	lifestyles • Land and sea use and tenure • Native title • Cultural heritage • Historical and maritime heritage • Landscape and aesthetics • Workforce and public health and safety	
Physical interaction	• Terrestrial fauna • Marine fauna • Land and sea use and tenure	This stressor is relevant during both the construction and operation stages of the Fourth Train Proposal. During construction, similar types of potential impacts to those associated with the construction of the Foundation Project may be expected, with the exception that no dredging is foreseen for the Fourth Train Proposal. Once operational, the Fourth Train Proposal is expected to result in an increased frequency of LNG and condensate vessel visits to the jetty on Barrow Island (see Section 2.2.3).
Physical disturbance	• Seabed substrates • Foreshore • Benthic primary producers (marine flora and corals) and habitats • Marine fauna	In State waters, laying of the Feed Gas Pipeline System and HDD activities for the Fourth Train Proposal will cause this stressor. The type and nature of potential impacts associated with these activities are likely to be similar to those of the Foundation Project, as a similar sea area will be affected. However, no dredging and no change to the MOF or LNG Jetty are anticipated for the Fourth Train Proposal (these were key contributors to this stressor in the Foundation Project). Therefore, impacts to the foreshore are not expected for the Fourth Train Proposal.
Atmospheric emissions, excluding dust	• Air quality • Flora and vegetation communities • Terrestrial fauna • Workforce and public health and safety	This stressor is relevant during both the construction and operation of the Fourth Train Proposal. Emission types during construction are likely to be similar to those of the Foundation Project; however, quantities will reflect the smaller size of the Fourth Train Proposal. Emissions from the Fourth Train Proposal construction will be occurring at the same time that the Foundation Project is finishing construction and becomes fully operational. The Fourth Train Proposal will generate additional operational emissions. The total emissions from the Gas Treatment Plant (i.e. including the Foundation Project) will increase once the Fourth Train Proposal is operational.
Dust	• Flora and vegetation communities • Terrestrial fauna • Landscape and	This stressor is relevant during the construction of the Fourth Train Proposal. However, dust quantities are expected to be smaller than for the Foundation Project as the area of earthworks for the Fourth Train Proposal is considerably smaller and many of the

Foundation Project (EIS/ERMP and PER)[1]		Relevance to the Fourth Train Proposal
Project Stressors	**Associated Environmental Factors**	
	aesthetics	roads are already sealed.
Solid and liquid waste disposal	• Soil and landforms • Surface water and groundwater quality • Seabed substrates • Water quality (marine) • Benthic primary producers (marine flora and corals) and habitats • Marine fauna • Workforce and public health and safety	This stressor is relevant during the construction and operation of the Fourth Train Proposal. The type and nature of potential impacts are likely to be similar to those of the Foundation Project although volumes of waste are likely to be proportionately less and there is no requirement in the Fourth Train Proposal to dispose of dredged spoil (a key contributor to this stressor in the Foundation Project). Additional wastes (i.e. from the Fourth Train Proposal in addition to those assessed and approved for the Foundation Project) may also be relevant.
Waste water	• Soil and landforms • Surface water and groundwater quality • Subterranean fauna • Seabed substrates • Water quality (marine) • Benthic primary producers (marine flora and corals) and habitats • Marine fauna • Workforce and public health and safety	This stressor is relevant during the construction and operation of the Fourth Train Proposal. The type and nature of potential impacts are likely to be similar to those of the Foundation Project, although discharge volumes are likely to be proportionately less. Additional waste water volumes (i.e. from the Fourth Train Proposal in addition to those assessed and approved for the Foundation Project) may also be relevant.
Creation of heat/ cold	• Flora and vegetation communities • Terrestrial fauna	This stressor is relevant during the construction and operation of the Fourth Train Proposal and relates to the creation or loss of shade used by terrestrial flora and fauna. The type and nature of potential impacts are expected to be similar to those of the Foundation Project, although the area affected is likely to be proportionately less.
Noise and vibration	• Terrestrial fauna • Subterranean fauna • Marine fauna	This stressor is relevant during the construction and operation of the Fourth Train Proposal. The type and nature of potential impacts may be similar to those of the Foundation Project. Additional disturbances (i.e. from the Fourth Train Proposal in addition to those assessed and approved for the Foundation Project) may also be relevant.
Creation of light or shade	• Flora and vegetation communities • Terrestrial fauna • Marine fauna • Landscape and aesthetics	This stressor is relevant during the construction and operation of the Fourth Train Proposal. The type and nature of potential impacts may be similar to those of the Foundation Project. Additional light or shade (i.e. from the Fourth Train Proposal in addition to those assessed and approved for the Foundation Project) may also be relevant.

Foundation Project (EIS/ERMP and PER)[1]		Relevance to the Fourth Train Proposal
Project Stressors	**Associated Environmental Factors**	
Fire	• Flora and vegetation communities • Terrestrial fauna	Fire remains a potential stressor for the Fourth Train Proposal (due to the presence of fuel, hot works, vehicle exhausts etc.).
Leaks or spills	• Soil and landforms • Surface water and groundwater quality • Flora and vegetation communities • Subterranean fauna • Seabed substrates • Water quality (marine) • Benthic primary producers (marine flora and corals) and habitats • Marine fauna	This stressor is relevant during the construction and operation of the Fourth Train Proposal. Consequences are likely to be similar to those of the Foundation Project; however, the likelihood may be altered given that the Fourth Train Proposal will be developed at the same time as the Foundation Project is completing construction and becoming fully operational.

[1] *Source: Chevron Australia 2005, 2006 and 2008.*

5.3.2 Environmental Factors Relevant to the Fourth Train Proposal

Drawing on the information presented in Table 5-1 and the preliminary analysis of the activities associated with the Fourth Train Proposal, Table 5-2 lists the environmental factors identified as being of particular relevance to the Fourth Train Proposal. Figure 5-1 and Figure 5-2 illustrate the likely interactions between stressors and environmental and socio-economic factors respectively, which are expected to be relevant to the Fourth Train Proposal.

Table 5-2 Environmental Factors Relevant to the Fourth Train Proposal

Environmental Factor Type [1]	Relevant Environmental Factors [1] [2]	Change Introduced by the Fourth Train Proposal compared to impacts assessed for the approved Foundation Project (see further detail in Appendix 5)
Terrestrial Environment	• Soils and landforms • Surface and groundwater • Terrestrial flora and vegetation communities • Terrestrial fauna • Subterranean fauna	The duration, spatial area, and/or magnitude of impacts predicted for the Foundation Project may be extended or changed as a result of the construction and operation of the Fourth Train Proposal. However, no impacts are anticipated for the Western Australian mainland.
Coastal and Nearshore Environment	• Marine fauna and benthic communities (except benthic primary producers) • Marine benthic primary producers and their	The duration, spatial area, and/or magnitude of impacts predicted for the Foundation Project may be extended or changed as a result of the construction and operation of the Fourth Train Proposal. However, as no dredging or

Environmental Factor Type [1]	**Relevant Environmental Factors [1] [2]**	**Change Introduced by the Fourth Train Proposal compared to impacts assessed for the approved Foundation Project** (see further detail in Appendix 5)
	habitats • Marine water quality • Seabed	changes to the MOF or LNG Jetty are anticipated for the Fourth Train Proposal, construction phase impacts are expected to be limited to the west coast of Barrow Island associated with installation of the Feed Gas Pipeline System.
Pollution Management	• Atmospheric emissions • Emissions of greenhouse gases • Generation of dust • Creation of light or shade • Discharges to sea (including run-off) • Noise and vibration • Leaks and spills	Additional emissions, discharges, and wastes will be generated by the Fourth Train Proposal, which may change the magnitude of resulting impacts on terrestrial and coastal and nearshore environmental factors and/or the area of influence. The total emissions from the Foundation Project and Fourth Train Proposal will increase. During construction, the duration of stressors will be extended beyond that envisaged for the Foundation Project.
Social Surrounds	• Public health and safety • Cultural heritage • Conservation areas • Land and sea use • Livelihoods • Local communities • Local and regional economy	The duration of impacts anticipated for the Foundation Project may be extended by construction of the Fourth Train Proposal.

[1] Term used by the EPA to broadly denote environmental receptors (EPA 2010b). The environmental factors presented are derived from those used in the Foundation Project approvals documents (Chevron Australia 2005, 2008).

[2] Relevant environmental factors are identified for areas in State jurisdiction only including coastal and nearshore waters, Barrow Island, and the nearby Pilbara coast that could be affected by construction and operation of the following components of the Fourth Train Proposal: the marine component of the Feed Gas Pipeline System within nearshore waters; the HDD site; the terrestrial component of the Feed Gas Pipeline System; the fourth LNG train at the Gas Treatment Plant and its associated utilities; supply vessel operations at the MOF and/or WAPET Landing; and the loading of LNG and condensate on to off-take vessels at the LNG Jetty. Environmental factors relevant to Commonwealth jurisdiction are identified in SEWPaC's Tailored Guidelines (presented for information in Appendix 3).

Environmental Factor	Potential Consequence	Stressor: Atmospheric emissions (except dust)		Dust		Creation of light or shade		Discharges to Sea (incl. runoff)		Noise and vibration emissions		Creation of heat/cold		Generation & disposal of solid waste (to land)		Physical disturbance (seabed or foreshore)		Physical Presence (of infrastructure)		Physical interaction		Introduction/ spread of non-indigenous species		Site disturbance / excavation (onshore)		Vegetation clearing		Spills & leaks		Fire	
		C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O
Atmosphere																															
Air Quality	Local air quality Regional air quality	■	■	■																										■	
Global concentrations of GHG in the atmosphere	Global concentrations of GHG in the atmosphere	■	■																											■	
Terrestrial Environment																															
Soil and landforms	Soil contamination Soil characteristics Landform													■	■									■		■		■	■	■	
Surface and groundwater	Water quality Hydrological patterns Groundwater recharge													■	■			■	■					■		■		■	■		
Terrestrial flora & vegetation communities including restricted flora	Impact to species or community Loss of species or community Habitat integrity		■	■		■	■															■	■	■		■		■	■	■	
Terrestrial fauna including protected species	Species behaviour Population size and viability Habitat integrity		■	■		■	■			■	■	■	■						■	■	■	■	■	■		■		■	■	■	
Subterranean fauna including protected species	Species behaviour Population size and viability Habitat integrity									■									■			■	■	■		■		■	■		
Marine Environment																															
Marine fauna including protected species and benthic communities (excl. BPPs)	Species behaviour Population size and viability Habitat integrity		■			■	■	■	■	■	■					■			■	■	■	■	■					■	■		
Marine benthic primary producers (BPPs) and their habitats	Impact to species or community Loss of species or community							X	X							■	X		■	■								■	■		
Marine water quality	Water quality		■					■	■							■	■											■	■		
Foreshore	Stability and integrity of beaches															X	X	X	X												
Seabed (sub-tidal and inter-tidal)	Benthic landforms Sediment physical characteristics Sediment contamination							■								■	X		■									■	■		

Key:

- ■ Interaction (impact or benefit) anticipated for the Fourth Train Proposal
- X Denotes an interaction that was relevant to the scope of the Foundation Project but is not relevant for the Fourth Train Proposal (i.e. dredging, Domestic Gas Pipeline and construction of the MOF and LNG Jetty)
- C Refers to the Construction Phase
- O Refers to the Operational Phase

Figure 5-1 Summary of Likely Interactions between Stressors and Environmental Factors for the Fourth Train Proposal

Socio-economic Factor	Potential Consequence	Stressor: Atmospheric emissions (except dust)		Dust		Physical Presence (of infrastructure)		Physical interaction		Introduction/ spread of non-indigenous species		Site disturbance / excavation (onshore)		Vegetation clearing		Spills & leaks		Fire	
		C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O
Society and Economy																			
Public health and safety	Public health, safety and wellbeing Access to health care services		■													■	■		
Cultural heritage	Historical and cultural associations Aboriginal and non-indigenous heritage											■							
Conservation Areas and national / world heritage places	Environmental and heritage values		■	■						■	■	■		■		■	■	■	
Land and Sea Use	Economic impact on other uses of the land or sea (e.g. shipping, fishing, recreation)					■	■	■	■							■	■		
Livelihoods	Employment and skills					■	■												
Local communities	Social, cultural and community structure and infrastructure of host communities					■	■												
Local and regional economy	Alignment with national, state and local socio-economic development policies and plans Economic development					■	■												

Key:

■ Interaction (impact or benefit) anticipated for the Fourth Train Proposal

C Refers to the Construction Phase

O Refers to the Operational Phase

Figure 5-2 Summary of Likely Interactions between Stressors and Socio-Economic Factors for the Fourth Train Proposal

Based on the results of the preliminary environmental analysis presented in Table 5-2, Figure 5-1 and Figure 5-2, impacts on the following environmental and socio-economic factors are identified as requiring further examination in the PER/Draft EIS for the Fourth Train Proposal:

- the terrestrial environment of Barrow Island, including impacts on the physical environment (i.e. soils and landform, air quality, ambient noise levels, light spill, surface and ground water quality and quantity) and on the biological environment (e.g. to terrestrial and subterranean fauna and to flora and vegetation communities). With the exception of air quality, impacts are expected to be restricted to Barrow Island. Impacts resulting from operational atmospheric emissions of the Fourth Train Proposal may extend to the Pilbara airshed.
- the State waters surrounding Barrow Island, including impacts on the physical characteristics of the seabed, marine water quality, marine fauna and marine benthic primary producers (BPPs; i.e. mangroves, seagrass, macroalgae, and corals) and their habitats. Similar to the terrestrial environment, impacts are expected to be restricted to State waters surrounding Barrow Island except for non-routine events.
- the society and economy of the State and the Pilbara region, including impacts on public health and safety, land and sea use, cultural heritage, conservation areas, local communities and their livelihoods and lifestyles.

Potential impacts of the Fourth Train Proposal on these factors are summarised in Appendix 5.

Notwithstanding the results of this preliminary environmental analysis, the Fourth Train Proposal will undergo an environmental risk assessment for the PER/Draft EIS during which the identified environmental stressors, environmental factors, and potential impacts will be revisited, confirmed, and/or amended.

5.3.3 Baseline Data

The baseline for the Fourth Train Proposal is the as-built and operational Foundation Project. This status takes into account other activities already operational on Barrow Island (i.e. WA Oil operations).

There is a considerable amount of data available from the Foundation Project to describe the pre-Foundation Project baseline condition of the marine and terrestrial environment. The Foundation Project has also generated numerous predictions about the status of the environment once it becomes operational (e.g. in its impact assessment reports and in modelling studies conducted as part of detailed engineering design [see Sections 5.3.5 and 6.7.6 for further details]).

Chevron Australia has considered the availability, geographical coverage, and validity of baseline data available from the Foundation Project to support the PER/Draft EIS for the Fourth Train Proposal. This preliminary environmental analysis for the Fourth Train Proposal concluded that sufficient, up-to-date, and valid information with appropriate spatial coverage is available to support the assessment of impacts on environmental factors in the PER/Draft EIS (see Appendix 5). However, for socio-economic factors, it was concluded that available data will need to be supplemented with more up-to-date secondary information (e.g. on shipping movements, fishing etc.; see Appendix 5 for further details).

5.3.4 Cumulative Impacts

In addition to impacts associated with the Foundation Project, the Fourth Train Proposal may result in cumulative impacts in two further ways:

- impacts that are additive on one environmental receptor. For example, flora and fauna may be subject to potential environmental effects from a number of different stressors of the Fourth Train Proposal and the Foundation Project including dust emissions, air emissions, vehicular and personnel movements, vegetation clearing, and spills and leaks. Such impacts are likely to be localised to Barrow Island and its surrounding waters.

- impacts of the Fourth Train Proposal and Foundation Project in addition to those of other developments. Locally (i.e. on Barrow Island), relevant developments include WA Oil operations. At a regional level (i.e. Barrow Island and the neighbouring Pilbara coast), the Wheatstone Project and other developments along the Pilbara coast will be relevant particularly for social receptors and with respect to air quality.

5.3.5 Potential Limitations

The environmental risk assessments for the Foundation Project provide a solid basis on which to frame the assessment of potential impacts for the Fourth Train Proposal. However, construction of the Foundation Project is currently in progress; therefore, relying on the conclusions and recommendations of the Foundation Project, and its approved mitigation and management mechanisms presents potential limitations for the Fourth Train Proposal. These include:

- impacts that may result from the Foundation Project that were either not previously anticipated, or are different to those predicted (i.e. better or worse than predicted)
- stress to environmental factors that may not result in a detectable impact for some time
- impacts to environmental factors by stressors not attributable to the Foundation Project (e.g. by natural events) that may make factors more vulnerable to impacts resulting from the Fourth Train Proposal.

Limited monitoring data are expected to be available within the timeframe of the Fourth Train Proposal's PER/Draft EIS. Experience and lessons from the implementation of construction-phase mitigation and management measures proposed for the Foundation Project and from site observations and audits will also be considered in the PER/Draft EIS, where relevant.

6.0 Proposed Studies and Investigations for the PER/Draft EIS

Chevron Australia, as proponent for the Fourth Train Proposal, is required to prepare a PER of the Fourth Train Proposal in accordance with the EPA's Guidelines for Preparing a Public Environmental Review (EPA 2010c) to address EP Act requirements.

As the Fourth Train Proposal is also subject to assessment by the Commonwealth Government under the EPBC Act (SEWPaC reference EPBC 2011/5942), Chevron Australia intends to present a combined PER/Draft EIS document for public review, which will also address matters of National Environmental Significance (NES). The scope of the assessment relevant to the EPBC Act is presented in SEWPaC's Tailored Guidelines (Appendix 3).

The remainder of this section focuses specifically on the scope of studies required to meet the EPA's requirements for PER.

6.1 Objectives of the PER/Draft EIS

The objectives of the PER/Draft EIS to meet the EPA's requirements are to:

- place the Fourth Train Proposal in the context of the local and regional environment
- describe components of the Fourth Train Proposal, so that the State Minister for Environment can consider approval of a well-defined project
- provide the basis of Chevron Australia's environmental management program for the Fourth Train Proposal, which shows that the environmental impacts resulting from the Fourth Train Proposal, including cumulative impacts, are reduced and managed to a level that is as low as reasonably practicable (ALARP)
- communicate clearly with stakeholders (including the public and government agencies), so that the EPA can obtain informed comment to assist in providing advice to the State Minister for Environment
- provide comprehensive documentation that sets out the reasons why the Fourth Train Proposal should be deemed to be environmentally acceptable by the State Minister for Environment.

6.2 Scope of the Assessment

The PER/Draft EIS will consider potential direct and indirect impacts of construction, commissioning, and operation of the Fourth Train Proposal on the environmental and socio-economic factors identified for assessment in Section 5.3.2. It will also identify impacts reasonably expected from the decommissioning of the Fourth Train Proposal, although this will be in outline only given the current stage of development.

The PER/Draft EIS will examine how the Fourth Train Proposal affects the impacts predicted in the various impact assessments conducted by the Foundation Project. A risk assessment process will be used to evaluate residual impacts (see Section 6.7).

The activities examined in the PER/Draft EIS will include those undertaken within State jurisdiction in the Fourth Train Proposal area (illustrated in Figure 1-1). Impacts will be examined within the area of influence noted in the preliminary environmental analysis results in Appendix 5.

6.3 Assessment Framework

The assessment of impacts in the PER/Draft EIS will be undertaken within the legal framework outlined in Section 3.0 of this Environmental Scoping Document. Impacts on environmental factors will also be examined in the context of the environmental objectives provided in Appendix 5 and the environmental principles discussed in Appendix 6. Where relevant and applicable, likely environmental consequences will be predicted and assessed in accordance with established guidelines and policies, as referenced in Section 3.4.

6.4 Project Description and Alternatives

The PER/Draft EIS will include a description of the Fourth Train Proposal in sufficient detail to support the subsequent discussion of environmental impacts. This will include:

- relevant maps, charts, and plans of the location and design of the Proposal
- the key characteristics of the Proposal in State (and Commonwealth) jurisdiction and how these relate to existing, approved activities (i.e. the Foundation Project)[2]
- a description of the supporting infrastructure and utilities that the Proposal may use, including any modifications to Foundation Project facilities[3] that are necessary to accommodate the Fourth Train Proposal
- a description of the nature and extent of the works proposed to construct, commission, and, in outline, to decommission the Fourth Train Proposal
- a description of how the Fourth Train Proposal will be operated, including:
    - a process flow/indicative mass balance diagram and associated description of the operational process, including the primary inputs, outputs, and waste/emissions streams that are expected during normal operation
    - a description of non-routine events and how these are proposed to be managed
- the proposed schedule for implementing the Proposal, including the expected design life of the Proposal
- workforce requirements
- management of other aspects related to the Proposal such as waste management and disposal[4].

Explanation will be provided to demonstrate how the Fourth Train Proposal has been designed to reflect forecast climatic conditions and constraints within the design life of the Proposal (i.e. associated with reasonably foreseeable climate change).

To provide context for the Proposal, the PER/Draft EIS will also include a description of the alternatives considered, including location, technology, and technique options. This will reflect the justification provided in Section 2.5 of this Environmental Scoping Document and the various engineering design studies being conducted for the Fourth Train Proposal.

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[2] As the Fourth Train Proposal is an expansion of the Foundation Project, the key characteristics of the Proposal will be summarised in a table along with those of the Foundation Project; this will allow readers to understand the nature and scale of the Proposal.

[3] 'Modifications to Foundation Project facilities' includes altering the basis upon which they were approved; e.g. extending their duration of use, changing their frequency of use, and/or changing the nature of their use beyond that covered in their existing approval.

[4] Note that none of the Fourth Train Proposal sites contain land requiring remediation under the *Contaminated Sites Act 2003* (WA).

6.5 Baseline

The PER/Draft EIS will include a description of the existing environment (the 'baseline') in a local and regional context covering the environmental factors identified in Section 5.3.2. This will include a description of:

- physical environment and processes
- terrestrial biodiversity, ecosystems, and ecosystem processes
- coastal and nearshore biodiversity, ecosystems, and ecosystem processes[5]
- relevant socio-economic characteristics, including heritage values and other users of the Fourth Train Proposal area who could be impacted by, or who could impact, the Fourth Train Proposal.

Where relevant, the description of the baseline will consider known or predicted changes to the environment that may occur irrespective of, but in the design life of, the Fourth Train Proposal. For example, changes brought about by reasonably foreseeable climate change to the extent that data are publicly available.

The baseline for the Fourth Train Proposal is the status of the environment with an as-built and operational Foundation Project. This status takes into account other activities already operational on Barrow Island (i.e. WA Oil operations).

The baseline will be established using:

- data gathered as part of the Foundation Project impact assessment studies, subsequent Environmental Management Plans and Monitoring Programs (see Section 4.0 for a summary)[6]
- predictions about the status of the environment with an operational Foundation Project taken from Foundation Project impact assessment studies and Environmental Management Plans, and from modelling studies that reflect the most up-to-date knowledge on the design of the Foundation Project (e.g. for air quality, noise, light, etc.)
- secondary information available in the public domain (e.g. for shipping movements, fishing etc.). Environmental factors likely to require more up-to-date baseline data are identified in the 'Additional Studies' column of Appendix 5.

6.6 Emissions, Discharges and Wastes from the Proposal

The PER/Draft EIS will describe how the Fourth Train Proposal will change the emissions, discharges, and wastes assessed and approved for the Foundation Project and will outline how these will be managed and, where relevant, disposed of. This will include atmospheric emissions, noise and vibration, light spill, and solid and liquid wastes reasonably expected from the construction and commissioning activities, routine and non-routine operation of the Fourth Train Proposal, and its future decommissioning.

Emissions, discharges and wastes will be discussed in the PER/Draft EIS in context with those generated, or predicted to be generated, by the Foundation Project. Where the Fourth Train Proposal could use utilities or infrastructure already approved under the Foundation Project, the

[5] Coastal and nearshore areas are those within State jurisdiction. The PER/draft EIS will also examine impacts on the marine environment (i.e. in Commonwealth jurisdiction) as required in SEWPaC's Tailored Guidelines for draft EIS (Appendix 3).
[6] Note: These data take into account other existing activities in the area, including WA Oil operations on Barrow Island.

PER/Draft EIS will document how the inclusion of the Fourth Train Proposal will affect the emissions, discharges and wastes already predicted and approved for the Foundation Project. If inclusion of the Fourth Train Proposal results in a significant change in associated impacts on environmental factors compared to the impacts assessed for the approved Foundation Project, the incremental and additional change will be evaluated further.

Where emissions, discharges, and wastes are expected to be significant (e.g. during routine and non-routine operations), they will be quantified and, where relevant, predicted using mathematical modelling/calculation. Based on the results of the preliminary environmental analysis, the following predictive modelling studies are anticipated:

- atmospheric emissions from the operational Gas Treatment Plant covering both routine and non-routine operations
- noise emissions from the operational Gas Treatment Plant covering both routine and non-routine operations
- light spill from the operational Gas Treatment Plant
- hydrocarbon spills during construction and operation of the Fourth Train Proposal.

Sections 6.6.1 to 6.6.5 provide more detail on the scopes of these modelling studies. Results from these modelling studies will be used to interpret potential impacts on relevant terrestrial and marine environmental factors.

With the exception of reject brine, wastewater generated by the Fourth Train Proposal's terrestrial facilities is expected to be injected below ground using infrastructure approved by the Foundation Project. The PER/Draft EIS will explain that wastewater volumes generated for injection by the Fourth Train Proposal and the Foundation Project can be accommodated in the subsurface aquifer. The Fourth Train Proposal will use the Foundation Project's reverse osmosis facilities; reject brine generated in support of the Fourth Train Proposal is expected to be discharged into the coastal and nearshore environment. Chevron Australia will justify that the volumes of fresh water required for the Fourth Train Proposal can be provided by the Foundation Project's reverse osmosis facilities and will not exceed the approved Foundation Project levels or levels that the Foundation Project is seeking approval for, in the case of the permanent reverse osmosis facilities. As such, the results from the relevant Foundation Project technical studies will be included in the PER/Draft EIS, and no additional modelling of wastewater discharges is currently anticipated specifically for the Fourth Train Proposal.

As the discharges and potential environmental impacts associated with the Foundation Project's reverse osmosis facilities are to be approved by Foundation Project, the Fourth Train Proposal will request to extend the duration of use of these facilities in the PER/Draft EIS. In the event that the quality or quantity of discharges is found to change significantly from the Foundation Project as a result of the implementation of the Fourth Train Proposal, modelling will be used to predict associated water quality and ecological impacts.

Significant operational solid and liquid waste that is predicted to result from the implementation of the Fourth Train Proposal (e.g. as illustrated in Table 6-1) will be outlined in the PER/Draft EIS, with a description of how it will be managed. Note that the predicted volumes shown in Table 6-1 are indicative and remain subject to change during engineering design.

Table 6-1: Indicative Operational Solid and Liquid Waste Volumes for the Fourth Train Proposal and the Fourth Train Proposal and Foundation Project combined

Waste Stream	Fourth Train Proposal Volume (tonnes/year)	Fourth Train Proposal and Foundation Project Volume (tonnes/year)
Contaminated sludge	600	2300
Molecular sieve	150	600
Mercury removal beds	50	200
Spent filters (hazardous)	50	200
Spent filters (non-hazardous)	5	20
Glycol solution	1400	5600

The management of solid and liquid waste will be outlined in the PER; briefly waste management will occur through a hierarchical application of measures including:

1. Source reduction
2. Re-use
3. Recycling
4. Recovery
5. Treatment
6. Responsible disposal.

For non-routine events such as spills, LNG train start-up, and upset operating conditions, the PER/Draft EIS will include a discussion on the likely frequency of such events when discussing associated emissions, discharges, and wastes. This discussion will be in the context of the Foundation Project approvals; i.e. if the frequency or duration of non-routine flaring is expected to increase as a result of the Fourth Train Proposal, the impact of that increase on environmental factors will be further assessed.

6.6.1 Atmospheric Pollutant Emissions

Atmospheric emissions of key atmospheric pollutants (NO_x, SO_x, CO and particulate matter [PM]), as well as the formation of secondary atmospheric pollutants such as ozone (O_3), will increase as a result of the extra energy requirements and process emissions generated by the operation of the Fourth Train Proposal. Ambient concentrations of these pollutants are anticipated to increase under routine and non-routine operating conditions compared to the air quality predictions made for the Foundation Project's emissions of these pollutants.

Emissions of acid gas during routine and non-routine operation of the Fourth Train Proposal are also expected to increase concentrations of air toxics such as benzene, toluene and ethyl-benzene and xylene (BTEX) and hydrogen sulfide (H_2S) in the ambient environment.

Dispersion modelling studies will be conducted to predict whether ambient concentrations of these atmospheric pollutants and air toxics are expected to be within acceptable regulatory limits, such that residual impacts on the flora and fauna of Barrow Island and of communities in the surrounding Pilbara region can be reduced to ALARP. Impacts of atmospheric pollutants and air toxics on the flora and fauna of Barrow Island will be assessed with reference to Ecological Risk Assessments conducted for the Foundation Project and reported in its Air

Quality Management Plan (Chevron Australia, 2011b). These Ecological Risk Assessments used the following criteria to assess impacts:

- Human exposure limits established in the National Environment Protection (Ambient Air Quality) Measure, the National Exposure Standards [NOHSC:1003–1995] (as amended – Safe Work Australia [SWA] 1995), the World Health Organisation (WHO)'s Air Quality Guidelines for Europe (WHO, 2000) (for fauna)
- Acid deposition and ozone criteria for vegetation established by the World Health Organisation (WHO, 2000).
- Published research data on reference concentrations and observed effect levels (e.g. Chilgren 1979 and Murray et al., 1994).

6.6.1.1 Purpose and Objectives

The purpose and objectives of the dispersion modelling and consequent air quality study includes:

- predicting the ambient airborne concentrations of the key atmospheric pollutants (i.e. NO_x, SO_x, CO, PM, and O_3) and air toxics (i.e. H_2S and BTEX) that may increase as a result of the operation of the fourth LNG train and associated infrastructure within the Gas Treatment Plant, under routine and non-routine operating conditions
- assessing the impacts on local and regional air quality against established air quality standards, or maximum allowable concentrations of air toxics at sensitive receptor locations and determining if the associated community and ecological impacts are acceptable.

Sensitive receptor locations will reflect the location of communities, the flora and fauna of Barrow Island, and protected areas in the surrounding West Pilbara region.

6.6.1.2 Scope

The scope of the atmospheric emissions modelling will include air emissions sources reasonably expected from the routine and non-routine operation of the fourth LNG train at the Gas Treatment Plant, and of emissions reasonably expected from additional condensate offloading and LNG shipping.

Quantities of fugitive air emissions (such as VOCs) from the Fourth Train Proposal, Foundation Project and existing sources on Barrow Island (i.e. WA Oil operations) will be included in an inventory of emissions in the PER/Draft EIS, but will not be included in modelling. This is because fugitive emissions from the Fourth Train Proposal and the Foundation Project combined are not expected to be significant, contributing approximately 0.3% of total emissions from the Combined Gorgon Gas Development. This will be justified in the PER/Draft EIS.

The air quality study will assess the atmospheric pollutant emissions of the Fourth Train Proposal in combination with those of the Foundation Project and other existing industrial emissions sources on Barrow Island (i.e. WA Oil operations). In addition, a regional study will assess the cumulative emissions of the Fourth Train Proposal and Foundation Project, together with other emissions from Barrow Island (i.e. WA Oil operations) and emissions sources on the nearby Pilbara mainland (see below), for regionally significant emissions, i.e. NO_x and O_3 (with volatile organic compounds as a precursor).

Finally, a separate study will assess the air toxics emissions (i.e. of H_2S and BTEX) of the Fourth Train Proposal in combination with those of the Foundation Project. The selection of H_2S and BTEX were identified as potentially significant emissions from the Fourth Train Proposal and were included in the air toxics modelling. Chevron Australia do not intend to include WA Oil air toxics emissions in this study because these were found to be not significant compared to those anticipated for the Foundation Project and Fourth Train Proposal combined (Table 6-2). The justification for omitting WA Oil emissions from this air toxics study will be provided in the PER/Draft EIS.

Table 6-2 Comparison of Air Toxics (BTEX) Emissions

Air Toxic	Annual Emissions (tonnes)	
	WA Oil [1]	Predicted Foundation Project and Fourth Train Proposal [2]
Benzene	2.50	~ 150.00
Toluene	1.40	~ 350.00
Ethylbenzene	0.12	~ 2.00
Xylenes	0.35	~ 110.00

[1] WA Oil figures are from data presented for the most recent National Pollutant Inventory reporting period (200910) available at: http://www.npi.gov.au/npidata/action/load/emission-by-individual-facility-result/criteria/state/null/year/2010/jurisdiction-facility/WA0014.

[2] Predicted Foundation Project and Fourth Train Proposal BTEX emissions reflect anticipated emissions due to acid gas venting.

6.6.1.3 Methodology

Air quality modelling for atmospheric pollutants will be consistent with the Western Australian Department of the Environment's (now DEC) Air Quality Modelling Guidance Notes (Department of the Environment 2006). The air quality modelling will:

- review, analyse, and describe local meteorology, addressing long-term trends for temperature, wind speed, wind direction, humidity, and rainfall
- present a load inventory for National Pollutant Inventory (NPI) substances emitted to air by the Fourth Train Proposal during routine and non-routine operations (including both point and fugitive sources)
- develop an emissions inventory for the region incorporating major industrial sources, including the Karratha, Dampier, Onslow, and Cape Lambert regions. Anticipated major industrial sources likely to be included are listed in Appendix 7. Information on these major industrial sources will be included, where available, from data obtained from the NPI, or information supplied to, or by Chevron Australia. Existing Chevron Australia operations on Barrow and Thevenard Islands will also be included. The impact of fires in the Pilbara and their impact on ozone formation will also be considered
- undertake local modelling of NO_2, SO_2, CO, and PM for the Fourth Train Proposal (covering the Fourth Train Proposal emissions in addition to those of the Foundation Project and WA Oil operations)
- undertake regional modelling of the concentrations of O_3 and nitrogen dioxide NO_2 (as representative for nitrogen oxides) for a number of scenarios.

Results of this modelling will be presented in an air quality modelling study report as:

- contour plots for the pollutants of concern, both for regional and local modelling
- tables showing the change from the baseline for both regional and local modelling cases
- a comparison with relevant air quality criteria for human health and environmental (flora and fauna) receptors, including a justification of the appropriateness of the selected criteria.

Assumptions made in determining emissions rates, volumes, and pollutant constituents, and the level of certainty in the results obtained will be reported in the PER/Draft EIS. Furthermore, the

PER/Draft EIS will include information on the smokeless performance of the Gas Treatment Plant flares, and the scenarios under which this performance may be compromised. Information will be provided on the expected frequency of those scenarios and smoke mitigation measures.

Dispersion modelling studies will also be conducted to predict the ground-level concentrations of air toxics reasonably expected from acid gas venting events from all four LNG trains at the Gas Treatment Plant. Incremental and additional impacts on ground-level concentrations of H_2S and BTEX from the operation of four LNG trains will be predicted and will include a frequency assessment component.

As the Gas Treatment Plant for the Foundation Project is under construction, no monitoring data will be available from the Foundation Project to verify the emissions and air quality predictions in the PER/Draft EIS.

The air quality and dispersion modelling results will inform the assessment of impacts on the flora and fauna of Barrow Island, and of sensitive human and ecological receptors on the West Pilbara mainland. The results will also feed into detailed design work to maintain air quality impacts within acceptable risk levels.

6.6.2 Greenhouse Gas Emissions

The Fourth Train Proposal will result in emissions of greenhouse gases from a range of sources including:

- construction activities on Barrow Island and offshore in the Fourth Train Proposal Area associated with the installation, construction, and commissioning of the offshore wells, the Feed Gas Pipeline System and the Gas Treatment Plant
- gas turbine exhausts used to drive electrical generators and liquefaction compressors
- vents and flares
- reservoir carbon dioxide
- fugitive sources such as compressor seals, storage tanks, valves, etc.
- stand-by generators and pumps
- provision of infrastructure support.

The annual greenhouse gas emissions from the Fourth Train Proposal are yet to be determined but are anticipated to be between approximately 1.8 and 3.7 MTPA carbon dioxide equivalent (CO_2e). This range reflects the current stage of proposal development – there is still uncertainty as to the exact nature of the development concept. Chevron Australia is undertaking technical studies with the objective of narrowing the range of possible development options, and therefore the range in emissions estimates, for inclusion in the PER/Draft EIS.

Chevron Australia has undertaken extensive assessments examining emissions reduction and greenhouse gas management as part of the Foundation Project. Where relevant, these existing studies and technical evaluations will be used to inform the Greenhouse Gas Management Assessment for the Fourth Train Proposal PER/Draft EIS.

6.6.2.1 Purpose and Objectives

The objective of the Greenhouse Gas Management Assessment will be to demonstrate that emissions from the Fourth Train Proposal have been reduced to a level that is ALARP, taking into account the obligations under the Barrow Island Act, the State Agreement and the approvals for the Foundation Project.

6.6.2.2 Scope

Given this Proposal’s development stage, Chevron Australia is investigating a range of viable options for greenhouse gas emissions management. This range of development and management options will be presented and evaluated in the PER/Draft EIS, together with:

- average anticipated reservoir CO_2 content for the Fourth Train Proposal gas fields
- total greenhouse gas emissions reasonably expected from each credible development and design option for the Fourth Train Proposal.

The PER/Draft EIS will discuss and evaluate a range of credible design options for managing both process and reservoir CO_2 emissions, and will examine the full scope of emissions from the Fourth Train Proposal, including:

- technical options for the management of reservoir CO_2, such as injection of reservoir CO_2 and venting
- the use of aero derivative gas turbines, industrial gas turbines, or electric drives to power the liquefaction compressors
- the use of aero derivative or industrial gas turbines for electrical power generation either in open cycle or combined cycle configuration
- opportunities to recover and use waste heat and pressure let down
- opportunities to recover and use, or otherwise manage, emissions from vent streams that would otherwise be vented to the atmosphere
- where vents cannot be redirected into the process stream, the opportunity to reduce the environmental impact of these vents
- opportunities to reduce and eliminate fugitive emissions streams.

The evaluation will draw on relevant assessments undertaken as part of the Foundation Project and complemented by additional studies. These additional studies include the detailed assessment of subsurface injection of reservoir CO_2 under Foundation Project approved parameters. The PER/Draft EIS will include the estimated volume of reservoir CO_2 generated as a result of the implementation of the Fourth Train Proposal and the results of CO_2 Dupuy Simulation Modelling predicting the behaviour of injected CO_2 from the Fourth Train Proposal and the Foundation Project in the Dupuy Formation. The level of assurance of the Fourth Train Proposal, in addition to the Foundation Project CO_2 plume migration in the Dupuy Formation over time will also be presented in the PER/Draft EIS.

Emissions profiles, as incremental (i.e. Fourth Train Proposal alone) and in combination with the Foundation Project, will be presented for each viable design option. The timing of Foundation Project and Fourth Train Proposal emissions will be described on the basis of each LNG train coming online. The PER/Draft EIS will also include an account of any technical, health, safety, environmental, or economic constraints reasonably expected for each viable option.

The emissions intensity estimates for the Fourth Train Proposal will be benchmarked against emissions from other comparable projects in Australia and a number of recent international projects (where data are publicly available). Life cycle emissions estimates will also be provided against a range of competing fuel types. To demonstrate the use of currently available best practice technologies, a benchmark comparison of process technologies included in the Fourth Train Proposal with technologies used in other recent comparable Australian and international projects will be included in the PER/Draft EIS, drawing on publicly available information.

Chevron Australia has a clear objective to focus its efforts on reducing emissions of greenhouse gases from the Fourth Train Proposal as opposed to seeking to offset those emissions; however, consideration will be given to the role that practicable, cost-effective, technically feasible, and operationally compatible greenhouse gas offsets might play in managing emissions from the Fourth Train Proposal.

Consideration will also be given to the role that a national legislative framework for managing greenhouse gas emissions, including the *Clean Energy Act 2011* (Cth), may have on the range of greenhouse gas management options assessed in the PER/Draft EIS.

6.6.2.3 Methodology

The technical, economic, and environmental practicality of greenhouse gas management options will be assessed using the following criteria:

- health and safety risk (using Chevron Australia's internal standards)
- economic (using Chevron Australia's estimate of Australia's forward emissions price curve)
- operability and reliability (using Chevron Australia's internal standards)
- other environmental impacts (e.g. impacts on key atmospheric pollutants [e.g. NO_x, SO_x, CO, PM, and O_3], water usage, land requirements).

The assessment will be undertaken with reference to the commitments on the Gorgon Joint Venturers within the Barrow Island Act, the State Agreement, previous approvals for the Foundation Project and the EPA's Guidance Statement No. 12 for Minimising Greenhouse Gas Emissions (EPA 2002). Greenhouse Gas Emissions estimates will be compiled using the factors and methodologies defined in the *National Greenhouse and Energy Reporting Act 2007* (Cth).

6.6.3 Noise Emissions

The addition of a fourth LNG train and associated equipment at the Gas Treatment Plant could change the noise profile of the operational Gas Treatment Plant compared to that predicted for the Foundation Project. Noise emissions may change as a result of routine and non-routine operations.

The change in noise emissions reasonably expected with the addition of the Fourth Train Proposal will be calculated and the resulting predicted noise profile modelled.

6.6.3.1 Purpose and Objectives

The noise emissions study will update predictions of noise levels from the Foundation Project to account for the addition of the Fourth Train Proposal infrastructure. Results will be used to determine impacts on terrestrial and marine fauna on and around Barrow Island.

6.6.3.2 Scope

The noise study will predict noise levels from the operating Foundation Project and Fourth Train Proposal infrastructure at the Gas Treatment Plant during normal operating conditions and also during start-up of the Fourth Train Proposal infrastructure. Both incremental (i.e. Fourth Train Proposal alone) and additional (i.e. Fourth Train Proposal in addition to the approved Foundation Project) noise emissions will be predicted for the operational Gas Treatment Plant.

6.6.3.3 Methodology

The noise study will be undertaken in accordance with EPA Guidance Statement No. 8 – The Assessment of Environmental Factors, Environmental Noise (EPA 2007) and other guidelines or legislation as applicable. The study will update the predictions of noise levels made in the most recent Foundation Project noise study.

Recognised modelling software will be used (e.g. SoundPlan) to calculate and graphically present both in-plant and surrounding noise levels generated by the Gas Treatment Plant. In-plant and surrounding noise predictions will be performed using the International Organization for Standardization's (ISO) 9613 prediction methods (International Organization for Standardization 1993, 1996).

Predicted noise levels at noise sensitive receptors on Barrow Island will be benchmarked against the Environmental Protection (Noise) Regulations 1997 to assess the impacts on human (worker) health. Noise impacts on terrestrial fauna will be assessed with reference to a 50 dB(A) contour, consistent with the approach used by the Foundation Project and published research. Noise impacts on marine fauna will be assessed with reference to published research (e.g. OSPAR 2009, NRC 2003, Simmonds et al. 2004, Simmonds et al. 2005 and Southall et al. 2007).

As the Gas Treatment Plant for the Foundation Project is under construction, no data will be available from the Foundation Project to verify the noise calculations in the PER/Draft EIS.

6.6.4 Light Spill

The lighting systems and operational controls for the Fourth Train Proposal will be designed to reflect the Long-term Marine Turtle Management Plan prepared for the Foundation Project (Chevron Australia 2010d). However, the proposed changes to the Foundation Project's Gas Treatment Plant in the Fourth Train Proposal include the following elements that may contribute to an increase in light spill:

- the physical presence of the new Fourth Train Proposal infrastructure at the Gas Treatment Plant
- potential for additional non-routine flaring reasonably expected with the operation of the fourth LNG train.

6.6.4.1 Purpose and Objectives

The light spill modelling outputs produced will be used to inform an assessment of impacts on terrestrial fauna and marine turtles from the operation of the Fourth Train Proposal's Gas Treatment Plant. However, as noted in the EPA's Environmental Assessment Guideline on Protecting Marine Turtles from Light Impacts (EPA 2010d), 'while modelling can be useful to compare the relative effects of different lighting designs, the actual behaviour of marine turtle hatchlings is a much more reliable guide to the impact of light on marine turtles than measurements and modelling based on standard light meter readings'.

6.6.4.2 Scope

The scope of the modelling study will include lighting in all areas inside the Gas Treatment Plant site where practicable, including:

- all lit process facilities
- ground flares
- Boil-off Gas flares
- utilities
- wavelength of luminaires
- shielding and screening effects of structures.

The PER/Draft EIS will include an explanation of the selection of areas and facilities included in the light modelling.

Where practicable, it will also take into consideration the effects of the following factors on light levels:

- topography (including dune heights)
- cloud cover.

6.6.4.3 Methodology

Light spill modelling will be undertaken for a number of scenarios, including the operation of the four LNG trains under normal operating conditions and under maintenance conditions where work is being carried out on one of the trains and/or the LNG tanks. Both the incremental change caused by the Fourth Train Proposal and the total light spill caused by the Foundation Project and the Fourth Train Proposal will be predicted and presented using light contours.

Results of the modelling will be used to compare the light spill attributable to the operation of the Fourth Train Proposal with predicted light spill levels for the Foundation Project. In particular, comparisons will be made of how the Fourth Train Proposal and Foundation Project together could alter the natural light regime. Light modelling results will also be used to test the design of lighting systems at the Gas Treatment Plant, and demonstrate the effectiveness of light management controls in reducing light spill to levels that are as low as reasonably practicable.

As the Gas Treatment Plant for the Foundation Project is under construction, no data will be available from the Foundation Project to verify light spill predictions in the PER/Draft EIS.

Ultimately, reasonably expected light spill impacts on marine turtles will be managed through the Long-term Marine Turtle Management Plan prepared for the Foundation Project (Chevron Australia 2010d), which will be updated to reflect the Fourth Train Proposal.

6.6.5 Hydrocarbon Spills

Accidental releases of hydrocarbons into the marine or terrestrial environment may occur during the construction, commissioning, operation, and future decommissioning of the Fourth Train Proposal.

6.6.5.1 Purpose and Objectives

Hydrocarbon spill modelling will be undertaken to predict the behaviour of marine hydrocarbon spills under different spill and environmental conditions and to understand the likelihood of a spill occurring and subsequently impacting sensitive receptors. The results will be used to assess impacts of accidental releases of hydrocarbons to the marine and coastal environment and any change in likelihood due to the Fourth Train Proposal compared to that assessed and approved for the Foundation Project. They will also be used to help determine the need for, and design of, mitigation measures so that the risk of spills occurring, and the impact they may have if they do occur, is reduced.

6.6.5.2 Scope

A series of hydrocarbon spill scenarios covering incidents during the construction and operation of the Fourth Train Proposal will be developed and assessed. Relevant scenarios will be identified as part of the environmental risk assessment associated with the preparation of the PER/Draft EIS; these are likely to include:

- well blowouts
- pipeline ruptures
- vessel collisions or groundings.

The scope of the study will cover accidental releases occurring at sea.

The likelihood of spills occurring in the terrestrial environment as a result of the Fourth Train Proposal will also be assessed relevant to that assessed for the approved Foundation Project. However, this is outside the scope of the hydrocarbon spill modelling.

6.6.5.3 Methodology

Hydrocarbon spill modelling will be undertaken to predict the behaviour of a spill in the marine environment. Selected scenarios will reflect:

- weather conditions, including cyclones
- seasonality.

Results will be plotted as risk contours on a spatial area incorporating relevant areas of the WA coastline.

Given the above stressors and for any given spill scenario in specific weather conditions, the likelihood of a spill reaching and impacting sensitive receptors in the marine environment will be assessed.

6.7 Assessment of Environmental Impacts

6.7.1 Assessment Method

The environmental impacts reasonably expected from the Fourth Train Proposal will be evaluated in the PER/Draft EIS.

Numerous impact assessments have been completed for the Foundation Project in its environmental approvals documentation and its subsequent Ministerial Deliverables/ Environmental Management Plans and Programs (hereafter referred to as EMPs). Therefore, the environmental assessment process for the Fourth Train Proposal will reflect the methodology and results of the most recent impact assessments completed for the Foundation Project. For most activities and environmental factors, the most recent impact assessments are those used in the various EMPs required in Statement No. 800.

The environmental assessment process for the Fourth Train Proposal will follow these steps:

1. Systematic identification of potential impacts of the Fourth Train Proposal on the identified environmental and socio-economic factors compared to those assessed and approved for the Foundation Project. Both incremental impacts of the Fourth Train Proposal in isolation, and the additional impact of the Fourth Train Proposal when added to the impacts assessed and approved for the Foundation Project will be identified. If this process reveals extra impacts or discounts any of the impacts identified in this Environmental Scoping Document, their inclusion or omission from the PER/Draft EIS will be justified.
2. Prediction of the magnitude and assessment of identified incremental and additional impacts taking into account known mitigation and management measures and any experience and lessons from the Foundation Project.
3. Determining the predicted environmental outcome for each environmental and social factor.

The environmental assessment approach will address and reflect the Environmental Principles and Objectives respectively established in the EPA's Guide to EIA Environmental Principles, Factors and Objectives (EPA 2010b). Objectives for each environmental factor expected to be relevant for the Fourth Train Proposal have been proposed by Chevron Australia in Appendix 5. Environmental Principles relevant to the Fourth Train Proposal are described in Appendix 6.

In addition, the following assumptions will be applied to the impact assessment for the Fourth Train Proposal:

- the mitigation and management measures committed to by the Foundation Project will be applied where the Fourth Train Proposal activities and designs are alike. Practicable alternative technologies or techniques to those used by the Foundation Project will also be assessed where relevant

- where available, experience gained from implementing the Foundation Project will be used. This aims to address some of the uncertainties introduced when relying on Foundation Project predictions (see Section 6.7.6).

As much of the Fourth Train Proposal will be designed to be similar to the Foundation Project, the impact assessment will, where relevant, draw upon the research undertaken for the Foundation Project, including studies completed for detailed EMPs required under State and Commonwealth Ministerial Conditions. In addition, the change in emissions and discharges will be predicted to support the assessment (see Section6.6).

The results of the impact assessment will be discussed in the PER/Draft EIS, including:

- Identification of all potential impacts on the identified environmental and socio-economic factors.
- For those residual impacts risk assessed as key, a discussion of the likely consequence, including quantification of the impact where practicable, an evaluation of mitigation and management options, and the predicted effectiveness of the proposed measures, will be provided.
- A statement whether any relevant impacts are likely to be unknown, unpredictable or irreversible.

6.7.2 Assessment of Impacts on the Terrestrial Environment

The terrestrial environment includes the following physical and biological environment factors:

- soils and landforms
- surface and ground water
- terrestrial flora and vegetation communities, including restricted flora
- terrestrial fauna, including protected species, their habitats, and their population viability
- subterranean fauna, including protected species.

Potential impacts of the Fourth Train Proposal on these environmental factors will be discussed in the PER/Draft EIS. Potential impacts include those identified in Table A5-1 in Appendix 5. Relevant stressors include:

- atmospheric emissions
- dust
- creation of light and/or shade
- noise and vibration emissions
- creation of heat and/or cold
- generation and disposal of solid waste
- physical presence of infrastructure
- introduction or spread of non-indigenous species
- physical interaction
- site disturbance/excavation
- vegetation clearing
- spills and leaks
- accidental fires.

These potential impacts and stressors will be revisited in a risk assessment process at the start of the PER/Draft EIS preparation process and any additional risks will be included in the assessment. If this process reveals extra impacts or discounts any of the impacts identified in this Environmental Scoping Document, their inclusion or omission from the PER/Draft EIS will be justified.

Impacts on the terrestrial environment are expected to be restricted to Barrow Island, with the exception of impacts on terrestrial flora and fauna associated with atmospheric emissions. Therefore, the scope of the assessment will be mainly restricted to Barrow Island, although impacts on flora and fauna from atmospheric emissions will also be examined at a regional (Pilbara) scale.

The assessment of impacts on the terrestrial environment will be presented as both the incremental change introduced by the Fourth Train Proposal alone, and the additional impact of the Fourth Train Proposal when added to the impacts assessed and approved for the Foundation Project, in recognition that the Fourth Train Proposal's terrestrial components are being developed as a 'brownfield' project. Where the Fourth Train Proposal may use utilities or infrastructure already approved under the Foundation Project, the incremental and additional change in associated impacts will be examined.

Where relevant, the assessment of impacts will use predictions of emissions, discharges, and wastes and associated predicted changes in environmental quality, as described in Section 6.6. Furthermore, predictions made and monitoring data collected by the Foundation Project will be used to help quantify Fourth Train Proposal impacts and available. Mitigation and management strategies will be evaluated, reflecting the experience gained from the implementation of the Foundation Project and from alternative techniques or technology, where practicable. The assessment and consideration of mitigation and management strategies will also reflect the EPA's Environmental Principles where relevant (see Appendix 6).

The EPA's Checklist for Documents Submitted for EIA on Marine and Terrestrial Biodiversity (EPA [undated]) will be completed and included with the PER/Draft EIS in accordance with the EPA's requirements.

6.7.3 Assessment of Impacts on the Coastal and Nearshore Environment

For the purposes of the PER/Draft EIS, the coastal and nearshore environment is defined as the zone between the high water mark and the limit of State waters. It comprises the following physical and biological environment factors:

- marine water quality
- seabed (i.e. subtidal and intertidal benthic landforms and sediment characteristics)
- marine fauna, including protected species, their habitats, communities, and their population viability
- marine benthic primary producers and their communities.

Potential impacts of the Fourth Train Proposal on these environmental factors will be discussed in the PER/Draft EIS. Potential impacts include those identified in Table A5-1 in Appendix 5. Relevant stressors include:

- atmospheric emissions
- creation of light and/or shade
- discharges to sea
- noise and vibration emissions
- physical presence of infrastructure
- physical interaction
- physical disturbance of the seabed or foreshore
- introduction or spread of non-indigenous species
- spills and leaks.

Potential impacts and stressors will be revisited in a risk assessment process at the start of the PER/Draft EIS preparation process, and any additional risks identified will be included in the assessment If this process reveals extra impacts or discounts any of the impacts identified in this Environmental Scoping Document, their inclusion or omission from the PER/Draft EIS will be justified.

The coastal and nearshore environment reasonably expected to be affected by the Fourth Train Proposal, and therefore the scope of the impact assessment, includes the waters surrounding Barrow Island and areas of the coast potentially affected by atmospheric emissions (i.e. Pilbara region) or by a leak or spill occurring either in State or Commonwealth jurisdiction but affecting State waters.

The assessment of impacts on the coastal and nearshore environment will be presented as both the incremental change introduced by the Fourth Train Proposal alone, and the additional impact of the Fourth Train Proposal when added to the impacts assessed and approved for the Foundation Project, where relevant. This recognises that the Fourth Train Proposal's marine components in State jurisdiction are largely being developed as a 'brownfield' project (i.e. using existing facilities such as the MOF and LNG Jetty). The exception is the marine component of the Fourth Train Proposal's Feed Gas Pipeline System and shore crossing. While these are planned to be developed adjacent to or close to Foundation Project sites or infrastructure (in State jurisdiction), the area they can reasonably be expected to disturb is likely to extend beyond that of the Foundation Project. Where the Fourth Train Proposal may use utilities or infrastructure already approved under the Foundation Project, the incremental and additional change in associated impacts will be examined.

Where relevant, the assessment of impacts will use predictions of emissions, discharges, and wastes and associated predicted changes in environmental quality, as described in Section 6.6. Furthermore, predictions made and monitoring data collected by the Foundation Project will be used to help quantify Fourth Train Proposal impacts where available. Mitigation and management strategies will be evaluated reflecting the experience gained from the implementation of the Foundation Project and from alternative techniques or technology, where practicable. The assessment and consideration of mitigation and management strategies will also reflect the EPA's Environmental Principles where relevant (see Appendix 6).

The EPA's Checklist for Documents Submitted for EIA on Marine and Terrestrial Biodiversity (EPA [undated]) will be completed and included with the PER/Draft EIS in accordance with the EPA's requirements.

6.7.4 Assessment of Socio-economic Impacts

The PER/Draft EIS will examine potential impacts on these socio-economic factors:

- public health, safety, and wellbeing, and public access to health care services
- historical, cultural, Aboriginal and non-indigenous heritage and cultural associations
- environmental and heritage values of conservation areas, national and World Heritage places
- other users of the land and sea (i.e. commercial shipping, fishing, and recreation).

For information, the PER/Draft EIS will also examine potential impacts of the Fourth Train Proposal on:

- livelihoods, including employment and skills
- local communities, i.e. the structure and infrastructure of any host communities
- local and regional economies, including alignment with national, State and local socio-economic development policies and plans.

Potential impacts of the Fourth Train Proposal on these socio-economic factors will be discussed in the PER/Draft EIS. Potential impacts include those identified in Table A5-3 in Appendix 5. Relevant stressors include:

- atmospheric emissions
- dust

- physical presence of infrastructure
- physical interaction
- introduction and/or spread of non-indigenous species
- site disturbance/excavation
- vegetation clearing
- spills and leaks
- accidental fire.

Potential impacts and stressors will be revisited in a risk assessment process at the start of the PER/Draft EIS preparation process, and any additions or changes will be reflected in the assessment. If this process reveals extra impacts or discounts any of the impacts identified in this Environmental Scoping Document, their inclusion or omission from the PER/Draft EIS will be justified.

Where relevant, the assessment of impacts will use predictions of emissions, discharges, and wastes and associated predicted changes in environmental quality, as described in Section 6.6. Mitigation and management strategies will be evaluated, reflecting the experience gained from the implementation of the Foundation Project and from alternative techniques or technology, where practicable. The assessment and consideration of mitigation and management strategies will also reflect the EPA's Environmental Principles where relevant (see Appendix 6).

6.7.5 Assessment of Cumulative Impacts

As described in Section 6.7, Chevron Australia will evaluate the environmental impacts reasonably expected with the implementation of the Fourth Train Proposal in combination with the Foundation Project, as relevant.

The following cumulative impacts will also be examined:

- impacts that are additive on one environmental factor of Barrow Island's terrestrial, nearshore, and coastal flora and fauna. For example, flora and fauna may be subject to potential environmental effects from a number of different stressors of the Fourth Train Proposal including dust emissions, air emissions, vehicular and personnel movements, vegetation clearing, and spills and leaks. Such impacts are likely to be localised to Barrow Island and its surrounding waters. For relevant sensitive receptors, the additional impact introduced by the Fourth Train Proposal when added to those assessed and approved for the Foundation Project will be examined. Additive impacts on an environmental or social factor will be assessed as part of the predicted environmental outcome for the factor.
- impacts of the Fourth Train Proposal (and Foundation Project) in addition to those of other developments on the terrestrial flora and fauna of Barrow Island and on local and regional air quality. Locally (i.e. on Barrow Island), relevant developments include the WA Oil Operations. For potential cumulative air quality impacts at a regional level (i.e. Barrow Island and the neighbouring Pilbara coast), the developments listed in Appendix 7 will be considered. Information on other developments will be sourced from publicly available data.

6.7.6 Addressing Potential Limitations

To address the potential limitations described in Section 5.3.5, Chevron Australia proposes to inform predictions by drawing on experience gained from the implementation of the Foundation Project. Available data will include:

- audit findings associated with the implementation of mitigation and management measures
- terrestrial environmental monitoring around the HDD site, Feed Gas Pipeline Systems, the Gas Treatment Plant, and Construction Village, and at other sites/areas being monitored by the Foundation Project. Available data are expected to include information on flora and

fauna and the presence of weeds and other non-indigenous species and may include construction noise measurements

- marine environmental monitoring for HDD activities including water quality, marine benthic primary producer habitats, and benthic invertebrates
- marine turtle monitoring as described in the Long-term Marine Turtle Management Plan (Chevron Australia 2010d).

It is noted that monitoring programs may not have been in place for sufficient time to detect impacts occurring over a longer timeframe.

The PER/Draft EIS will document relevant uncertainties regarding predicted impacts.

6.8 Proposed Environmental Management

Where relevant to the design of the Fourth Train Proposal, Chevron Australia intends to apply the same environmental mitigation and management measures as for the Foundation Project. This includes an overall environmental management system supported by a series of EMPs.

Where impacts identified for the Fourth Train Proposal can be managed and monitored on the same basis as the EMPs that have been approved for the Foundation Project, Chevron Australia proposes to apply these same EMPs to the Fourth Train Proposal (e.g. by way of minor amendments to expand their scope and address any incremental or additional impacts). Where relevant, Chevron Australia proposes to present the EMPs as combined Foundation Project and Fourth Train Proposal documents.

The following EMPs have been identified in this respect:

- Aboriginal Cultural Heritage Management Plan
- Air Quality Management Plan
- Best Practice Pollution Control Design
- Coastal and Marine Baseline State and Environmental Impact Report (Feed Gas Pipeline and the Shore Crossing)
- Decommissioning and Closure Plan
- Fauna Handling and Management Common User Procedure
- Fire Management Plan
- Greenhouse Gas Abatement Program
- Horizontal Directional Drilling Management and Monitoring Plan
- Long-term Marine Turtle Management Plan
- Marine Environmental Quality Management Plan
- Offshore Feed Gas Pipeline Installation Management Plan
- Post-Construction Rehabilitation Plan
- Project Site Rehabilitation Plan
- Reverse Osmosis Brine Disposal Management and Monitoring Plan
- Short Range Endemics and Subterranean Fauna Monitoring Plan
- Solid and Liquid Waste Management Plan
- Terrestrial and Quarantine Management System

- Terrestrial and Subterranean Baseline State and Environmental Impact Report
- Terrestrial and Subterranean Environment Monitoring Program
- Terrestrial and Subterranean Environment Protection Plan
- Traffic Management Common User Procedure
- Vegetation Clearing Audit Common User Procedure.

The PER/Draft EIS will describe the environmental management framework proposed for the Fourth Train Proposal including the overall management system as well as any required changes to reflect the Fourth Train Proposal in these EMPs. Hyperlinks to the Foundation Project EMPs will be provided in the PER/Draft EIS for reference.

Experience gained in implementing relevant EMPs during Foundation Project construction will be gathered and reflected in the revised EMPs to ensure that the mitigation and management measures proposed for the Fourth Train Proposal are effective.

In addition, and in accordance with EPA Guidance Statement No. 19 (EPA 2008) and the Western Australian Government's Environmental Offsets Policy 2011, the PER/Draft EIS will consider Chevron Australia's need for providing and reviewing its offsets for any residual environmental impacts associated with the Fourth Train Proposal. The Environmental Offsets Reporting Form (as provided in EPA 2008) will be included for any specific offsets proposed as part of the PER/Draft EIS.

7.0 Stakeholder Engagement

Chevron Australia will undertake transparent stakeholder and community engagement throughout the environmental approvals process and the construction and operation of the Fourth Train Proposal. A stakeholder engagement plan will be developed to guide the stakeholder consultation process for the Fourth Train Proposal.

Stakeholder engagement for the Foundation Project commenced in early 2002 and has continued since. A broad and diverse cross-section of government, industry, and community representatives are involved in this process. Stakeholder engagement for the Fourth Train Proposal will build on the framework established during the Foundation Project.

7.1 Aims of Stakeholder Engagement

The aims of the stakeholder engagement program for the Fourth Train Proposal are to:

- inform stakeholders about the Fourth Train Proposal by providing accurate and accessible information
- provide adequate opportunities and timeframes for stakeholders to consider the Fourth Train Proposal and to engage in meaningful dialogue
- identify and attempt to resolve potential issues
- consider and address issues raised by stakeholders and provide feedback.

7.2 Stakeholder Identification

The stakeholder engagement program will involve consultation with a range of stakeholders, including environmental non-government organisations (NGOs), local communities, indigenous stakeholders, industry associations, and representatives of local, State, and Commonwealth governments. Stakeholder organisations identified for the Fourth Train Proposal include, but are not limited to, those listed in Table 7-1.

7.3 Stakeholder Engagement Undertaken to Date

A number of discussions with State and Commonwealth government agencies in relation to the Fourth Train Proposal have already been undertaken prior to and during the preparation of this Environmental Scoping Document.

In addition, initial project briefings have been conducted with the Shire of Roebourne and the Shire of Ashburton, as well as with the following three key indigenous groups: Thanlanyji, Kurama Marthudunera, and Yabburara/Mardudhunera.

7.4 Planned Stakeholder Engagement

Stakeholder engagement will continue as an integral part of the Fourth Train Proposal. In particular, discussions will be held with key identified stakeholders as part of the PER/Draft EIS preparation process. During the PER/Draft EIS public review process, further engagement will take place to allow stakeholders the opportunity to raise and discuss any issues with Chevron Australia, in addition to making public submissions.

In addition to direct engagement with stakeholders, other communication methods will be used to inform the broader community of the PER/Draft EIS process. These communications will include Chevron Australia's Frontier Magazine and the Gorgon Project Update newsletter (both available on the Chevron Australia website at: http://www.chevronaustralia.com/media/publications.aspx#z), and website postings of relevant public documents.

Table 7-1 Stakeholders Identified for the Fourth Train Proposal

Government	Non-Government
Commonwealth: • Minister for the Environment • Minister for Resources • Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) • Department of Resources, Energy and Tourism (DRET) **Western Australia:** • Minister for Mines • Minster for the Environment • Minister for State Development • Minister for Lands • Environmental Protection Authority (EPA) • Office of the Environmental Protection Authority (OEPA) • Department of Environment and Conservation (DEC) • Department of Mines and Petroleum (DMP) • Department of Planning • Department of Regional Development and Lands • Department of Fisheries • Department of Commerce • Department of Transport • Department of State Development • Department of Health **Other:** • Conservation Commission of WA • Dampier Port Authority • Fire and Emergency Services Authority • Shire of Ashburton • Shire of Roebourne	• Conservation Council of WA • Onslow Community Reference Group • Karratha Community Reference Group • Australian Conservation Foundation • Greenpeace • Marine and Coastal Communities Network • Western Australian Fishing Industry Council • Recfishwest • Wilderness Society of WA • Worldwide Fund for Nature • Waterbird Conservation Group • Wildflower Society of WA • Australian Marine Conservation Society • Western Australian Naturalists' Club • Western Australian Weeds Committee • Royal Society of WA • Pilbara Wildlife Carers Association • Western Australian Speleological Group • Environmental Weeds Action Network of WA • Birds Australia (WA Group) • Care for Hedland Environment Association • Cape Conservation Group • Nickol Bay Naturalists Club • Humane Society International • Chamber of Commerce and Industry WA • Chamber of Minerals and Energy WA • Australian Petroleum Production and Exploration Association (APPEA) • Thanlanyji • Kurama Marthudunera • Yabburara/Mardudhunera

8.0 Assessment Schedule and Team

8.1 Assessment Schedule

Chevron Australia's proposed schedule for the environmental approvals process is provided in Table 8-1. The proposed schedule aligns with the EPA's Environmental Assessment Guidelines No. 6 – Timelines for Environmental Impact Assessment of Proposals (EPA 2010e).

Table 8-1 Proposed PER/Draft EIS Development Schedule

Task/Milestone	Indicative Schedule
PER/Draft EIS submitted to OEPA and SEWPaC for review	June 2012
OEPA and SEWPaC review and provide comments on the PER/Draft EIS	5 weeks from receipt
PER/Draft EIS submitted to OEPA and SEWPaC for public release	October 2012
Public Review Period	8 weeks
OEPA prepares and forwards summary of Submissions (on PER component) to Chevron Australia	3 weeks from close of public review period
Response to the Submissions / Final EIS submitted to OEPA and SEWPaC for consideration	May 2013
OEPA assesses proposal and prepares an assessment strategy, with the response to submissions for consideration by the EPA	7 weeks from receipt of Response to Submissions[1]
OEPA consults with Chevron Australia and key government agencies on draft recommended conditions	2 weeks
EPA submits EPA Report to the Minister and publishes the EPA Report	5 weeks from EPA meeting
Appeal period to the Minister on the EPA Report	2 weeks

Note 1: The indicative schedule presented assumes that Chevron Australia's initial Response to Public Submissions document will be acceptable to the OEPA. If the Response to Public Submissions is inadequate, the OEPA will advise the proponent of this within four weeks for the first draft and within three weeks for any subsequent draft.

8.2 Assessment Team

The PER/Draft EIS will be prepared by Chevron Australia's in-house team of scientists and engineers, supported by specialist inputs from consultants and contractors, where required.

8.3 Peer Review

Chevron Australia intends to engage a number of stakeholders on various elements of the Fourth Train Proposal during the preparation of the PER/Draft EIS.

Appendix 1 References

The following documentation is either directly referenced in this document or is a recommended source of background information.

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Appendix 2 Acronyms, Terms and Abbreviations

The following acronyms and abbreviations are commonly used in Gorgon Gas Development documentation.

ABS	Australian Bureau of Statistics
Acid Gas	A mixture of hydrogen sulfide (H_2S) and carbon dioxide (CO_2).
Additional impact	The impact of the Fourth Train Proposal when added to the impacts assessed and approved for the Foundation Project
Additive impact	Where a particular factor is affected by more than one stressor from the Fourth Train Proposal (e.g. noise and changed water quality affecting the behaviour of marine mammals)
Administrations and Operations Complex	Facilities approved under the Foundation Project comprising administration offices and maintenance workshops on Barrow Island to support the operation and maintenance of the Foundation Project and future Fourth Train Proposal infrastructure
Air Toxics	Gaseous, aerosol, or particulate pollutants that are present in the air in low concentrations with characteristics such as toxicity or persistence so as to be a hazard to human, plant or animal life.
Airshed	A volume of air confined to a distinct geographic region, and within which pollutants are contained
ALARP	As Low As Reasonably Practicable Defined as a level of risk that is not intolerable, and cannot be reduced further without the expenditure of costs that are grossly disproportionate to the benefit gained.
Ambient Air	As described in the National Environment Protection (Ambient Air Quality) Measure (National Environment Protection Council [NEPC] 2003), ambient air is considered the external air environment, and does not include the air environment inside buildings or structures.
Ancillary Systems and Facilities	This refers to the following relevant to the Fourth Train Proposal: • fuel gas and recycle gas systems • power generation • heating medium system • pressure relief/liquids disposal, flare and vent system.
APASA	Asia Pacific Applied Science Associates
APPEA	Australian Petroleum Production and Exploration Association
ARI	Assessment on Referral Information (for the proposed, now approved, Jansz Feed Gas Pipeline dated September 2007) as amended or supplemented from time to time
Atmospheric	Any emission or discharge to air, for any period of time, of solid, liquid

Emissions	or gaseous matter. Examples include, but are not limited to, dust and greenhouse gases.
Atmospheric Pollutants	As described in the National Environment Protection (Ambient Air Quality) Measure (NEPC 2003) includes carbon monoxide (CO), nitrogen dioxide (NO_2), photochemical oxidants (such as ozone – O_2 sulphur dioxide (SO_2), lead and particles (such as PM_{10}). In principle, this includes gaseous, aerosol or particulate pollutants that are present in the air in low concentrations with characteristics such as toxicity or persistence so as to be a hazard to human, plant or animal life.
AU$	Australian dollar
Avifauna	Birds of a particular region.
Barge Landing	*see* WAPET Landing
Barrow Island Act	Western Australian *Barrow Island Act 2003*
Bathymetric	Relating to measurements of the depths of oceans or lakes.
Benthic	Living upon or in the sea floor.
Benthic Habitats	Areas of the seabed that support living organisms. Examples include, limestone pavement, reefs, sand and soft sediments.
BOG	Boil-off Gas; vapours produced as a result of heat input and pressure variations that occur within various LNG storage and offloading operations stages.
BPP	Benthic Primary Producer; photosynthesising organisms (mangroves, seagrasses, algae) or organisms that harbour photosynthetic symbionts (corals, giant clams).
BTEX	Benzene, Toluene, Ethylbenzene and Xylene compounds
Calcarenite	Rock formed by the percolation of water through a mixture of calcareous shell fragments and quartz sand causing the dissolved lime to cement the mass together.
CALM	Former Western Australian Department of Conservation and Land Management (now DEC)
CALM Act	Western Australian *Conservation and Land Management Act 1984*
CAMBA	China–Australia Migratory Bird Agreement
Carbon Dioxide (CO_2) Injection System	The mechanical components being constructed on Barrow Island to enable the injection of Foundation Project reservoir carbon dioxide, including, but not limited to, compressors, pipelines and wells.
Chevron Australia	Chevron Australia Pty Ltd
CO	Carbon monoxide

CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
Commonwealth Waters	Waters stretching from three to 300 nautical miles from the Australian coast.
Construction	Offshore, includes the installation and commissioning of offshore infrastructure (Feed Gas Pipeline System, subsea wells etc.), drilling and testing of wells. Onshore, includes the preparation of terrestrial sites and the construction and commissioning of terrestrial infrastructure.
Construction Village	Dedicated village on Barrow Island to accommodate the construction workforce.
Cth	Commonwealth of Australia
Cumulative Impact	Impacts of the Fourth Train Proposal and the approved Foundation Project when combined with other past, present and reasonably foreseeable future actions (both related and unrelated) in the region.
DEC	Western Australian Department of Environment and Conservation
Demersal	Living on the seabed or just above it.
DIA	Western Australian Department of Indigenous Affairs.
Different impact	An impact predicted for the Fourth Train Proposal that was not relevant or assessed for the approved Foundation Project
Direct Impact	An impact that occurs as a direct result of the Proposal (e.g. change in air quality as a result of air emissions generated by the Proposal).
DMP	Western Australian Department of Mines and Petroleum (formerly Western Australia Department of Industry and Resources [DoIR])
DoIR	Former Western Australian Department of Industry and Resources (now DMP)
Domestic Gas	Gas destined for the domestic gas market
DomGas	Domestic Gas
Downstream	Includes the Gas Treatment Plant, MOF and LNG jetty, construction village and associated facilities and other infrastructure such as upgrades to the airport, roads and other utilities.
DRET	Commonwealth Department of Resources, Energy and Tourism
DRI	Direct Reduced Iron
Dust	A generic term used to describe solid airborne particles generated and dispersed into the air by processes such as handling, crushing and grinding of organic or inorganic materials such as rock, ore, metal, coal,

	wood or grain and stockpiling of materials.
Easement	A right held by the proponent to make use of the land of another for the installation and operation of a pipeline. Also referred to as a right-of-way.
EIS	Environmental Impact Statement
EIS/ERMP	Environmental Impact Statement/Environmental Review and Management Programme (for the Proposed Gorgon Development dated September 2005) as amended or supplemented from time to time.
EMPs	*See* 'Ministerial Deliverables/Environmental Management Plans and Programs.
Environmental Factor	Term used by the Western Australian Environmental Protection Authority (EPA 2010b) meaning receptors; i.e. characteristics of the environment such as water quality, fauna and flora etc. that may be subject to impact.
Environmental Principle	Refers to the principles of environmental management contained in section 4A of the Western Australian *Environmental Protection Act 1986* (EP Act), namely: • Precautionary Principle • Principle of intergenerational equity • Principle of the conservation of biological diversity and ecological integrity • Principles relating to improved valuation, pricing and incentive mechanisms • Principle of waste minimisation.
EP Act	Western Australian *Environmental Protection Act 1986*
EPA	Western Australian Environmental Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EPBC Reference: 2003/1294	Commonwealth Ministerial Approval (for the Gorgon Gas Development) as amended or replaced from time to time.
EPBC Reference: 2005/2184	Commonwealth Ministerial Approval (for the Jansz Feed Gas Pipeline) as amended or replaced from time to time.
EPBC Reference: 2008/4178	Commonwealth Ministerial Approval (for the Revised Gorgon Gas Development) as amended or replaced from time to time.
ERM	Environmental Resources Management Pty Ltd
ESE	Environmental, Social and Economic
Feed Gas	Unprocessed hydrocarbons gathered from the offshore wells comprising natural gas, natural gas condensate (condensate) and produced

	formation water (produced water).
Feed Gas Pipeline System	Pipeline from the offshore gas wells to the Gas Treatment Plant including associated power umbilicals etc
Foundation Project	The combined initial Gorgon Gas Development, Revised and Expanded Gorgon Gas Development, and Jansz Feed Gas Pipeline
Foundation Project Footprint	Consists of the cleared areas and uncleared areas approved to be cleared on Barrow Island used for the construction and operation of the Gorgon Gas Development and Jansz Feed Gas Pipeline.
Fourth Train Proposal	Gorgon Gas Development Fourth Train Expansion Proposal
Fourth Train Proposal Footprint	Refers to the areas of cleared and uncleared terrestrial land that will be required for the construction and operation of the Fourth Train Proposal.
Gas Condensate	Hydrocarbon liquid dissolved in saturated natural gas that comes out of solution when the pressure drops below the dewpoint.
Gas Treatment Plant	Includes the following components: Liquefied Natural Gas (LNG) Trains, LNG Tanks, Gas Processing Drivers, Power Generators, Flares, Condensate Tanks, and Utilities Area. Reference to the Foundation Project's Gas Treatment Plant relates to the Gas Treatment Plant facilities for three LNG trains approved as part of the Foundation Project.
GHG	Greenhouse Gas
GJV	Gorgon Joint Venturers
Gorgon Gas Development	The Gorgon Gas Development as approved under Statements No. 800 and 865 and EPBC Reference: 2003/1294 and 2008/4178, as amended or replaced from time to time.
Gorgon Gas Development Foundation Project	*see* Foundation Project
Gorgon Gas Development Fourth Train Expansion Proposal	*see* Fourth Train Proposal
Gorgon Joint Venturers	The Joint Venturers from time to time as defined in the Gorgon Gas Processing and Infrastructure Project Agreement.
Greater Gorgon Area	The offshore area, situated in Commonwealth waters, encompassing a number of petroleum title blocks in the Carnarvon Basin to the west of Barrow Island. The area is illustrated in Figure 1-1. This definition should not be confused with the definition of the Greater Gorgon Area in the State Agreement.
Greenhouse Gases	Components of the atmosphere that contribute to the greenhouse effect. These include the six commonly reported GHGs under the Kyoto

	Protocol – methane (CH_4), carbon dioxide (CO_2), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6).
Groundwater	Water that exists beneath the earth's surface in underground streams and aquifers.
GUFT	Gorgon Foundation Project Upstream Facilities Team
H_2S	Hydrogen sulfide
ha	Hectare
Habitat	The area or areas in which an organism and/or assemblage of organisms lives. It includes the abiotic factors (e.g. substrate and topography) and the biotic factors.
HDD	Horizontal Directional Drilling
Hydrology	The movement, distribution and quality of water on earth including surface and groundwater
Incremental impact	The impact of the Fourth Train Proposal in isolation. Incremental impacts include impacts of the Fourth Train Proposal considered to be 'different' to those assessed by the approved Foundation Project (termed 'different impacts')
Indirect Impact	An impact which occurs as a consequence of a direct impact (e.g. changed plant growth as a result of reduced air quality caused by air emissions from the Proposal). Can also be referred to as a secondary or higher order impact.
Injection Lines	Used to supply chemical treatments to the wellheads.
ISO	International Organization for Standardization
JAMBA	Japan–Australia Migratory Bird Agreement
Jansz Feed Gas Pipeline	The Jansz Feed Gas Pipeline as approved in Statement No. 769 and EPBC Reference: 2005/2184, as amended or replaced from time to time.
KJVG	Kellogg Joint Venture Gorgon
km	Kilometre
km/h	Kilometres per hour
km^2	Square kilometres
Licence	A licence granted under section 91 of the *Land Administration Act 1997* (WA), in accordance with section 7 of the Ratifying Act.
Light Spill	Brightening of the environment from both direct light and light glow.

Liquid Waste	Waste that contains free liquids, which will readily separate from the solid waste under ambient temperature and pressure.
LNG	Liquefied Natural Gas
Long-term Impact	In the context of this Proposal, taken to be an impact which is expected to last for five years or more.
LPG	Liquefied Petroleum Gas
m	Metre
m/s	Metres per second
Macroalgae	Benthic marine plants that are non-flowering and lack roots, stems and vascular tissue. Can be seen without the aid of a magnification; includes large seaweeds.
Marine Disturbance Footprint (MDF)	The area of the seabed to be disturbed by construction or operation of the Fourth Train Proposal's Feed Gas Pipeline System and associated shore crossing.
MARPOL	The International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. Also known as MARPOL 73/78.
MDF	Marine Disturbance Footprint
MEG	Monoethylene glycol; used as a hydrate inhibitor
mg/L	Milligrams per litre
Ministerial Deliverables / Environmental Management Plans and Programs	The deliverables required as a condition of approval for the Foundation Project as defined in Ministerial Statements issued with respect to the Foundation Project (*see* 'Statement No…'). Ministerial Deliverables include various Environmental Management Plans, monitoring programs, best practice reviews, and other documents as listed in Section 6.8 of this Environmental Scoping Document. For simplicity, these various deliverables are together referred to as 'EMPs' in this Environmental Scoping Document.
Ministerial Statements	Statements, issued by the Western Australian State Minister of Environment, granting approval – with associated conditions – for the implementation of a proposal under the *Environmental Protection Act 1986* (WA). In the context of this document, this relates to the Ministerial Statements issued with respect to the Foundation Project (*see* 'Statement No…').
MOF	Materials Offloading Facility
MTPA	Million Tonnes Per Annum
MW	Megawatt

Nearshore	Close to shore; or within three nautical miles of Barrow Island.
NEPC	National Environment Protection Council
NES	[Matters of] National Environmental Significance, as defined in Part 3, Division 1 of the EPBC Act (Cth).
NGO	Non-Government Organisation
nm	Nautical miles
NO_2	Nitrogen dioxide
NOHSC	National Occupational Health and Safety Commission
Nominal	Representative value of a measurable property determined under a set of conditions, by which a product may be described. The actual value will be close to, but may not be exactly the same, as this representative value once real world factors have been taken into account in accordance with standard engineering practice.
NO_x	Nitrogen oxides (NO and NO_2)
NPI	National Pollution Inventory
NRC	National Research Council of the United States National Academies
NWS	North West Shelf
O_3	Ozone
OEPA	Office of the (Western Australian) Environmental Protection Authority
Operations Workforce Accommodation	Dedicated accommodation facility on Barrow Island to house the operations workforce for the Foundation Project and the future Fourth Train Proposal.
OSPAR	Oslo/Paris Convention for the Protection of the Marine Environment of the North-East Atlantic
PEC	Priority Ecological Community
PER	Public Environmental Review
PGPA	Policy, Government and Public Affairs
PM	Particulate Matter
PM_{10}	A dust fraction with an aerodynamic diameter of less than 10 microns.
Pollution	Direct or indirect alteration of the environment to its detriment or degradation.
Practicable	Having regard to local conditions and circumstances including but not limited to personnel safety, weather or geographical conditions, costs, environmental benefit and the current state of scientific and technical

	knowledge.
Priority Flora	Priority Flora is a non-legislative category aimed to manage those plant taxa listed by the DEC on the basis that they are known from only a few collections, or a few sites, but which have not been adequately surveyed. Such flora may be rare or threatened, but cannot be considered for declaration as rare flora until such survey work has been undertaken.
Proposal Area	Refers to 'Fourth Train Proposal Area' illustrated in Figure 1-1, which incorporates the geographic area within which the key elements of the Fourth Train Proposal will be installed/constructed and operated. Excluded from the Proposal Area are locations that may be used to support the implementation of the Fourth Train Proposal (e.g. supply bases).
Residual impact	Impact remaining after the application of proposed mitigation and management measures
Risk	The chance of something happening that will have an impact upon objectives; measured in terms of consequence and likelihood.
Risk Assessment	In environmental assessment terms, a thorough process of evaluating impacts that combines estimates of consequences and likelihood.
RO	Reverse Osmosis
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
Seagrass	Benthic marine plants, which have roots, stems, leaves and inconspicuous flowers with fruits and seeds much like terrestrial flowering plants. Unrelated to seaweed.
Sensitive Receptor	Individuals, communities or components of the environment that could be adversely affected by a stressor and is particularly sensitive or vulnerable to a change.
SEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities
Short-term Impact	In the context of this Proposal, an impact that occurs for less than five years.
SKM	Sinclair Knight Merz
SO_2	Sulfur dioxide
Sox	Oxides of sulfur
sp. (plural: spp.)	Species
SREs	Short Range Endemics
State Agreement	The Gorgon Gas Processing and Infrastructure Project Agreement, Schedule 1 of the *Barrow Island Act 2003* (WA).

State Government	Government of Western Australia
State Waters	The marine environment within three nautical miles of the coast of Barrow Island or the mainland of Western Australia.
Statement No. 748	Western Australian Ministerial Implementation Statement No. 748 (for the Gorgon Gas Development) as amended from time to time [superseded by Statement No. 800].
Statement No. 769	Western Australian Ministerial Implementation Statement No. 769 (for the Jansz Feed Gas Pipeline) as amended from time to time.
Statement No. 800	Western Australian Ministerial Implementation Statement No. 800 (for the Gorgon Gas Development) as amended from time to time (see also Statement 865).
Statement No. 865	Western Australian Ministerial Statement No. 865 to Amend Conditions Applying to a Proposal (under section 46 of the EP Act) for the Gorgon Gas Development. This Statement amends Conditions 18, 20 and 21 of Statement No. 800 relating to the management of dredging and dredged spoil disposal.
Stygofauna	Groundwater-dwelling aquatic fauna
Subsea Gathering System	In the context of this Proposal, this comprises subsea structures, jumpers, cluster manifolds and gas flowlines.
Substrate	The surface a plant or animal lives upon. The substrate can include biotic or abiotic materials. For example, encrusting algae that lives on a rock can be substrate for another animal that lives above the algae on the rock.
Surficial	Of or pertaining to the surface.
SWA	Safe Work Australia
TAPL	Texaco Australia Pty Ltd
Taxon (plural: taxa)	A taxon (plural taxa), or taxonomic unit, is a name designating an organism or a group of organisms.
TDF	Terrestrial Disturbance Footprint
TEC	Threatened Ecological Community
Terrestrial Disturbance Footprint (TDF)	The terrestrial area to be disturbed by construction or operation of the Fourth Train Proposal.
Troglofauna	Obligate cave- or karst-dwelling terrestrial subterranean fauna occurring above the watertable.
Uncleared Land	As defined in the Barrow Island Act.
UNCLOS	United Nations Convention on the Law of the Sea

Upstream	Gas field wells and subsea installation, marine and terrestrial components of the Feed Gas Pipeline system including HDD activities.
USEPA	United States Environmental Protection Agency
Vegetation	Any aquatic or terrestrial plant, whether it is dead or alive. Examples include, but are not limited to, grass, shrubs, trees, tree stumps, tree roots, logs, seeds and brush.
Venting	Discharge/release of gas to the atmosphere without prior combustion
VOCs	Volatile Organic Compounds
WA	Western Australia
WAPET	West Australian Petroleum Pty. Ltd.
WAPET Landing	Proper name referring to the site of the barge landing existing on the east coast of Barrow Island prior to the date of Statement No. 800.
Waters Surrounding Barrow Island	Refers to the waters of the Barrow Island Marine Park and Barrow Island Marine Management Area (approximately 4169 ha and 114 693 ha respectively) as well as the port of Barrow Island representing the Pilbara Offshore Marine Bioregion which is dominated by tropical species that are biologically connected to more northern areas by the Leeuwin Current and the Indonesian Throughflow, resulting in a diverse marine biota is typical of the Indo–West Pacific flora and fauna.
Weeds	Plants that establish in natural ecosystems, subsequently adversely impact on natural processes and ultimately result in the decline of the native community.
WHO	World Health Organisation
Wildlife Conservation Act	Western Australian *Wildlife Conservation Act 1950*

Appendix 3 SEWPaC's Tailored Guidelines for the Preparation of a Draft Environmental Impact Statement

A copy of SEWPaC’s Tailored Guidelines for the Preparation of a Draft EIS for the Fourth Train Proposal is provided here for information.

Appendix 4 Legally Protected Species Potentially Occurring in Areas Subject to the Fourth Train Proposal

Listed Species Protected under State Legislation	Common Name	Status		Presence in Proposal Area [1]
		***Wildlife Conservation Act 1950* (WA)**	**DEC**	
Avifauna				
Ardeotis australis	Australian Bustard	-	Priority 4	Possible
Malurus leucopterus edouardi	White-winged Fairy-wren (Barrow Island), Barrow Island Black and White Fairy-wren	Schedule 1	-	Likely
Mammals				
Balaenoptera musculus	Blue Whale	Schedule 1	-	Likely
Bettongia lesueur unnamed subsp.	Burrowing Bettong (Boodie)	Schedule 1	-	Likely
Dugong dugon	Dugong	Schedule 4	-	Likely
Eubalaena australis	Southern Right Whale	Schedule 1	-	Unlikely
Hydromys chrysogaster	Rakali or Water-rat	-	Priority 4	Likely
Isoodon auratus barrowensis	Golden Bandicoot (Barrow Island)	Schedule 1	-	Likely
Lagorchestes conspicillatus conspicillatus	Spectacled Hare-wallaby (Barrow Island)	Schedule 1	-	Likely
Macropus robustus isabellinus	Barrow Island Wallaroo, Barrow Island Euro	Schedule 1	-	Likely
Megaptera novaeangliae	Humpback Whale	Schedule 1	-	Likely
Petrogale lateralis lateralis	Black-flanked Rock-wallaby	Schedule 1	-	Likely
Reptiles				
Caretta caretta	Loggerhead Turtle	Schedule 1	-	Possible
Chelonia mydas	Green Turtle	Schedule 1	-	Likely
Dermochelys coriacea	Leatherback Turtle, Leathery Turtle	Schedule 1	-	Possible
Eretmochelys imbricate	Hawksbill Turtle	Schedule 1	-	Likely
Lepidochelys olivacea	Olive Ridley Turtle	Schedule 1	-	Possible
Natator depressus	Flatback Turtle	Schedule 1	-	Likely
Subterranean Fauna				
Amphipoda *Nedsia fragilis*	-	Schedule 1	-	Likely
Amphipoda *Nedsia humphreysi*	-	Schedule 1	-	Likely
Amphipoda *Nedsia hurlberti*	-	Schedule 1	-	Likely
Amphipoda *Nedsia sculptilis/macrosculptilis*	-	Schedule 1	-	Likely
Amphipoda *Nedsia straskraba*	-	Schedule 1	-	Likely
Amphipoda *Nedsia*	-	Schedule 1	-	Likely

Listed Species Protected under State Legislation	**Common Name**	**Status**		**Presence in Proposal Area [1]**
		***Wildlife Conservation Act 1950* (WA)**	**DEC**	
urifimbriata				
Eleotridae *Milyeringa veritas*	Blind Gudgeon	Schedule 1	-	Likely
Ramphotyphlops longissimus	Blind Snake	-	Priority 2	Likely
Schizomida Draculoides bramstokeri	-	Schedule 1	-	Likely
Spirobolida Speleostrophus nesiotes	-	Schedule 1	-	Likely

[1] The Fourth Train 'Proposal Area' is defined in Figure 1-1. Presence in the Proposal Area is based on evidence gathered and presented to government as part of Foundation Project approvals (Chevron Australia 2009).

Appendix 5 Results of the Preliminary Environmental Analysis of the Fourth Train Proposal

Tables A5–1 to A5–3 present the results of the Preliminary Environmental Analysis conducted during the preparation of this Environmental Scoping Document. The tables provide a link between the potential environmental impacts of the Fourth Train Proposal and the additional investigations identified by Chevron Australia as being necessary to address the OEPA's requirements for the PER.

Table A5–1 covers environmental factors in State jurisdiction, including coastal waters, Barrow Island, and the nearby Pilbara coast. It encompasses areas affected by construction and operation of the marine component of the Feed Gas Pipeline System within nearshore waters; the HDD sites; the terrestrial component of the Feed Gas Pipeline System; the fourth LNG train at the Gas Treatment Plant and its associated utilities; supply vessel operations at the MOF and/or WAPET Landing; and the export of LNG and condensate from the LNG Jetty.

Table A5–2 considers impacts and associated proposed investigations for emissions, discharges and wastes that are reasonably expected to be generated by the Fourth Train Proposal.

Table A5–3 covers socio-economic factors potentially affected by the Fourth Train Proposal.

Notwithstanding the results of the preliminary environmental analysis presented here in Tables A5–1 to A5–3, the Fourth Train Proposal will undergo a thorough environmental risk assessment at the start of the PER/Draft EIS during which the environmental stressors, environmental factors, and potential impacts identified during this preliminary environmental analysis will be revisited, confirmed, and/or amended.

Table A5–1 Preliminary Environmental Analysis Results – Terrestrial, Nearshore and Coastal Environment (in State jurisdiction)

Environmental Factor	Relevant Area	Environmental Objective	Potential Impacts	Additional Investigations	Potential Management
Terrestrial Environment					
Soils and landforms	Areas surrounding the Fourth Train Proposal Footprint on Barrow Island (see Section 2.3)	To maintain the integrity, ecological functions, and environmental values of soil and landforms	Exposure and erosion of topsoil, sedimentation of water courses, changes in natural drainage patterns, soil compaction, soil inversion, disturbance to geological features (i.e. caves) and changes in landform during construction. Potential contamination of soil resulting from spills and leaks.	Assess the change in impact compared to the Foundation Project. Where available and relevant, use monitoring data, audit results and observations from the Foundation Project to substantiate construction-phase predictions. Use baseline data collected for the Foundation Project.	Mitigate impacts initially through engineering design and constructability review. For residual impacts, review relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project including the various applicable EMPs (see Section 6.8).
Surface and groundwater	Groundwater and surface freshwater resources on and beneath areas that will be affected by the construction and operation of the Fourth Train Proposal infrastructure on Barrow Island	To maintain the quantity and quality of water so that existing and potential environmental values, including ecosystem function, are protected. To minimise the potential for erosion due to stormwater flow.	Reduction in the quality of surface and groundwater due to sedimentation and turbidity, discharge of hydrotest water, surface run-off, change in groundwater recharge, and HDD cuttings dewatering during construction; and the discharge of bilge and ballast water and surface run-off during operation. Potential contamination of water from hydrocarbon leaks and spills.	Assess the change in impact identified and managed for the Foundation Project. Where available and relevant, use monitoring data, audit results and observations from the Foundation Project to substantiate construction-phase predictions. Use baseline data collected for the Foundation Project.	Mitigate impacts initially through concept selection, engineering design, and constructability review. For residual impacts, review relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project including the various applicable EMPs (see Section 6.8).
Terrestrial flora and vegetation communities, including restricted flora	Areas surrounding the Fourth Train Proposal Footprint on Barrow Island (see Section 2.3), Barrow Island more generally and potentially extending to the wider West Pilbara	To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystems levels through the avoidance or management of adverse impacts and improvement in knowledge.	Possible clearance of up to 10 ha of vegetation for the purposes of HDD activities and during excavation for the terrestrial component of the Feed Gas Pipeline System. Damage and loss of vegetation due to vehicle and personnel movements during construction	Assess the extent to which construction and operation of the Fourth Train Proposal changes the impacts identified for the Foundation Project. Where available and relevant, use monitoring data, audit results and observations from the Foundation Project to	Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project, including: • Definition of a Terrestrial Disturbance Footprint (TDF) • Terrestrial and Marine Quarantine Management

Environmental Factor	Relevant Area	Environmental Objective	Potential Impacts	Additional Investigations	Potential Management
	airshed (for air quality impacts).	To protect Declared Rare and Priority Flora, consistent with the provisions of the Wildlife Conservation Act.	and operation. Risk of fire as a result of hot works and vehicle use during construction and operation. Potential for non-indigenous species to be introduced or spread during construction and operation. Indirect impacts due to dust generated during construction and due to air emissions during operations.	substantiate construction-phase predictions. Use results of operational and non-routine atmospheric emissions modelling to evaluate the potential for the Fourth Train Proposal to impact flora and vegetation communities on Barrow Island and in the wider West Pilbara airshed. Use baseline data collected by the Foundation Project.	System • Various EMPs (Section 6.8). Identify how the Fourth Train Proposal affects the scope of the TDF approved for the Foundation Project.
Terrestrial fauna including protected species	Areas surrounding the Fourth Train Proposal Footprint on Barrow Island (see Section 2.3), and Barrow Island more generally.	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through avoidance or management of adverse impacts and improvement of knowledge. To protect Specially Protected (Threatened) Fauna, consistent with the provisions of the Wildlife Conservation Act 1950.	Direct and indirect disturbance of fauna and/or their habitat during HDD activities, construction of the terrestrial component of the Feed Gas Pipeline System, and as a result of vehicle and personnel movements, dust, noise, creation of heat and shade and light spill around the Gas Treatment Plant. Disturbance to fauna during operations associated with personnel and vehicle movements, noise and light emissions. Potential for non-indigenous species to be introduced or spread during construction and operation. Potential for additive impacts on the fauna of Barrow Island, including protected species, associated with multiple stressors.	Assess the change in risk to terrestrial fauna and protected species compared to the Foundation Project. Evaluate impacts on fauna of operational light, noise and air emissions from the Gas Treatment Plant on sensitive fauna using modelled predictions. Where available and relevant, use monitoring data, audit results and observations from the Foundation Project to substantiate construction-phase predictions. Use baseline data established for the Foundation Project.	Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project, including: • Definition of a TDF • Terrestrial and Marine Quarantine Management System • Various EMPs (Section 6.8). Identify how the Fourth Train Proposal affects the scope of the TDF approved for the Foundation Project.

Environmental Factor	Relevant Area	Environmental Objective	Potential Impacts	Additional Investigations	Potential Management
Subterranean fauna including protected species	Areas beneath the Fourth Train Proposal Footprint on Barrow Island (see Section 2.3) and within its zone of hydrogeological influence.	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through avoidance or management of adverse impacts and improvement of knowledge. To protect Specially Protected (Threatened) Fauna, consistent with the provisions of the Wildlife Conservation Act 1950.	Disturbance to subterranean fauna resulting from HDD activities and during excavation for the terrestrial component of the Feed Gas Pipeline System. Potential for non-indigenous species to be introduced or spread during construction and operation. Indirect impacts may occur due to changes to organic inputs to groundwater following vegetation clearance of up to 10 ha of uncleared land and changes to groundwater infiltration rates.	Assess how the Proposal impacts subterranean fauna drawing on the predictions made and any evidence gathered by the Foundation Project. Use baseline data established for the Foundation Project.	Mitigate impacts initially through concept selection, engineering design and constructability review. Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project, including: • Terrestrial and Marine Quarantine Management System • Various EMPs (Section 6.8).
Nearshore and Coastal Environment (in State Jurisdiction)					
Marine fauna including protected species and benthic faunal communities (except benthic primary producers)	Coastal and nearshore waters surrounding the Fourth Train Proposal facilities (i.e. shore approach of the Feed Gas Pipeline System, offshore HDD site, the MOF and LNG Jetty and their approaches). Pilbara coastline and coastal waters for impacts reasonably expected from accidental spills.	To maintain the abundance, diversity, geographic distribution and productivity of marine fauna at species and ecosystems levels through the avoidance or management of adverse impacts and improvement in knowledge. To avoid, reduce and/or mitigate against impacts on the ecological functions and environmental values of marine benthic habitats (except benthic primary producer habitats). To protect Specially Protected (Threatened) Fauna consistent with the provisions of the Wildlife	Disturbance to the behaviour of marine fauna, including marine turtles and other protected species, resulting from physical interaction, light spill, wastewater discharges, and noise generated during HDD activities and construction of the shore approach of the Feed Gas Pipeline System. Also potential for any changes in light spill and wastewater discharges from the operational Gas Treatment Plant and Feed Gas Pipeline System to affect marine fauna and/or because of an anticipated increased frequency of LNG and condensate export activities. Impacts could also occur as a result of a hydrocarbon spill or resulting from the introduction or	Assess the change in impacts to marine fauna generated by the construction and operation of the Fourth Train Proposal, compared to those predicted for the Foundation Project. Where available and relevant, use monitoring data, audit results and observations from the Foundation Project to substantiate construction-phase predictions. Use baseline data collected for the Foundation Project. Use modelling to predict the geographical extent and magnitude of potential impacts reasonably expected from hydrocarbon spills and from light spill from the operational Gas	Mitigate impacts initially through concept selection, engineering design and constructability review. Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project, including: • Definition of a Marine Disturbance Footprint (MDF) • Terrestrial and Marine Quarantine Management System • Various EMPs (Section 6.8). Identify how the Fourth Train Proposal affects the scope of the MDF approved for the Foundation Project.

Environmental Factor	Relevant Area	Environmental Objective	Potential Impacts	Additional Investigations	Potential Management
		Conservation Act 1950.	spread of non-indigenous species	Treatment Plant.	
Marine benthic primary producers (BPP) and their habitats.	Coastal and nearshore waters surrounding the Fourth Train Proposal facilities (i.e. shore approach of the Feed Gas Pipeline System, offshore HDD site, the MOF and LNG Jetty and their approaches). Pilbara coastline and coastal waters for impacts reasonably expected from accidental spills.	To maintain the abundance, diversity, geographical distribution, ecological function and productivity of mangroves, marine macrophytes (seagrass, macroalgae) and corals through the avoidance or management of adverse impacts and improvement in knowledge.	Loss and/or disturbance to coral communities during laying of the Feed Gas Pipeline System including shore crossing activities, and loss and/or stress on BPPs and their habitats in the event of a spill, leak, or through the accidental introduction or spread of non-indigenous species.	Assess the change in impact compared to that predicted for the Foundation Project. Where available and relevant, use monitoring data (e.g. associated with Foundation Project HDD activities) to validate impact predictions. Use baseline data collected for the Foundation Project. Use modelling to predict the geographical extent and magnitude of potential impacts reasonably expected from hydrocarbon spills (for realistic construction and/or operational phase scenarios).	Mitigate impacts initially through concept selection, engineering design and constructability review. Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project, including: • Definition of a MDF • Terrestrial and Marine Quarantine Management System • Various EMPs (Section 6.8). Identify how the Fourth Train Proposal affects the scope of the MDF approved for the Foundation Project.
Marine water quality	Coastal and nearshore waters surrounding the Fourth Train Proposal facilities (i.e. shore approach of the Feed Gas Pipeline System, offshore HDD site, the MOF and LNG Jetty and their approaches). Pilbara coastline and coastal waters for impacts reasonably	To maintain the quality of marine water so that existing and potential environmental values, including ecosystem functions and integrity of the seabed and the coast, are maintained.	Change in water quality on the west coast of Barrow Island due to the construction of the Feed Gas Pipeline System and associated HDD activities. Potential change in water quality on the east coast of Barrow Island associated with discharges from additional shipping and in the event that the Fourth Train Proposal affects Foundation Project approved wastewater disposal infrastructure. Also potential to affect marine water quality resulting from spills	Assess the change in impact compared to that predicted for the Foundation Project. Where available use monitoring data to validate impact predictions (e.g. associated with Foundation Project HDD activities). Use baseline data collected for the Foundation Project. Use modelling to predict the geographical extent and magnitude of potential impacts reasonably expected from	Mitigate impacts initially through engineering design and constructability review. Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project, including the various applicable EMPs (Section 6.8).

Environmental Factor	Relevant Area	Environmental Objective	Potential Impacts	Additional Investigations	Potential Management
	expected from accidental spills and leaks.		and leaks during the construction and operational phases.	hydrocarbon spills (for realistic construction and/or operational phase scenarios).	
Foreshore (including beach and primary dune systems)	North Whites Beach and its primary dune system	To maintain the integrity, ecological functions and environmental values of the soil and landform of the coast.	No impacts associated with planned Fourth Train Proposal activities are anticipated for the beach or primary dune system. However, impacts may occur as a result of unplanned activities including: • change in landform and deposition of drilling fluid onto the beach in the event of an accidental HDD frac-out • deposition of hydrocarbons onto the beach in the event of a spill occurring offshore • erosion/wash-out of dune system due to alteration in drainage at the HDD site and/or onshore Feed Gas Pipeline System route.	Assess the change in impact compared to that predicted for the Foundation Project. Use data and evidence collected by the Foundation Project to substantiate impact predictions where these are available. Use baseline data collected for the Foundation Project.	Impacts to the foreshore have been avoided through selection of the HDD technique to cross the shore of Barrow Island. Avoid credible residual impacts through site selection, engineering and site design, constructability reviews, and careful planning of construction activities. Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project, including its various EMPs (Section 6.8).
Seabed (subtidal and intertidal)	Seabed surrounding Barrow Island. Pilbara coast for impacts reasonably expected from accidental spills and leaks.	To maintain the integrity, ecological functions and environmental values of the seabed	Change in seabed profile and seabed composition due to the physical presence of the Feed Gas Pipeline System as it approaches the shore of Barrow Island. Anchor and chain scour to the seabed. Sedimentation and associated changes to sediment profile due to HDD activities and laying of the Feed Gas Pipeline System in nearshore waters.	Assess the change in impact compared to that predicted for the Foundation Project. Use monitoring data (e.g. associated with Foundation Project HDD activities) to validate impact predictions where available. Use baseline data collected for the Foundation Project.	Mitigate impacts initially through Feed Gas Pipeline System route selection, constructability reviews, and execution plans. Review the relevance and effectiveness of applying the same mitigation and management measures approved for the Foundation Project, including its various EMPs (Section 6.8).

Environmental Factor	Relevant Area	Environmental Objective	Potential Impacts	Additional Investigations	Potential Management
			Potential contamination of seabed sediment during construction and operation of the marine component of the Feed Gas Pipeline System as a result of leaks and spills.	Use modelling to predict the geographical extent and magnitude of potential impacts reasonably expected from hydrocarbon spills (for realistic construction and/or operational phase scenarios).	

Table A5–2 Preliminary Environmental Analysis Results – Emissions, Discharges and Wastes

Environmental Stressor	Relevant Area	Environmental Objective	Potential Impacts	Additional Investigations	Possible Management
Atmospheric emissions (including dust but excluding greenhouse gases)	Airshed surrounding Barrow Island and the adjacent Pilbara coast	To meet statutory requirements and acceptable standards, and thereby avoid or mitigate any adverse effects of atmospheric emissions on environmental values or the health, welfare, and amenity of people and land uses	Reduction in air quality during construction of terrestrial infrastructure, operation of the Gas Treatment Plant, and reasonably expected emissions from the loading and export of additional LNG and condensate.	Predict and assess the potential change in air quality reasonably expected from the implementation of the Fourth Train Proposal compared to the Foundation Project. Use atmospheric dispersion modelling to establish the baseline for atmospheric pollutants (i.e. the operational Foundation Project and existing emissions sources on Barrow Island) and to predict the change in operational air quality resulting from the Fourth Train Proposal. As the Foundation Project is not yet operational, note that no data are available to validate modelling.	Initially, mitigate impacts through the same mitigation and management mechanisms approved for the Foundation Project where relevant and effective, including concept selection, engineering design, and various relevant EMPs (Section 6.8). Review the effectiveness of Foundation Project mitigation and management and revise where necessary. Where relevant and practicable, examine the feasibility of realistic alternative technologies.
Emissions of greenhouse gases	Global atmosphere	To reduce emissions to levels as low as reasonably practicable on an ongoing basis and consider offsets to further reduce cumulative emissions	During the construction phase, emissions generated from vessel, vehicle and equipment engines and power generation. During operation, management of reservoir and process CO_2 at the Gas Treatment Plant.	Use calculations of emissions from the operational Foundation Project to establish the baseline. Estimate the key emission sources reasonably expected from the operational Fourth Train Proposal and assess alternative options for their reduction. Estimate the volume of additional CO_2 generated by the implementation of the Fourth Train Proposal and present the results of CO_2 Dupuy Simulation Modelling predicting the behaviour of injected CO_2 from the Fourth Train Proposal and	Evaluate realistic options for reducing emissions of reservoir and process greenhouse gases. Manage impacts through concept selection, engineering design, and updates to relevant Foundation Project EMPs.

Environmental Stressor	Relevant Area	Environmental Objective	Potential Impacts	Additional Investigations	Possible Management
				Foundation Project in the Dupuy Formation. Present the level of assurance of CO_2 plume migration in the Dupuy Formation over time. As the Foundation Project is not yet operational, note that no data are available to validate the calculations.	
Light spill	Barrow Island, its coast, and surrounding nearshore waters	To avoid or manage potential impacts from light overspill	Disturbance to the behaviour and possibly breeding of marine turtles and terrestrial fauna resulting from artificial lighting at construction and operational work sites.	Assess the change in light spill introduced by the Fourth Train Proposal compared to the Foundation Project. Use light spill modelling to establish the baseline for the Fourth Train Proposal (i.e. operational Foundation Project) and to predict the change in light spill caused by the operation of the fourth LNG train at the Gas Treatment Plant. Note that no monitoring data will be available to validate modelled predictions.	Engineering design will primarily be used to manage light spill. Likely impacts of light on marine turtles will be managed through the Long-term Marine Turtle Management Plan. Use of lighting systems will also be managed through other EMPs (e.g. HDD Management and Monitoring Plan). Review the effectiveness of Foundation Project mitigation and management measures, and revise where necessary. Where relevant and practicable, examine the feasibility of realistic alternative technologies.
Discharges to sea (including run-off)	Coastal and nearshore waters surrounding the Fourth Train Proposal facilities (i.e. shore approach of the	To meet statutory requirements and acceptable standards and thereby avoid or mitigate any adverse affects of discharges on the environmental values of the	Reduction in marine water quality due to run-off with entrained sediment and contaminants, discharge of hydrotest water, RO brine, bilge and ballast water. Potential contamination of water from hydrocarbon leaks and spills.	To the extent possible, identify and estimate any change in discharges to sea compared to those anticipated for the Foundation Project. Where wastewater infrastructure could be used by the Fourth Train	Manage likely impacts through concept selection, engineering design, constructability reviews, and using the same mitigation and management measures approved for the Foundation

Environmental Stressor	Relevant Area	Environmental Objective	Potential Impacts	Additional Investigations	Possible Management
	Feed Gas Pipeline System, offshore HDD site, the MOF and LNG Jetty and their approaches).	marine environment or the health, welfare, and amenity of people and sea users		Proposal, document the incremental change and additional volumes / durations / concentrations etc. as relevant, introduced by the Fourth Train Proposal compared to that assessed and approved for the Foundation Project. Use baseline information and technical studies conducted for Foundation Project approvals, where available and the results of the engineering studies completed for the Fourth Train Proposal for the assessment of impacts. Where available and relevant, use monitoring data, audit results and observations from the Foundation Project to substantiate construction-phase predictions. Use baseline data collected for the Foundation Project.	Project where relevant and effective, including various EMPs (Section 6.8). Review the effectiveness of mitigation and management measures, and revise where necessary. Where relevant and practicable, examine the feasibility of realistic alternative technologies.
Noise and vibration	Barrow Island, its coast, and surrounding waters	To avoid adverse noise and vibration impacts to terrestrial and marine fauna, by benchmarking noise against statutory requirements and acceptable standards	Disturbance to and potential impacts on the behaviour and breeding of terrestrial and marine fauna as a result of noise generated during construction and operation of the Fourth Train Proposal. Note there are no public premises or communities on Barrow Island that will be impacted by the Fourth Train Proposal thus the Environmental Protection (Noise) Regulations do not apply.	To the extent possible, describe any changes in construction-phase noise taking into account the relevant activities of the Foundation Project. Limited noise monitoring data are expected to be available (e.g. from the Foundation Project's HDD activities) to substantiate construction-phase terrestrial noise estimates. Use noise modelling to establish the baseline (i.e. operational Foundation Project) and to	Manage likely impacts through engineering design, construction methods and various EMPs (see Section 6.8). Review the effectiveness of mitigation and management measures, and revise where necessary. Where relevant and practicable, examine the feasibility of realistic alternative technologies.

Environmental Stressor	Relevant Area	Environmental Objective	Potential Impacts	Additional Investigations	Possible Management
				predict changes introduced by addition of an operational Fourth Train Proposal at the Gas Treatment Plant.	
Leaks and spills	Coastline and waters surrounding Barrow Island and along the nearby Pilbara coast.	To handle and store hydrocarbons and other chemicals in a manner that reduces the potential for leaks, spills, and emergency situations to impact on the environment to as low as reasonably practicable	Potential to impact terrestrial and coastal and nearshore environmental factors as described in Table A5–1.	Use modelling to predict the geographical extent and magnitude of potential impacts reasonably expected from hydrocarbon spills (for realistic construction and/or operational phase scenarios).	Manage likely impacts through concept selection, engineering design, constructability reviews, and the various EMPs (see Section 6.8) developed for the Foundation Project where relevant and effective. Review the effectiveness of mitigation and management measures, and revise where necessary.

Table A5–3 Preliminary Environmental Analysis Results – Society and Economy

Socio-economic Factor	Relevant Area	Socio-economic Objective	Potential Impacts	Additional Investigations	Potential Management
Public health and safety	Onslow and the Pilbara region	To avoid adverse impacts on the health and/or wellbeing of the public or their access to health care services	Pressure on public health infrastructure in the event of a major industrial accident occurring during the construction and operation of the Fourth Train Proposal. Increased health and safety risk to the public due to vessel interactions. Reduction in environmental health (specifically air quality) reasonably expected from operational air emissions from the Fourth Train Proposal.	Assess impacts on public health reasonably expected from implementation of the Fourth Train Proposal compared to the Foundation Project. Review and incorporate any experience gained from the construction of the Foundation Project. Supplement baseline data available for the Foundation Project with more up-to-date statistics gathered from secondary sources.	Mitigate likely impacts through project execution planning, Chevron Australia's policies and procedures, and compliance with overarching safety legislation. A number of EMPs referenced in Section 6.8 will also contribute towards managing impacts on public health and safety (e.g. Air Quality Management Plan).

Socio-economic Factor	Relevant Area	Socio-economic Objective	Potential Impacts	Additional Investigations	Potential Management
Cultural heritage	Barrow Island and its surrounding waters	To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation	Construction may impact sites of cultural and/or archaeological heritage at sea and on Barrow Island. However, no known sites are expected to be directly affected.	Assess the potential impacts to cultural heritage using baseline information obtained by the Foundation Project and additional secondary data where relevant.	Avoid likely impacts through concept selection. Manage any key residual impacts by applying the same mitigation and management measures as implemented for the Foundation Project where relevant and effective, including the provisions in the Aboriginal Cultural Heritage Management Plan. Review the need to update the spatial coverage of this Plan and draw on any lessons and experience gained from implementation of the Foundation Project.
Conservation areas	Barrow Island, Montebello-Barrow Island Marine Conservation Reserve, the Barrow Island Marine Park, Bandicoot Bay Conservation Area, Muiron Islands Marine Management Area, and Ningaloo Marine Park (and World Heritage Area)	To protect the environmental and heritage values of areas identified as having significant environmental and/or national and World Heritage attributes	Reduction in environmental value in the event of a substantial accidental release of hydrocarbon and/or as a result of operational air emissions.	Assess the change in impact introduced by implementation of the Fourth Train Proposal. Review performance to date of the Foundation Project against the objective for this factor and apply any lessons learnt to the Fourth Train Proposal. Use modelling to predict the dispersion of operational air emissions and the spread of accidental hydrocarbon spills occurring in the marine environment.	Likely impacts will be managed through engineering design to reduce the likelihood of accidents occurring, EMPs (see Section 6.8) emergency response planning, oil spill contingency planning, and implementation of the Terrestrial and Marine Quarantine Management System. Review the effectiveness of mitigation and management measures, and revise where necessary.
Land and sea use	Barrow Island, its coast, and surrounding waters	To avoid adversely interfering with, or compromising, other economic users of the land or marine	Temporary restriction on public use of marine areas due to the establishment of exclusion zones, use of cyclone moorings and vessel movements during the laying of the	Assess the extent to which impacts to other land and sea users may change with the addition of the Fourth Train Proposal. Take into account more	Manage likely impacts through constructability reviews and applying the same mitigation and management measures as approved for the Foundation

Socio-economic Factor	Relevant Area	Socio-economic Objective	Potential Impacts	Additional Investigations	Potential Management
		environment	Feed Gas Pipeline System and its associated HDD activities in nearshore waters, and the approach of LNG and condensate export vessels during operation.	up-to-date baseline information on shipping, fishing, and recreational use of surrounding waters (to the extent it is available from public sources) and any experience gained from the Foundation Project.	Project. This includes application of various EMPs associated with construction (see Section 6.8), where relevant and effective. Review and draw on any lessons and experience gained from implementation of the Foundation Project.
Livelihoods	Onslow and the Pilbara, and Western Australia, as a whole	To deliver employment and skill development opportunities that benefit the local and regional population	Potential benefits associated with labour and service demand during construction and operation.	Assess impacts and benefits of implementing the Fourth Train Proposal. Take into account more up-to-date information on the baseline (using publicly available information) and any experience gained from implementation of the Foundation Project.	Manage likely impacts through project execution planning, contracting, and employment strategies (including, as relevant, the Gorgon Project's Australian Industry Participation Policy and Plan and the Gorgon Project Social Impact Management Plan [Environmental Resources Management (ERM) 2009; under revision]). Review and draw on any lessons learnt and experience gained from implementation of the Foundation Project.
Local communities	Onslow and the Pilbara area	To avoid compromising the social infrastructure, cultural and community structures of the local host community and, where relevant, to share benefits with the community	Change in community structures and culture and competition with the local community for the use of social infrastructure as a result of construction activities being extended on Barrow Island (beyond that of the Foundation Project).	Determine how implementation of the Fourth Train Proposal changes the risk to local communities, compared to that predicted for the Foundation Project. Draw on more up-to-date baseline information and experience gained from the Foundation Project.	Manage likely impacts through project execution planning, stakeholder engagement, and through the Gorgon Project Social Impact Management Plan (ERM 2009; under revision). Review and draw on any lessons learnt and experience gained from implementation of the Foundation Project.
Local and regional economy	Onslow and the Pilbara and Western Australia,	To contribute to the achievement of State and local development	Positive benefits on the local and regional economy due to an extended demand for labour,	Assess how the Fourth Train Proposal changes the impacts and benefits anticipated for the	Manage likely impacts through project execution planning, contracting and employment

Public

Socio-economic Factor	Relevant Area	Socio-economic Objective	Potential Impacts	Additional Investigations	Potential Management
	as a whole	policies and plans with respect to socio-economy so that benefits are brought to the regional and local economy and negative impacts on the economy are avoided or managed	equipment, supplies, and services during construction of the Fourth Train Proposal (i.e. beyond that for the Foundation Project).	Foundation Project. Update baseline data available from the Foundation Project using secondary sources. Where available, use data collected for the Foundation Project to substantiate predictions.	strategies (including as relevant the Gorgon Project's Australian Industry Participation Policy and Plan and the Gorgon Project Social Impact Management Plan [ERM 2009; under revision]). Review and draw on any lessons learnt and experience gained from implementation of the Foundation Project.

Appendix 6 Consideration of Relevant Environmental Principles for the Fourth Train Proposal

Table A6–1 describes how the PER/Draft EIS for the Fourth Train Proposal will consider relevant Environmental Principles as stated in section 4A of the EP Act.

Chevron Australia's commitment to the environmental principles contained in the EP Act are enshrined within the Gorgon Development Sustainability Principles that were developed for the Gorgon Development in the ESE Review (ChevronTexaco Australia 2003). These Sustainability Principles have subsequently been integrated as overarching principles into the Environmental Management System for the Foundation Project, a system which will also be used to manage environmental performance of the Fourth Train Proposal. The Gorgon Gas Development Sustainability Principles are reproduced here in Table A6–2.

At a higher level, Chevron Australia's commitment to sound environmental management in all aspects of its operations is reflected in Chevron Policy 530 – Protecting People and the Environment (see Figure A6–1). Further details on Chevron Australia's environmental management framework was presented in the supporting information to the referral of the Fourth Train Proposal (Chevron Australia 2011c).

Table A6–1 Environmental Principles of Relevance to the Fourth Train Proposal

Principle	Relevant (Yes/No)	If yes, consideration
1. The precautionary principle Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In application of this precautionary principle, decisions should be guided by: • Careful evaluation to avoid, where practicable, serious or irreversible damage to the environment • An assessment of the risk – weighted consequences of various options.	Yes	Chevron Australia has committed to this principle through the Gorgon Development Sustainability Principles (see Table A6–2). This principle will be used as the basis of the environmental risk assessment and mitigation, management and monitoring approach in the PER/Draft EIS. Where uncertainty remains over the consequence or likelihood of an environmental impact occurring as a result of studies undertaken in the PER/Draft EIS, a precautionary approach will be adopted. An example of this is the implementation of the Long-term Marine Turtle Management Plan to address uncertainty over impacts of the Foundation Project to marine turtles nesting on Barrow Island.
2. The principle of intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations.	Yes	This principle is included within the Gorgon Development Sustainability Principles (see Table A6–2) and is reflected in the decisions Chevron Australia will make about the Fourth Train Proposal. Alongside the Precautionary Principle, this principle forms a basis upon which the PER/Draft EIS will be grounded.
3. The principle of conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Yes	This principle is reflected in the Gorgon Development Sustainability Principles (see Table A6–2). The Environmental Objectives established for the assessment of impacts in the PER/Draft EIS (see Appendix 5) also reflect this principle.

Principle	Relevant (Yes/No)	If yes, consideration
4. Principles relating to improved valuation, pricing and incentive mechanisms Environmental factors should be included in the valuation of assets and services. The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance, and abatement. The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of waste. Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structure, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solution and responses to environmental problems.	Yes	The environmental implications, (including their associated costs, where relevant), of Chevron Australia's actions are incorporated into a systematic decision-making process that aims to deliver world-class performance in safety, health, environment, reliability, and efficiency. For example, market prices for environmental implications are taken into account alongside technical, economic, health and safety, operability and reliability criteria when selecting design options and alternatives. Where relevant, the PER/Draft EIS will reference market instruments (e.g. the carbon tax) to support the assessment of impacts.
5. The principle of waste minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	Yes	Chevron Australia's commitment to Environmental Stewardship, embodied in its Policy 530, includes specific reference towards efforts to prevent and reduce waste (see Figure A6–1). The generation and disposal of waste will be included as a stressor and considered in the PER/Draft EIS. This principle will also be reflected in the various EMPs that have been prepared and implemented for the Foundation Project and that will be updated to reflect the Fourth Train Proposal. These include the Solid and Liquid Waste Management Plan and activity-specific EMPs (e.g. the HDD Management and Monitoring Plan etc).

Table A6-2 Gorgon Gas Development Sustainability Principles

Principle	Definition
Clean Energy Supply	The Gorgon Gas Development will meet Western Australian, Australian, and international demands for competitive, clean energy sources. It will also enhance energy competition and security of supply in Australia.
Economic Benefit Delivery	Current and future economic growth in Australia will benefit from the Gorgon Gas Development . It will foster economic growth and business development, generate government revenue, provide commercial returns to the Joint Venturers, and contribute to the wealth generated by Australia's natural resource base.
Biological and Ecological Integrity Protection	The Gorgon Gas Development will not disrupt ecological structure and function, nor will it result in a loss of biological diversity on Barrow Island.
Social Equity and	Communities will benefit from improved quality of life and wellbeing resulting

Principle	Definition
Community Wellbeing Enhancement	from contributions of the Gorgon Gas Development, such as creation of jobs.
Future Generations Commitment	The Gorgon Gas Development will meet the needs of the present generation and assist future generations to meet their needs.
Efficient Resource Use	International best practice and continual improvement principles will be applied to efficiently manage resources and wastes.
Precautionary Principle Application	Where there are threats of serious or irreversible damage, lack of full scientific certainty will not be used as a reason for postponing cost-effective measures to prevent environmental damage.
Community Respect and Safeguards	The Joint Venturers will respect community values, community diversity and safeguard the wellbeing of the public and workforce throughout the life of the Gorgon Gas Development.
Stakeholder Engagement	The Joint Venturers will seek the views of stakeholders and take their interests into account throughout development of the Gorgon gas field.
Accountability	The Joint Venturers are committed to the highest standards of governance and accountability. They will report regularly to the community on the sustainability performance of the Gorgon Gas Development.

Source: Chevron Australia 2005.

ABU

Policy 530 - Operational Excellence
Achieving World-Class Performance

Chevron
Human Energy™

It is the policy of Chevron Corporation to protect the safety and health of people and the environment and to conduct our operations reliably and efficiently. The systematic management of **safety, health, environment, reliability and efficiency** to achieve world-class performance is defined as Operational Excellence (OE). Our commitment to OE is embodied in The Chevron Way value of protecting people and the environment, which places the highest priority on the health and safety of our workforce and protection of our assets and the environment.

We will accomplish this through disciplined application of our Operational Excellence Management System (OEMS). Our OEMS consists of three parts: Leadership Accountability, Management System Process and OE Expectations.

Leadership is the largest single factor for success in OE. Leaders are accountable not only for achieving results, but achieving them in the right way by behaving in accordance with our values. Leaders direct the Management System Process to drive improvement in OE results. The Management System Process consists of five steps:

Vision and Objectives	Developing an OE vision, world-class objectives, metrics and targets based on corporate objectives, benchmarking data and other applicable critical business drivers.
Assessment	Completing a comprehensive evaluation to identify priority areas in OE processes and performance against established objectives.
Planning	Developing three-year plans to manage priorities and incorporating those plans into business plans and assigning accountabilities.
Implementation	Implementing planned actions and monitoring plan progress and OE performance.
Review	Annually evaluating progress on performance and identifying necessary adjustments to plans that result in the goal of achieving world-class results.

We will assess and take steps to manage potential risks to our employees, contractors, the public and the environment within the following framework of OE Expectations:

1. **Security of Personnel and Assets** Providing a secure environment in which business operations may be conducted successfully.
2. **Facilities Design and Construction** Designing and constructing facilities to prevent injury, illness and incidents and to operate reliably, efficiently and in an environmentally sound manner.
3. **Safe Operations** Operating and maintaining facilities in a manner that does not cause injuries, illnesses or incidents.
4. **Management of Change** Managing both permanent and temporary changes to prevent incidents.
5. **Reliability and Efficiency:**
   - Reliability - Operating and maintaining facilities to sustain mechanical integrity and prevent incidents.
   - Efficiency - Maximizing efficiency of operations and conserving natural resources.
6. **Third-Party Services** Systematically addressing and managing contractor conformance to OE through contractual agreements.
7. **Environmental Stewardship** Working to prevent pollution and waste; striving to continually improve environmental performance and limiting impacts from our operations.
8. **Product Stewardship** Managing potential risks of our products throughout the products' life-cycles.
9. **Incident Investigation** Investigating incidents to identify, broadly communicate and correct root causes of incidents to reduce the likelihood of recurrence.
10. **Community Awareness and Outreach** Reaching out to the community and engaging in open dialogue to build trust.
11. **Emergency Management** Having preparedness plans in place to quickly and effectively respond to and recover from any emergency.
12. **Compliance Assurance** Complying and verifying conformance with company policy and all applicable laws and regulations; applying responsible standards where laws and regulations do not exist; enabling employees and contractors to understand their safety, health and environmental responsibilities.
13. **Legislative and Regulatory Advocacy** Working ethically and constructively to influence proposed laws and regulations, and debate on emerging issues.

Roy Krzywosinski, Managing Director
25/02/2008

Figure A6–1 ABU Policy 530 – Operational Excellence

Appendix 7 Pilbara Developments for Pilbara Airshed Modelling

Based on correspondence with the DEC during preparation of this Environmental Scoping Document, atmospheric emissions from the following major industrial sources in the West Pilbara are anticipated to be included in cumulative atmospheric emissions modelling for the Fourth Train Proposal:

Operating Facilities

- Karratha Gas Plant (5 trains)
- Pilbara Iron – Dampier Power Station (120 megawatts [MW])
- Pilbara Iron – Cape Lambert Power Station (105 MW)
- West Pilbara Power Station – Karratha (86 MW)
- Yurralyi Maya Power Station – Karratha (184 MW constructed, with a total of 276 MW approved)

Under Construction

- Gorgon LNG Plant (3 trains)
- Pluto LNG Plant (2 trains)
- Sino Iron (mine and power station of approx 450 MW)
- Devils Creek Domestic Gas Project

Approved

- Sino Iron 14 MTPA Pellet Plant and Direct Reduced Iron (DRI) Plant (approved with mine and power station being constructed but unlikely to be built)
- Balmoral South (up to 600 MW power station, 80 MTPA mine and 14 MTPA Pellet and DRI Plant)
- Burrup Nitrates Pty Ltd – Ammonium Nitrate
- Macedon Domestic Gas plant
- Wheatstone LNG Plant – Onslow (5 trains)

Being Assessed

- Dampier Nitrogen – Ammonium Nitrate
- Mineralogy Pty Ltd's Mineralogy Expansion Project at Cape Preston (power stations and pellet plants)
- Anketell Port (power station and operations)
- Cape Lambert Magnetite project (not submitted as yet)

Not Progressing

- Dampier Urea (no change since 2005)
- Dampier Ammonia.

Appendix C: Key Stakeholder List

Key Stakeholder List

Commonwealth Government

- AusIndustry
- Australian Customs and Border Protection Service
- Australian Maritime Safety Authority
- Australian Quarantine Inspection Service
- Department of the Environment
- Department of Industry
- Key Shadow Ministers and staff
- Minister for Agriculture
- Minister for Education
- Minister for Employment
- Minister for Foreign Affairs
- Minister for Immigration and Border Protection
- Minister for Indigenous Affairs
- Minister for Industry
- Minister for Infrastructure and Regional Development
- Minister for Social Services
- Minister for the Environment
- Minister for Trade and Investment
- National Offshore Petroleum Safety and Environmental Management Authority (formerly National Offshore Petroleum Safety Authority)
- Prime Minister
- Treasurer
- Western Australian Federal Members of Parliament and Senators.

State Government

- Attorney General
- Conservation Commission
- Dampier Port Authority
- Department of Aboriginal Affairs
- Department of Commerce (WorkSafe)
- Department of Environment Regulation
- Department of Fire and Emergency Services
- Department of Fisheries

- Department of Health
- Department of Lands
- Department of Mines and Petroleum
- Department of Parks and Wildlife
- Department of Planning
- Department of Regional Development
- Department of State Development
- Department of Transport
- Environmental Protection Authority (Board and Office of the EPA)
- Key Shadow Ministers
- Mining and Pastoral Members of Parliament
- Minister for Education; Aboriginal Affairs
- Minister for Environment; Heritage
- Minister for Emergency Services
- Minister for Finance; Transport
- Minster for Fisheries
- Minister for Local Government; Community
- Minister for Mines and Petroleum
- Minister for Planning; Culture and the Arts
- Minister for Regional Development; Lands; Minister Assisting the Minister for State Development
- Minister for State Development; Science
- Minister for Training and Workforce Development
- Minister for Transport
- Pilbara Development Commission
- Premier
- Relevant National Party Members of Parliament
- Relevant parliamentary committees
- State Government Gorgon Local Content Steering Committee
- Treasurer
- Western Australia Police.

Local Government

- Shire of Ashburton
- Shire of Roebourne.

Community Groups and eNGOs

- Australian Conservation Foundation (WA)
- Birds Australia (WA)
- Cape Conservation Group
- Care for Hedland Environmental Association
- Conservation Council of Western Australia
- Environmental Weeds Action Network of WA
- Greenpeace
- Humane Society International
- Karratha Community Liaison Group
- Marine and Coastal Communities Network
- Nickol Bay Naturalists' Club
- Onslow Community Reference Group
- Pilbara Wildlife Carers Association
- Recfishwest
- Royal Society of Western Australia
- Waterbird Conservation Group
- Western Australian Naturalists' Club
- Western Australian Speleological Group
- Western Australian Weeds Committee
- Wilderness Society of WA
- Wildflower Society of WA
- World Wildlife Fund.

Indigenous Groups

- Kurama Marthudunera Native Title Claimants
- Thanlanyji Native Title Claimants
- Yabburara/Mardudhunera Native Title Claimants
- Yamatji Marlpa Aboriginal Corporation.

Industry Groups and Representatives

- Australian Fisheries Management Authority
- Australian Mines and Metals Association
- Australian Petroleum Production and Exploration Association
- Chamber of Commerce and Industry Western Australia
- Chamber of Minerals and Energy of Western Australia
- Charter Boat Owners and Operators Association of Western Australia

- Expert Panels (including Marine Turtle Expert Panel and Quarantine Expert Panel)
- Western Australian Fishing Industry Council.

External Stakeholders

- Media.

Appendix D: Technical Studies

Appendix D1: Gorgon Gas Development Fourth Train Proposal Air Quality Assessment

GORGON GAS DEVELOPMENT

FOURTH TRAIN PROPOSAL

AIR QUALITY ASSESSMENT

Prepared for

Chevron Australia

Prepared by

Air Assessments

June 2012
Final

CVX Doc. No.: G4-NT-REP00000005

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Final B	Owen Pitts	29 June 2012		

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Glossary

Term	***Definition***
%	percent
$\mu g/m^3$	micrograms per cubic metre
µm	micro metre
<	less than
>	greater than
^0C	degrees Celsius
AGRU	Acid Gas Recovery Unit
BOG	Boil Off Gas
BoM	Bureau of Meteorology
BRAMMC	Burrup Rock Art Monitoring Management Committee
BTEX	Benzene, toluene, ethyl- benzene and xylenes
BWI	Barrow Island
CO	Carbon monoxide
CO_2	Carbon dioxide
CSIRO	Commonwealth Scientific Industrial Research Organisation
CTM	Chemical Transport Model
DEC	Department of Environment and Conservation
DEP	Department of Environmental Protection
DLN	Dry Low NO_X burner
e.g.	for example
EPA	Environmental Protection Agency
EPP	Environmental Protection Policy
FTP	Fourth Train Proposal
GFP	Gorgon Foundation Project
GJ	Gigajoule
GJ/s	Gigajoules per second
GRS	Generic Reaction Set
GRT	Gross Tonnage
g/s	grams per second
HNO_3	Nitric acid
i.e.	that is
km	kilometre
kW	kilowatt
LAI	Leaf Area Index
LNG	Liquified Natural Gas
m	metre
M	million
m/s	metres per second
m^2	square metres
m^3	cubic metres
m^3/s	cubic metres per second
mg	milligram
MCR	Maximum Continuous Rating
MEG	Mono-ethylene glycol
Mt	million tonnes
Mtpa	million tonnes per annum
MW	Megawatt
Ne	Plume rise enhancement factor (number of effective stacks)

NEPM	National Environmental Protection Measure
No.	Number
NO	Nitric oxide
NH_3	Ammonia gas
NH_4+	Ammonium ion
NO_2	Nitrogen dioxide
NO_3-	Nitrate ion
NO_X	Oxides of nitrogen
NPI	National Pollution Inventory
O_3	Ozone
OLM	Ozone limiting method
PM	Particulate matter (fine dust)
$PM_{2.5}$ and PM_{10}	Particulate matter less than 2.5 or 10 microns, respectively
ppb	Parts per billion
ppmv	Parts per million by volume
PS	Power Station
RTO	Regenerative Thermal Oxidiser
SO_2	sulphur dioxide
TAPM	The Air Pollution Model
TIBL	Thermal Internal Boundary Layer
tpa	tonnes per annum
tph	tonnes per hour
VOC	Volatile Organic Compounds

Executive Summary

Chevron Australia Pty Ltd (Chevron) is constructing a 3 Train (15 Mtpa) LNG facility at Barrow Island off the north west coast of Australia - the Gorgon Gas Development. Associated with the production processes, a range of air emissions including oxides of nitrogen (NO_X), volatile organic compounds (VOCs) including benzene, toluene, ethyl benzene and xylenes (BTEX), and small quantities of sulphur dioxide and airborne particulate matter are emitted.

The initial Gorgon Gas Development was assessed as a 2 Train (10 Mtpa) LNG project in 2005 (Chevron, 2005) with approval given by the Government of Western Australia in September 2007. In September 2008, following studies that recommended an additional 5 Mtpa train was required to improve the project economics and execution, Chevron submitted an impact assessment for a Revised and Expanded Gorgon Proposal. This was approved in August 2009. The initial Gorgon Gas Development and the Revised and Expanded Proposal are collectively termed the "Foundation Project".

Since receiving approval for the Foundation Project, the opportunity for progressing a fourth LNG train was identified after additional hydrocarbon resources in the Greater Gorgon Area were discovered. As part of the environmental assessment, this report assesses the air quality impact of nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), particulate matter below 10 µm (PM_{10}), particulate matter below 2.5 µm ($PM_{2.5}$), ozone and atmospheric acidic deposition. This study does not cover impacts of benzene, toluene or hydrogen sulphide (H_2S), which are to be covered under other studies.

To assess the impacts, two models have been utilised. TAPM, used to predict local impacts on a scale out to 10 km from the plant, with TAPM-CTM used to predict regional scale ozone and NO_2 and to predict acid deposition.

The results from the local TAPM modelling for the LNG plant by itself indicated that:

- The Fourth Train Proposal will result in concentrations of the pollutants assessed to be well below their respective NEPM criteria and only marginally above that from the Foundation Project.
- For the Fourth Train Proposal assuming no RTO for train 4, the maximum concentration predicted from the project at any location is at most 29% of its NEPM criteria, this being for the maximum 1-hour NO_2 concentrations[1].
- For the Fourth Train Proposal assuming an RTO for train 4 (to combust the VOCs including benzene to water vapour and carbon dioxide), the predicted concentrations of all pollutants assessed in this study apart from SO_2 remain the same as for the case without an RTO. The SO_2 concentrations are predicted to increase significantly, but still remain well below the standard at all locations. Maximum 1-hour, 24-hour and annual average SO_2 concentrations are predicted to

[1] Note, impacts from substances such as benzene, toluene and H_2S are assessed in other studies as requiring specialist models.

be at most 37, 20 and 9% of their respective NEPM standards. This occurs because the RTO is the largest source of SO_2 as it oxidizes the H_2S in the AGRU gas stream to SO_2.

- Modelling for the expected worst case emission scenario, a full plant black start, results in only a small increase in the maximum CO, NO_2 and particulate concentrations. The maximum 1-hour NO_2 concentration increases from 29 to 31% of the NEPM standard, whilst the maximum 8-hour CO concentration increases from 0.3 to 0.4% of its NEPM standard. The change is only minor because although the black start flaring is estimated to cause a large emission of NO_X, CO etc, the very large amount of heat released is predicted to result in very large plume rise, such that the plume is not mixed to the ground. Maximum 24-hour particulate concentrations increase from 6 to 9% of the NEPM $PM_{2.5}$ reporting standard, which is again low and in any case occurs on the Plant site itself.

Considering existing sources on Barrow Island along with the Fourth Train Proposal it is predicted that:

- Existing sources are predicted to result in higher concentrations of NO_2, CO and PM than from the Fourth Train Proposal. The existing NO_2 concentrations are relatively high at 54% of the 1-hour and 86% of the annual average NEPM standard, with these occurring immediately adjacent to the Tanker Terminal sources and the Central Power Station. These concentrations remain unchanged with the addition of the Gorgon sources.
- Likewise existing maximum CO concentrations are predicted to be 5.2% of the NEPM standard and are predicted to remain unchanged with the addition of the Gorgon sources; and
- The existing PM concentrations are also predicted to be 65% of the NEPM PM_{10} standard (using the maximum to compare to the goal) and 85% of the NEPM $PM_{2.5}$ annual reporting standard. This is predicted to occur next to the Tanker Terminal diesel generator though the majority of the cumulative concentrations are due to background levels. With the addition of the Gorgon Fourth Train Proposal, the levels are predicted to remain unchanged at 65% of the NEPM PM_{10} standard and increase marginally to 86% of the NEPM $PM_{2.5}$ annual reporting respectively.
- As existing sources of SO_2 are low, cumulative predictions are the same as that predicted from the Gorgon Fourth Train Proposal.

The results from the regional TAPM-CTM modelling indicated that:

- The maximum highest ozone levels from natural sources in the region are predicted to be up to 70 and 88% of the 1-hour and 4-hour NEPM standards. These relatively high levels are due to emissions from bush fires. The second highest 1-hour and 4-hour concentrations which, for natural sources, are more strictly comparable to the NEPM, are predicted at 70% and 86% of the standard. This indicates the significant contribution that fires make to ozone levels in the region.
- With the addition of all existing and proposed anthropogenic sources, including the approved Gorgon Foundation Project, the maximum and second highest 1-hour ozone concentrations anywhere are predicted to increase from 70 to 84% and from 70 to 73% of the NEPM 1-hour

standard. The maximum and second highest 4-hour concentrations however are predicted to remain the same as from "natural" sources only at 88 and 86% of the 4-hour standard.

- For assessing the Fourth Train Proposal routine operation impacts, three options were modelled. These are with the Train 4 AGRU emissions being either vented to air, reinjected or combusted by a RTO.

  For the option of venting to air, the peak 1-hour ozone concentrations are predicted to increase on and near Barrow Island with the maximum 1-hour ozone concentration increasing from 84 to 101 ppb (101% of the NEPM standard). The second highest concentration however, shows no change at 73% of the NEPM 1-hour standard. Without venting (the reinjection or RTO options), the maximum and second highest 1-hour concentrations are predicted to be lower than from the Gorgon Foundation Project at 82 and 69% of the NEPM 1-hour standard. This reduction is considered to occur as the ozone concentrations are primarily dependent on VOC emissions, which are not increased with these two options, with the small increase in NO_X actually acting to reduce the peak ozone levels.

  For the predicted 4-hour ozone concentrations, there is little difference in the maximums predicted between the three options as the highest 4-hour averages are due to other sources such as fires. With venting, the maximum and second highest 4-hour ozone concentrations are 88% and 84% of their respective standards; with re-injection, they are predicted to be 86 and 85% of the standards; and with an RTO, 91 and 84% of the standards.

- To assess the impacts of the Fourth Train proposal non-routine operations, two cases, the "pigging" case in which three AGRUs vent continually and the black start case were assessed. The predicted maximum ozone concentrations anywhere on the model grid from the pigging operations were generally slightly lower than that predicted from the Fourth Train Proposal routine operation with its AGRU venting. On Barrow Island however, the predicted concentrations were typically higher than any of the other cases modelled (excluding the maximum and second highest concentrations at the Chevron Camp). These maximums however, are very unlikely to occur as they would require three AGRUs to be venting at the same time during the worst case dispersive conditions. Predicted concentrations from non routine black starts were very low and as such are not an issue.

- At the mainland sites, there is generally negligible difference for the various Gorgon scenarios modelled indicating little contribution from the Gorgon Project there and that the impacts are generally localised to the Barrow Island region.

The deposition modelling was conducted using TAPM-CTM including all other existing and proposed sources. The results indicate:

- With the Fourth Train AGRU emissions reinjected, the maximum sulphur and nitrogen deposition rates (wet and dry) on Barrow Island would be 0.32 and 0.97 kg/ha/yr. With the Fourth Train AGRU emissions directed to an RTO, the maximum sulphur and nitrogen depositions are 2.4 and 0.97 kg/ha/yr respectively. These predictions are below the adopted WHO guidelines of 4 to 8 kg/ha/year for sulphur and 15 to 20 kg/ha/year for nitrogen deposition.

- At distant areas such as Coral Bay, the deposition rates are much less, well below their respective criteria with total deposition rates for both cases at around 0.29 kg/ha/year of sulphur and 0.93 kg/ha/year of nitrogen.

1 Introduction

1.1 Background

The Gorgon Gas Development is located on Barrow Island, off the North West coast of Western Australia. The initial Gorgon Gas Development was assessed as a two 5 Mtpa train LNG project in 2005 (Chevron, 2005) with approval given by the Government of Western Australia in September 2007. In September 2008, following studies that recommended an additional 5 Mtpa train was required to improve the project economics and execution, Chevron submitted an impact assessment for a Revised and Expanded Gorgon Proposal. This was approved in August 2009. The initial Gorgon Gas Development and the Revised and Expanded Proposal are collectively termed the Foundation Project.

Since receiving approval for the Revised and Expanded Project, the opportunity for progressing a fourth LNG train was identified after additional hydrocarbon resources in the Greater Gorgon Area were discovered. The Fourth Train Proposal (FTP) (also known as the Gorgon Expansion Project) involves the installation of facilities for gathering gas from these new offshore fields in the Greater Gorgon Area, transporting the gathered gas to the front end of the Gas Treatment Plant and processing it through a fourth 5 Mtpa LNG plant on Barrow Island.

To assess the possible impacts due to atmospheric emissions from the four 5 Mtpa LNG Plant, Chevron have requested Air Assessments to undertake an air quality assessment of nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), particulate matter below 10 µm (PM_{10}), particulate matter below 2.5 µm ($PM_{2.5}$), ozone (O_3) and atmospheric acidic deposition. This study does not address impacts on air quality of benzene, toluene, ethyl benzene and xylenes (collectively referred as BTEX) or hydrogen sulphide (H_2S) associated with acid gas venting emissions from the plant, as these are to be covered under other studies.

1.2 Scope of Work

The following previous modelling assessments of the Gorgon Gas Development have been made to date:

- The original 2005 two train assessment which used the model DISPMOD for predicting the local impacts and TAPM (The Air Pollution Model) with the Generic Reaction Set (GRS) mechanism for predicting the regional photochemical smog impacts;
- The 2008 three train assessment which used TAPM to predict local concentrations and TAPM with the GRS scheme for the regional modelling; and
- Modelling in 2010/2011 to further investigate the three train assessment, which used TAPM with the GRS scheme and TAPM-CTM for to predict ozone and NO_2 with specialised models such as Canary to model the heavier than air releases from the Acid Gas Removal Unit (AGRU).

For the Fourth Train Proposal, the following scope of work was undertaken:

- Undertake local modelling (within 10 km of the plant) for NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$ using TAPM. Note, that other pollutants such as BTEX and H_2S are to be addressed in separate studies. The local modelling is to be conducted for a number of routine and non routine scenarios;

- Undertake a regional assessment using TAPM-CTM to predict ozone and NO_2 concentrations. This model was selected as recent studies have shown this to be more accurate than TAPM with the GRS scheme and also as TAPM-CTM enables fire emissions to be included to enable a true cumulative assessment as required by the DEC modelling guidelines (see also **Section 4.5** for more details). For the Fourth Train Proposal, the following was agreed:
  - Develop an emission inventory for the region incorporating the major industrial sources in the Pilbara;
  - Incorporate emissions from bushfires in the region using emission estimates developed by the Commonwealth Scientific Industrial Research organisation (CSIRO); and
  - Undertake regional modelling for the existing sources, the Gorgon Foundation project and a number of Future scenarios.
- Undertake local and regional deposition modelling of sulphur and nitrogen compounds.

2 Atmospheric Emissions

2.1 Introduction

This section provides details on the atmospheric emissions of concern from the proposed LNG plant and other sources in the region. Emissions of concern from the LNG plant and associated facilities and activities are NO_X, SO_2, CO, PM, H_2S and VOC, especially BTEX. Besides the Gorgon Gas Development, other sources that are significant in the region are:

- WA Oil operations on Barrow Island, with the main sources consisting of the power station, pumps, flares and associated shipping;
- Major sources on the mainland such as the Karratha Gas Plant and the Pluto LNG plant near Dampier;
- Power stations in the region such as at Dampier, Karratha, Cape Lambert and Paraburdoo;
- Shipping;
- Emissions from bushfires which can be the dominant source;
- Emissions from domestic sources, small commercial facilities such as from service stations, dry cleaning, evaporative losses from tanks etc which are relatively minor because of the low population of the Pilbara; and
- Emissions from vegetation (terpenes etc) and soils (NO_X).

2.2 Gorgon Gas Development Emissions

2.2.1 Sources

Emission sources from the initial Gorgon Gas Development have been described previously in Chevron (2005) and SKM (2008a). These in summary are:

- The compressor gas turbines on the LNG trains. There are two gas turbine (GT) driven compressors for each train, a mixed refrigerant (MR) compressor and a propane refrigerant (PR) compressor. These GTs are Frame 7 gas turbines fitted with dry low NO_X burners. Emissions of concern are primarily NO_X;
- Power station gas turbines generators (GTG). These are large Frame 9 gas turbines which are fitted with dry low NO_X burners. Emissions of concern are primarily NO_X;
- Heating medium heaters. These are required for start-up of the heating medium system from a black start. It is estimated that this will occur 4 days/year (96 hours). Outside these times they will be on standby with low fuel usage;
- Flares. Under routine operation they will have low gas consumption rates and therefore have low emissions. Under non routine conditions however, large quantities of gas are flared which will result in large quantities of NO_X, CO and VOCs being emitted. The flares include the main plant flares which are ground flares (for the wet and dry gas streams) and boil off gas (BOG) flares which are housed in enclosures;
- AGRU vents. Under normal conditions the AGRU gas stream for trains 1 to 3 will be compressed and reinjected into the Dupuy formation. In the case of failure in the various aspects of the system, up to 20% down time may occur overall from the AGRUs where the AGRU gas is vented directly to atmosphere. This case results in a high pressure, near sonic

release with the major pollutants besides CO_2 being BTEX and H_2S. For the proposed fourth train, either the AGRU acid gas will be continually vented direct to atmosphere or sent to a RTO where the volatile gases and H_2S are oxidised to CO_2, H_2O and SO_2.

- VOC emissions from condensate ship loading. These occur as the VOC-rich vapour in the ships hold headspace is displaced during loading;
- Ship and vehicular combustion sources. Ship emissions have been included, particularly for SO_2, due to the high sulphur fuels that can be used. Note, motor vehicle emissions are neglected as a small source in terms of emissions, though they can result in relatively high ground level concentrations immediately adjacent to highly trafficked roads under stable, light wind conditions; and
- Fugitive dust from motor vehicle traffic, especially on unpaved roads. This source as per the 2005 and 2008 assessments was omitted, even though it is considered to be the largest source of particulate. This source is very difficult to quantify accurately and therefore model, and is therefore considered best addressed through a monitoring and management program.

2.2.2 Emission Scenarios

For the operation of the LNG plant, there are a number of variations in the emissions that can occur. For this modelling assessment, these are simplified into normal/routine operation and a number of the major non-routine operations. In the 2008 assessment, the scenarios considered were the routine case, and three non-routine cases consisting of a cold start up, emergency flaring and CO_2 venting (3 AGRUs venting). Since 2008, Chevron have undertaken an extensive review of these scenarios and developed a revised matrix of these which is listed in **Table 2-1**. Of note is that the non routine cases have been simplified to two non routine scenarios that are considered to give rise to the likely highest emissions. That is, they are likely “worst case” scenarios.

Table 2-1 Gorgon Gas Development Atmospheric Emissions – Scenario Definitions

Scenario Definition	Anticipated Frequency of Operations	Local Modelling Run (2)	Regional Modelling Run (3)
Scenario 1 **Foundation Project - Routine Operations with 1 AGRU Venting** • Three trains operating • All five GE Frame 9 Gas Turbine Generators operating for a 410 MW plant load • All six GE Frame 7 Process Gas Turbines operating • Two heating medium heaters on hot standby • Wet and Dry Gas flares operated on pilot and flare enrichment gas, no non-routine flaring • BOG flares operated on pilot and purge fuel gas only, no non-routine flaring • One AGRU venting; acid gas from two trains injected • Concurrent condensate loading operations	Up to 20% of the Gas Treatment Plant uptime	Local Case 1	Regional Case 2 (1)
Scenario 2a **FTP - Routine Operations and 2 AGRUs Venting** • Four trains operating • All six GE Frame 9 Gas Turbine Generators operating for a 547 MW plant load • All eight GE Frame 7 Process Gas Turbines operating • Two heating medium heaters on hot standby • Wet and Dry Gas flares operated on pilot and flare enrichment gas, no non-routine flaring • BOG flares operated on pilot and purge fuel gas only, no non-routine flaring • Two AGRU venting including the AGRU emissions from Train 4 • Concurrent condensate loading operations	Up to 20% of the Gas Treatment Plant uptime	Local Case 2	Regional Case 3
Scenario 2b **FTP - Routine Operations and 1 AGRU Venting** • As per Scenario 2a but with • One AGRU venting; with AGRU emissions from three trains including Train 4 injected	Up to 20% of the Gas Treatment Plant uptime	The same as Local Case 2	Regional Case 4
Scenario 2c **FTP - Routine Operations and 1 AGRU Venting and 1 AGRU vent gas incinerated in RTO** • As per Scenario 2a but with • One AGRU from trains 1 to 3 venting, with the AGRU emissions from the proposed Train 4 incinerated in an RTO	Up to 20% of the Gas Treatment Plant uptime	Local Case 3	Regional Case 5
Scenario 3 – "Pigging" **FTP - Non-Routine Operations: 3 Trains and 3 AGRUs Venting (during CO_2 Injection Pipeline Pigging Operations)** • Three trains operating with one train in maintenance • Five GE Frame 9 Gas Turbine Generators online (1 GTG shutdown) • Six GE Frame 7 Process Gas Turbines online (2 GTs tripped) • Two heating medium heaters on hot standby • Wet and Dry Gas flares flaring at routine flaring rates • BOG flares operated on pilot and purge fuel gas only, no non-routine flaring • Three AGRUs venting; no acid gas injected • Concurrent condensate loading operations	1 in a 5 year event (CO_2 pipeline pigging operations conducted during a train shutdown for maintenance)	The same as Local Case 1	Regional Case 6 (increase in VOC emissions)
Scenario 4 "Black Start" **FTP - Non-Routine Operations: Full Plant Restart** • First train of the four in start up • One GE Frame 9 Gas Turbine Generator at spinning reserve (40% load, outside DLN regime) • Two GE Frame 9 Gas Turbine Generator at routine conditions • Two Heating Medium Heaters at 100% load conditions • Non-Routine flaring at 490 tonnes/hr • One AGRU venting • Two GE Frame 7 Gas Turbines – operated under low load (outside DLN regime)	1 in a 5 year event (complete plant restart. I.e. black restart due to total loss of power).	Local Case 4	Regional Case 7

Notes:

1) Regional Case 1 is a case that includes background or natural sources only, including emissions from bush fires.

2) Local modelling addresses near-source impacts of NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$.
3) Regional modelling addresses regional scale ozone and NO_2 concentrations arising from NO_X and VOC emissions from the proposal in addition to other regional precursor emissions.

Alongside each scenario in **Table 2-1** is the case number, indicating whether the case is modelled within the local or regional scale modelling.

Further details of the scenarios for plant emissions are presented in the following sections (**Sections 2.2.3** and **2.2.4**). The associated shipping emissions and VOC venting from ship-loading that are also modelled for all scenarios are described later in **Sections 2.3.4** and **2.2.6.**

2.2.3 Routine Emissions (Foundation Project and Fourth Train Proposal) – Scenarios 1, 2a, 2b and 2c

Emissions for modelling the Foundation Project and the Fourth Train Proposal for routine conditions are presented in **Table 2-2** based on the operational details in **Table 2-1**. Scenarios are based on:

- Full load emissions for units operating, except where noted as for the heating medium heaters which are on standby and the flares which are flaring at low routine rates;
- For trains 1 to 3, one AGRU is assumed to be continuously venting to air which is slightly conservative as these will be normally reinjected into the Dupuy formation. The cumulative frequency of the AGRUs being vented to air for the Foundation Project is estimated at up to 20% per annum expressed as a five year rolling average. Note, the scenario when more than one AGRU from the trains 1 to 3 (the Foundation Project) is venting to air is considered as a non-routine case as detailed in **Section 2.2.4**; and
- Three options for the treatment of the AGRU emissions from the Fourth Train Proposal (Scenarios 2a, 2b and 2c). One option (2a) where the Fourth Train AGRU emissions are reinjected, one (2b) where the emissions will be vented continually to air, and one (2c) with the AGRU emissions directed to a RTO to combust the VOCs and H_2S. The choice of AGRU emission options will be finalised before final design and have been requested to be modelled so as to assess their relative impacts.

Besides the listed sources, there are other minor sources which have not been considered. These are the diesel generators which are only required during a black start, with testing of these required for ½ hour each week or a total of 26 hours per year.

Table 2-2 Gorgon Gas Development Stack Emissions Parameters - Routine Operations – Scenarios 1 to 2

Source	Easting GDA94 (m)	Northing GDA94 (m)	Stack Height (m)	Stack Tip Radius (m)			Exit Velocity (m/s)	Exit Temp. (deg C)	NO_X as NO_2 (g/s)	CO (g/s)	NM-VOC (g/s)	PM (g/s)	SO_2 (g/s)	Benzene (g/s)	Toluene (g/s)	Xylene (g/s)	H_2S (g/s)
MR Compressor Gas Turbine Driver				Actual	Ne	Modelled											
1KT-1510	338,552	7,700,584	45	2.26	1.36	2.64	25.8	224	10.72	3.92	0.255	0.556	0.004	0.0015	0.02	0.008	0.0
2KT-1510	338,554	7,700,473	45	2.26	1.36	2.64	25.8	224	10.72	3.92	0.255	0.556	0.004	0.0015	0.02	0.008	0.0
3KT-1510	338,735	7,700,586	45	2.26	1.36	2.64	25.8	224	10.72	3.92	0.255	0.556	0.004	0.0015	0.02	0.008	0.0
4KT-1510 (expansion)	338,647	7,700,116	45	2.26	1.36	2.64	25.8	224	10.72	3.92	0.255	0.556	0.004	0.0015	0.02	0.008	0.0
PR Compressor Gas Turbine Driver																	
1KT-1530	338,735	7,700,476	45	2.26	1.36	2.64	25.8	224	10.72	3.92	0.255	0.556	0.004	0.0015	0.02	0.008	0.0
2KT-1530	338,921	7,700,588	45	2.26	1.36	2.64	25.8	224	10.72	3.92	0.255	0.556	0.004	0.0015	0.02	0.008	0.0
3KT-1530	338,921	7,700,479	45	2.26	1.36	2.64	25.8	224	10.72	3.92	0.255	0.556	0.004	0.0015	0.02	0.008	0.0
4KT-1530 (expansion)	338,647	7,700,020	45	2.26	1.36	2.64	25.8	224	10.72	3.92	0.255	0.556	0.004	0.0015	0.02	0.008	0.0
Power Gas Turbine Generators																	
GT-4001	338,267	7,700,223	45	3.3	1.66	4.25	27.9	550	14.92	5.45	0.355	0.833	0.004	0.0020	0.027	0.011	0.0
GT-4002	338,346	7,700,125	45	3.3	1.66	4.25	27.9	550	14.92	5.45	0.355	0.833	0.004	0.0020	0.027	0.011	0.0
GT-4003	338,270	7,700,131	45	3.3	1.66	4.25	27.9	550	14.92	5.45	0.355	0.833	0.004	0.0020	0.027	0.011	0.0
GT-4004	338,346	7,700,033	45	3.3	1.66	4.25	27.9	550	14.92	5.45	0.355	0.833	0.004	0.0020	0.027	0.011	0.0
GT-4005	338,270	7,700,039	45	3.3	1.66	4.25	27.9	550	14.92	5.45	0.355	0.833	0.004	0.0020	0.027	0.011	0.0
GT-4006 (expansion)	338,346	7,699,941	45	3.3	1.66	4.25	27.9	550	14.92	5.45	0.355	0.833	0.004	0.0020	0.027	0.011	0.0
Heating Medium Heater (F-4101A)	338,035	7,700,189	30.3	1.7	1	1.7	0.15	225	0.08	negl	negl	0.007	negl	negl	0.0004	0.00015	0.0
Heating Medium Heater (F-4101B)	338,035	7,700,164	30.3	1.7	1	1.7	0.15	225	0.08	negl	negl	0.007	negl	negl	0.0004	0.00015	0.0
Wet Gas Flare	337,873	7,701,291	2	NA	1	0.39	20	1000	0.105	0.897	0.0232	negl	negl	negl	negl	negl	negl
Dry Gas Flare	337,591	7,701,574	2	NA	1	1.36	20	1000	1.06	9.07	0.92	negl	0.058	0.0008	0.0004	0.0004	negl
BOG Flare (A-6203A)	339,173	7,700,238	25	NA	1	0.14	20	1000	0.01	0.10	0.0017	negl	negl	negl	negl	negl	negl
BOG Flare (A-6203B)	339,173	7,700,218	25	NA	1	0.14	20	1000	0.01	0.10	0.0017	negl	negl	negl	negl	negl	negl
AGRU vents																	
1V-1102.Venting to Air	338,225	7,700,507	56	0.224	1	0.224	257 (50)	49	0	0	8.1	0	0	25.5	60.2	19.1	8.1
2V-1102. To injection	338,302	7,700,507	56	0.224	1	0.224	NA	NA	0	0	0	0	0	0	0	0	0
3V-1102. To injection	338,379	7,700,507	56	0.224	1	0.224	NA	NA	0	0	0	0	0	0	0	0	0
4V-1102 Venting to Air	338,569	7,700,092	56	0.224	1	0.224	257 (50)	49	0	0	8.1	0	0	25.5	60.2	19.1	8.1
Alternative (4V) routed to RTO	338,565	7,699,960	50	0.75	1	0.75		122 (19)	0.86	3.70	0.008	0.0	15.29	0.02	0.06	0.02	0.008
Total 3 Train Foundation Project									**140.3**	**60.9**	**12.3**	**7.52**	**0.10**	**25.5**	**60.5**	**19.2**	**8.1**
FTP – 4th Train AGRU Injected									**176.7**	**74.2**	**13.2**	**9.47**	**0.11**	**25.5**	**60.5**	**19.2**	**8.1**
FTP – 4th Train AGRU Vented									**176.7**	**74.2**	**21.1**	**9.47**	**0.11**	**51.0**	**120.7**	**38.3**	**16.2**
FTP – 4th Train AGRU to RTO									**177.5**	**77.9**	**13.1**	**9.47**	**15.4**	**25.5**	**60.6**	**19.3**	**8.11**

Notes: Values in brackets used in modelling to account for heavier than air effects (See **Section 4.12**), Ne is the plume rise enhancement factor see (**Section 4.8**).

The emissions presented in **Table 2-2** indicate that the addition of the Fourth Train Proposal will:

- Increase the total NO_X emissions from 140 g/s in the Foundation Project to around 177 g/s for the three options;
- With the re-injection or RTO options for the Fourth Train AGRU emissions, there will be a negligible change to the VOC and H_2S emissions above that from the Foundation Project. With the RTO option, there will, however, be a relatively large increase in the SO_2 emissions from oxidising H_2S to SO_2 (although the SO_2 emissions will still be quite small by industrial standards); and
- The option of venting the AGRU emissions from the Fourth Train will result in an approximate doubling of the VOC emissions as the AGRU is the major VOC source at the LNG plant.

2.2.4 Non Routine Operations

Emissions for two non-routine operations, "pigging" operations of the CO_2 injection pipeline and a complete plant restart (black start) are presented in **Table 2-2** and **Table 2-3**. These are considered to be worst case scenarios.

The pigging emissions have been estimated for the case when the pipeline to the re-injection field is being cleaned (pigging) which could last for up to five days in total. In this case, the three CO_2 injection trains will be shutdown and acid gas will be vented at the AGRU main acid gas vents. It is also assumed that the fourth LNG train and AGRU will be turned off and under maintenance. Emissions of combustion gases during pigging will be lower than with all four LNG trains operating, though VOC emissions will be higher as three AGRUs at full load are being vented directly to air. Flaring emissions during pigging will remain low at the routine rates.

The black start scenario will occur when the whole plant has been offline and requires a full restart. This may occur if a strong cyclone, earthquake, tsunami or any other unplanned event, disrupts the gas supply to the power generation plant and as a result, the LNG plant is shut-down for several days to a week. During a black start, the Plant is started up sequentially with the following main steps undertaken:

1. Start up of two GTGs (required for a single LNG train start-up), one at a time, gradually ramping up each turbine from 0 to greater than 70% load. The fuel gas will be supplied from the feed gas pipelines, which will be shut in and "packed". The first turbine may take up to 8 hours to ramp up from 0 to 50% load where it will be operating outside its DLN regime. The start up time of the second turbine is much shorter (of the order of 0.5 hours) with the GTGs collectively brought online to their normal load over an estimated time period of 24 hours.
2. As soon as the first gas turbine generator is brought online, the start-up of the MEG system will commence and continue for up to 48 hours, until full MEG supply to the wellheads is established and the wells are opened and start producing. Therefore field gas will start flowing through the pipelines again approximately 48 hours after the first GTG was started up.
3. Heating requirements for the MEG system will be provided by the two Heating Medium Heaters. These may operate at rates of up to 100% of their capacity until all four LNG trains have been started up and the waste heat recovery units are all working. Field feed gas will start flowing into the Plant initially at 25% of the normal 4 x Five MTPA Plant throughput rate to allow starting up of the inlet facilities, the first train AGRU and the CO_2 compression and injection system. Approximately 2/3 of this gas will be flared (the rest of the gas will be

processed through the fractionation system to produce propane and mixed refrigerant sufficient to allow start-up of Train 1), and acid gas vented continuously for 24 hours until the CO_2 injection system is stabilised and treated feed gas for the first LNG train is free of acid gas components, water and other contaminants.

4. The LNG gas turbines will be started up simultaneously with the inlet facilities commissioning activities, however they will be run at low loads and therefore have been assumed to work outside their DLN period for the whole 24 period prior to starting up the LNG train. With the flow of gas into the LNG train, they are expected to ramp up to their DLN regime over 8 hours and from then on, operate within that regime.
5. Once there is good quality gas for the first LNG train, gas will be let through the first train, which will reduce flaring rates steeply over the 24-48 hour period required to cool down the train.
6. This start-up sequence is then repeated for each next train, though the flaring rates will never be as high as during the inlet, AGRU and CO_2 Injection systems start-up for the first train. The remaining GTGs and GTs will also be started up sequentially with the start up of trains 2, 3 and 4.
7. Emergency diesel generators are expected to be used prior to starting up the first GTG and not during the black start procedure.
8. This whole black start procedure for the FTP may take up to 8 days.

Based on the above start up sequence, the start up of the first train will result in the largest combustion emissions due to the high flaring and operation of gas turbines outside their DLN mode, both for extended periods of time. In this case, both NO_X and CO emissions are much higher than usual, though BTEX emissions are lower than normal.

Table 2-3 Gorgon Gas Development Stack Emissions Parameters – Pigging Operation – Scenario 3

Source	Easting GDA94 (m)	Northing GDA94 (m)	Stack Height (m)	Stack Tip Radius (m)			Exit Velocity (m/s)	Exit Temp. (deg C)	NO_X as NO_2 (g/s)	CO (g/s)	NM-VOC (g/s)	PM (g/s)	SO_2 (g/s)	Benzene (g/s)	Toluene (g/s)	Xylene (g/s)	H_2S (g/s)
MR Compressor Gas Turbine Driver				Actual	Ne	Modelled											
1KT-1510	338,552	7,700,584	45	2.26	1.36	2.64	25.8	224	10.72	3.92	0.255	0.556	0.004	0.0015	0.02	0.008	0.0
2KT-1510	338,554	7,700,473	45	2.26	1.36	2.64	25.8	224	10.72	3.92	0.255	0.556	0.004	0.0015	0.02	0.008	0.0
3KT-1510	338,735	7,700,586	45	2.26	1.36	2.64	25.8	224	10.72	3.92	0.255	0.556	0.004	0.0015	0.02	0.008	0.0
4KT-1510 (Off line)	338,647	7,700,116	45	2.26	1.36	2.64	25.8	224	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR Compressor Gas Turbine Driver																	
1KT-1530	338,735	7,700,476	45	2.26	1.36	2.64	25.8	224	10.72	3.92	0.255	0.556	0.004	0.0015	0.02	0.008	0.0
2KT-1530	338,921	7,700,588	45	2.26	1.36	2.64	25.8	224	10.72	3.92	0.255	0.556	0.004	0.0015	0.02	0.008	0.0
3KT-1530	338,921	7,700,479	45	2.26	1.36	2.64	25.8	224	10.72	3.92	0.255	0.556	0.004	0.0015	0.02	0.008	0.0
4KT-1530 (Off line)	338,647	7,700,020	45	2.26	1.36	2.64	25.8	224	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Power Gas Turbine Generators																	
GT-4001	338,267	7,700,223	45	3.3	1.66	4.25	27.9	550	14.92	5.45	0.355	0.833	0.004	0.0020	0.027	0.011	0.0
GT-4002	338,346	7,700,125	45	3.3	1.66	4.25	27.9	550	14.92	5.45	0.355	0.833	0.004	0.0020	0.027	0.011	0.0
GT-4003	338,270	7,700,131	45	3.3	1.66	4.25	27.9	550	14.92	5.45	0.355	0.833	0.004	0.0020	0.027	0.011	0.0
GT-4004	338,346	7,700,033	45	3.3	1.66	4.25	27.9	550	14.92	5.45	0.355	0.833	0.004	0.0020	0.027	0.011	0.0
GT-4005	338,270	7,700,039	45	3.3	1.66	4.25	27.9	550	14.92	5.45	0.355	0.833	0.004	0.0020	0.027	0.011	0.0
GT-4006 (Offline)	338,346	7,699,941	45	3.3	1.66	4.25	27.9	550	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heating Medium Heater (F-4101A)	338,035	7,700,189	30.3	1.7	1	1.7	0.15	225	0.08	negl	negl	0.007	negl	negl	0.0004	0.00015	0.0
Heating Medium Heater (F-4101B)	338,035	7,700,164	30.3	1.7	1	1.7	0.15	225	0.08	negl	negl	0.007	negl	negl	0.0004	0.00015	0.0
Wet Gas Flare	337,873	7,701,291	2	NA	1	0.39	20	1000	0.105	0.897	0.0232	negl	negl	negl	negl	negl	negl
Dry Gas Flare	337,591	7,701,574	2	NA	1	1.36	20	1000	1.06	9.07	0.92	negl	0.058	0.0008	0.0004	0.0004	negl
BOG Flare (A-6203A)	339,173	7,700,238	25	NA	1	0.14	20	1000	0.01	0.10	0.0017	negl	negl	negl	negl	negl	negl
BOG Flare (A-6203B)	339,173	7,700,218	25	NA	1	0.14	20	1000	0.01	0.10	0.0017	negl	negl	negl	negl	negl	negl
AGRU vents																	
1V-1102 Venting to Air	338,225	7,700,507	56	0.224	1	0.224	257 (50)	49	0	0	8	0	0	25.5	60.2	19.1	8.1
2V-1102 Venting to Air	338,302	7,700,507	56	0.224	1	0.224	257 (50)	49	0	0	8	0	0	25.5	60.2	19.1	8.1
3V-1102 Venting to Air	338,379	7,700,507	56	0.224	1	0.224	257 (50)	49	0	0	8	0	0	25.5	60.2	19.1	8.1
4V-1102 (Off line)	338,569	7,700,092	56	0.224	1	0.224	NA	NA	0	0	0	0	0	0	0	0	0
Total									**140.3**	**60.9**	**28.3**	**7.52**	**0.10**	**76.5**	**180.9**	**57.4**	**24.3**

Notes: Values in brackets used in modelling to account for heavier than air effects (See **Section 4.12**), Ne is the plume rise enhancement factor see (**Section 4.8**). BTEX for GTs and flares which are small are based on NPI emission factors.

Table 2-4 Gorgon Gas Development Stack Emissions Parameters – Black Start – Scenario 4

Source	Easting GDA94 (m)	Northing GDA94 (m)	Stack Height (m)	Stack Tip Radius (m)			Exit Velocity (m/s)	Exit Temp. (deg C)	NO_X (g/s)	CO (g/s)	NM-VOC (g/s)	PM (g/s)	SO_2 (g/s)	Benzene (g/s)	Toluene (g/s)	Xylene (g/s)	H_2S (g/s)
MR Compressor Gas Turbine Driver				Actual	Ne	Modelled											
1KT-1510) Outside DLN	338,552	7,700,584	45	2.26	1.35	2.63	21.9	224	30.6	3.33	0.22	0.47	0.003	0.0013	0.017	0.007	0.0
2KT-1510) (offline)	338,554	7,700,473	45	2.26	1	2.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	00	0.0	0.0
3KT-1510) (offline)	338,735	7,700,586	45	2.26	1	2.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	00	0.0	0.0
4KT-1510) (offline)	338,647	7,700,116	45	2.26	1	2.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	00	0.0
PR Compressor Gas Turbine Driver																	
1KT-1530) Outside DLN	338,735	7,700,476	45	2.26	1.35	2.63	21.9	224	30.6	3.33	0.22	0.47	0.003	0.0013	0.017	0.007	0.0
2KT-1530) (offline)	338,921	7,700,588	45	2.26	1	2.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	00	0.0
3KT-1530) (offline)	338,921	7,700,479	45	2.26	1	2.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	00	0.0
4KT-1530) (offline)	338,647	7,700,020	45	2.26	1	2.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	00	0.0
Power Gas Turbine Generators																	
GT-4001 (Normal)	338,267	7,700,223	45	3.3	1.66	4.25	27.9	550	14.92	5.45	0.355	0.833	0.004	0.0020	0.027	0.011	0.0
GT-4002 (Normal)	338,346	7,700,125	45	3.3	1.66	4.25	27.9	550	14.92	5.45	0.355	0.833	0.004	0.0020	0.027	0.011	0.0
GT-4003 (Outside DLN)	338,270	7,700,131	45	3.3	1	3.3	23.7	550	42.6	4.63	0.30	0.76	0.0035	0.0017	0.023	0.0093	0.0
GT-4004 (offline)	338,346	7,700,033	45	3.3	1	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	00	0.0
GT-4005 (offline)	338,270	7,700,039	45	3.3	1	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	00	0.0
GT-4006 (offline)	338,346	7,699,941	45	3.3	1	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	00	0.0
Heating Medium Heater (F-4101A)	338,035	7,700,189	30.3	1.7	1.65	2.19	7.15	335	4.12	negl	0.239	0.33	0.204	0.0014	0.018	0.0074	0.0
Heating Medium Heater (F-4101B)	338,035	7,700,164	30.3	1.7	1.65	2.19	7.15	335	4.12	negl	0.239	0.33	0.204	0.0014	0.018	0.0074	0.0
Wet Gas Flare – Non Routine	337,873	7,701,291	2	NA	1	9.06	20	1000	409	817	175	negl	12	negl	negl	negl	0.13
Dry Gas Flare –Routine	337,591	7,701,574	2	NA	1	1.36	20	1000	1.06	9.07	0.92	negl	0.058	negl	negl	negl	negl
BOG Flare (A-6203A)	339,173	7,700,238	25	NA	1	3.04	20	1000	9.17	18.3	5.62	negl	0.0016	negl	negl	negl	negl
BOG Flare (A-6203B)	339,173	7,700,218	25	NA	1	3.04	20	1000	9.17	18.3	5.62	negl	0.0016	negl	negl	negl	negl
AGRU vents																	
1V-1102 Venting to Air Start up	338,225	7,700,507	56	0.224	1	0.224	76 (15)	49	0	0	2.4	0	0	7.6	17.8	5.7	2.4
2V-1102	338,302	7,700,507	56	0.224	1	0.224	0	0	0	0	0	0	0	0	0	0	0
3V-1102	338,379	7,700,507	56	0.224	1	0.224	0	0	0	0	0	0	0	0	0	0	0
4V-1102	338,569	7,700,092	56	0.224	1	0.224	0	0	0	0	0	0	0	0	0	0	0
Total									**570**	**885**	**191**	**4.02**	**12.5**	**7.61**	**17.9**	**5.76**	**2.53**

Notes: Values in brackets used in modelling to account for heavier than air effects (See **Section 4.12**), Ne is the plume rise enhancement factor see (**Section 4.8**). BTEX for GTs and flares which are small are based on NPI emission factors.

2.2.5 Changes in Emissions to that Modelled in Previous Assessments

The emissions presented in **Table 2-2** associated with Train 4 operations are based on a very preliminary design regarding the number and size of equipment items, as well as the design options presented (e.g. acid gas disposal options). This design may change as the Expansion Project improves its project and design definition. For comparison to the previous assessments, the following changes are noted that will impact on the predicted air quality:

- The Foundation Project gas turbine and compressor stacks heights have been increased from 40 m to 45 m. This will aid in dispersion and reduce the ground level concentrations;
- The positions of the wet and dry flares have been shifted to the north of the plant area providing a greater separation between the flares and the plant. This will aid in dilution as not all emissions occur from the one area; and
- Slight revision in the estimates of NO_X emissions from the gas turbines.

2.2.6 Condensate Ship-loading Emissions

During loading of the third party condensate carriers with condensate, the VOC rich vapour within the ship's hold is displaced and is released to air through a mast riser situated at least 6 m above the ship's deck or by a pressure release valve that ensures an exit velocity of at least 30 m/s. The VOC emissions from the Gorgon Gas Development were estimated in detail using the model HYSYS to produce a dynamic prediction of VOC emissions. This was undertaken as it is considered that standard NPI emission methods are very simplistic and considerably understate the emissions for these more volatile products and higher ambient temperatures. The emissions from ships for the Gorgon Gas Development as well as from the other LNG plants are listed in **Table 2-5**.

Table 2-5 Estimates of VOC Emissions (g/s) from Ship Loading

	Units	Gorgon	Wheatstone	WA Oil BWI Operations	Karratha Gas Plant	Pluto
Size		15 and 20 Mtpa LNG	25 Mtpa LNG	Oil	16.3 Mtpa LNG	2 trains 11.9 Mtpa LNG
Emissions per loading	(kg VOC Per tonne Condensate)	1.32	1.32	0.165	NK	NK
Loading Operations	Frequency	One every 19 (or 14) days (2 per month)	3 per month	Eight per year (1 per month)	Once every 5.6 days (6 per month)	Once every 24 days (2 per month)
Loading Rate	(m^3/hr)	5000	-	2000	-	-
Time of loading	(hours)	25	-	20	-	-
NMVOC	(g/s)	1200	Estimated based on Gorgon values	77	300	300
Benzene	(g/s)	26.6		1.6	2.4	2.4
Toluene	(g/s)	18.2		1.0	3.2	3.2
Xylenes	(g/s)	6.6		0.3	0.44	0.44
Ethyl benzene	(g/s)	0.8		0.04	Negl	Negl

Notes:
1) NK- Not Known.
2) The Gorgon Gas Development emissions are based on the model HYSYS.
3) Loading rates assumed are 5000m^3/hr for Gorgon and 2000m^3/hr for WA Oil.

4) Woodside emission are as estimated by Woodside (Woodside, 2011) excepting for Paraffins which was selected to be more consistent with the BTEX paraffin ratios as determined from HYSYS.
5) WA Oil crude oil VOC emissions based on AP-42 method as it was deemed to be more appropriate for crude oil.

Condensate emissions rates for the other Pilbara projects were estimated from:

- Wheatstone LNG. As condensate ship-loading emissions estimates were not available, these have been estimated based on the Gorgon Gas Development emissions; and
- Karratha Gas Plant and Pluto emissions based on estimates provided by Woodside.

To simplify the modelling, the condensate loading emissions were assumed to occur for a 24 hour period (midnight to midnight) at the frequency determined by the number of ships required per year in **Table 2-5**. As regional modelling using TAPM-CTM is run on monthly files (see **Section 4.6**), each month was assumed to have 2, 3, 5 and 2 condensate ships for the Gorgon, Wheatstone, Karratha Gas Plant and Pluto LNG plants respectively. These were assumed to occur on set days for each month.

Note, the emissions from ship-loading of oil tankers from offshore facilities (Cossack Pioneer etc, see **Section 2.3**), have been based on the data supplied in their NPI reporting. However based on the comparison between HYSYS and the NPI techniques for condensate, these emissions may be understated.

2.3 Other Anthropogenic Sources in the Region

2.3.1 WA Oil Barrow Island sources

The major existing stationary combustion sources on Barrow Island as at 2011 are listed below.

Central Power Station (CPS)
This consists of the following:

- Gas turbine (GT4) with a nominal capacity of 3 MW at maximum temperature conditions (or 4 MW at ISO conditions, 15 degrees Celsius). This gas turbine is in continuous use;
- Two 2 MW gas turbines, with one on stand by (GT1);
- Five 0.9 MW Caterpillar gas fired reciprocating engines, though generally at most two used at any one time;
- One diesel generator (Cummins) for backup use when gas supplies are not available; and
- One black-start diesel generator which is used very infrequently.

Tanker Terminal Area

- The tanker terminal pump, used to pump condensate from the storage tanks to ships. This consists of two nominal 1.24 MW (at 1000 rpm) gas fired reciprocating engines. These are used around 7 times a year for about 20 hours continuously at a power demand of about 0.615 MW each; and
- The tanker terminal diesel generator, which is a small 0.2 MW diesel fired reciprocating engine that is used continuously at near full load.

Campsite

- One MTU (1 MW) distillate fired reciprocating engine. This is only used infrequently, less than 4 days a year when GT4 is not operational.

Isolated Locations

- Four waterflood motors located around the island for use in gas lift production. These are Ingersoll-Rand 0.73 MW KVGR-48 gas engines. WA Oil have advised that these are going to be replaced with electrically driven units; and
- Two ground pit flares for flaring excess gas.

For the cumulative air quality assessment of the Fourth Train proposal, “existing” sources are required that will be operational when the Gorgon Project operates. Therefore, sources that are temporary, such as those associated with the construction of the Gorgon Project, the Bridging Power Station (BPS) and the Temporary Power Station (TPS) are excluded. Likewise for the WA Oil operations, sources that are being decommissioned, such as the gas lift pumps and waterflood motors should also not be included.

Of the existing sources, the CPS current installed generation capacity greatly exceeds the maximum demand, with redundancy in units and fuel supplies. Data from WA Oil shows that for the period 9 Jan 2011 to 9 Jan 2012 that the median demand was 4.665 MW, with a 90% demand of 4.912 MW and maximum demand of 5.184 MW. This demand is typically met by GT 4 and two caterpillar gas engines alone. Data for this period showed that GT4 and two gas engines were used for 93% of the time with GT4 and one or zero gas engines for 2.4% of the time. When gas supplies are not available a combination of GT1, the MTU and sometimes the Cummins using diesel fuel are used to generate the load (4.6% of the time). Therefore for the modelling assessment of the future existing sources, GT4 and two Caterpillar engines at reasonably high load were used as well as the two sources at the tanker terminal area and the two ground flares.

A summary of the WA Oil emission sources modelled is presented in **Table 2-6**. These have been estimated based on the above availability for the future, the instrument specifications where available and NPI emission factors where not available. It is noted that there is some uncertainty in the emissions as they are based typically on generic factors, and the emission factors for gas fired equipment based on usage of standard gas, though the WA Oil gas has a higher energy content.

Table 2-6 Summary of WA Oil Emissions for the "Existing" Case

Source	Easting (m)	Northing (m)	Release Height (m)	Exit Temp (deg C)	Internal Diameter (m)	Exit Velocity (m/s)	NO_X (g/s)	CO (g/s)	SO_2 (g/s)	PM (g/s)
Central Power Station										
0.9MW gas engine (90% load)	332,338	7,697,305	3.3	450	0.35	22.6	1.14	1.11	negl	negl
0.9MW gas engine (90% load)	332,338	7,697,300	3.3	450	0.35	22.6	1.14	1.11	negl	negl
Gas Turbine 4 (full load)	332,297	7,697,293	8.0	445	1.14	38.2	2.13	0.55	negl	0.013
Tanker Terminal Area										
Tanker Terminal Pump East	339,967	7,701,540	8.0	468	0.30	30.1	1.95	7.33	negl	0.007
Tanker Terminal Pump West	339,961	7,701,550	8.0	468	0.30	30.1	1.95	7.33	negl	0.007
Tanker Terminal Diesel Generator (0.2 MW)	339,795	7701589	3.0	565	0.2	23.3 (1)	0.96	0.25	negl	0.08
Flare Pits										
CPF	332,874	7,701,038	2	1000(2)	0.746(2)	20(2)	0.18	0.349	negl	negl
J station Flare	331,909	7,696,971	2	1000(2)	2.58(2)	20(2)	2.10	4.18	negl	negl
Total							11.6	22.2	negl	0.107

Notes:
1) Horizontal exhaust
2) Emission parameters based on assuming an equivalent stack based on the method of TCEQ

Table 2-6 indicates that the total emissions are up to 11.6 g/s of NO_X, 22.2 g/s CO, neglible amounts of SO_2 and 0.107 g/s of PM with the tanker terminal pumps operating.

2.3.2 Other Regional Industrial Sources in 2011

A summary of existing industrial emissions in the region is summarised in **Table 2-7**.

Table 2-7 Summary of Major Anthropogenic Sources (g/s) of Atmospheric Emissions in the Modelling Region

Source	Reference	NO_X	CO	SO_2	PM	Benzene	Xylenes	Toluene
Existing								
Karratha Gas Plant	SKM (2006) and this Study	412	147	2.3	21.4	6.3	4.3	9.4
Dampier PS	This Study	19	5	0.1	0.5	0.0	0.0	0.0
Cape Lambert PS	This Study	10	2	0.0	0.4	0.0	0.0	0.0
Burrup Fertilisers	This Study	8	20	0.4	0.3	0.0	0.0	0.0
Yurralyi Maya PS	SKM (2008b)	30	18	1.3	1.4	0.0	0.0	0.1
West Pilbara PS – Karratha	PAE (2008)	10	6	0.4	0.7	0.0	0.0	0.0
Other small operations in Cape Lambert Dampier area	NPI	6	2	0.1	0.0	0.0	0.0	0.0
WA Oil - Barrow Island	This Study	12	22	0.0	0.1	0.0	0.0	0.0
Other Over-water Sources	NPI	208	170	17.8	6.4	0.3	0.9	2.2
Other Overland Sources	NPI	961	370	9.0	39.8	2.4	2.4	2.1
Total	NPI	**1676**	**762**	**31.4**	**71**	**9.0**	**7.6**	**13.8**
Existing Sources but at 2020 Estimates								
Pilbara Towns	This study	77	449	1.9	7.0	2.5	7.9	9.0
Shipping - Ports and Channels	This study	176	22	94.8	16.8	0.9	0.2	0.2
Condensate Ship Loading	This study	0	0	0.0	0.0	5.4	1.2	3.9
Total		**253**	**471**	**96.7**	**23.8**	**8.8**	**9.3**	**13.1**
Future Industry								
Gorgon LNG (4 Train) with RTO	This Study	178	78	15.4	9.5	25.5	19.3	60.5
Pluto LNG (2 Train)	This Study	89	138	9.7	3.4	0.42	0.02	0.02
Wheatstone LNG (5 Train)	SKM (2010)	224	82	3.8	11.6	0.0	0.2	0.4
Sino Iron Project PS	AA (2008)	38	46	2.2	0.0	0.0	0.0	0.1
Sino Iron Project approved Pellet Plants	AA (2008)	283	192	45.2	57.5	0.0	0.2	0.5
Balmoral South PS and Pellet Plants	AA (2008)	307	196	48.4	54.0	0.0	0.2	0.6
Devils Creek Gas Project	SKM (2008c)	5	2	11.0	0.0	0.0	0.0	0.0
Anketell Point PS	ENVIRON (2010)	98	24	14.1	0.0	0.0	0.0	0.0
Macedon Domestic Gas	GHD (2010a)	47	10	0.0	0.0	0.0	0.2	0.6
Dampier Nitrogen	GHD (2010b)	15	2	0.1	0.6	0.0	0.0	0.0
Burrup Nitrates - (TANPF)	BNPL (2010)	4	1	0.0	1.6	0.0	0.0	0.0
Sino Iron Project- Mine Vehicles	AA (2008)	40	17	1.0	2.3	0.1	0.1	0.1
Balmoral South - Mine Vehicles	AA (2008)	79	34	2.0	4.7	0.2	0.2	0.1
Cape Lambert Port B - Mine Vehicles	This Study	3	1	0.0	0.2	0.0	0.0	0.0
Anketell Port – Vehicles	This Study	3	1	0.0	0.2	0.0	0.0	0.0
Future total (g/s)		**1413**	**824**	**153**	**146**	**26**	**20.4**	**62.3**
Total (g/s)		**3,342**	**2,057**	**281**	**241**	**44**	**37**	**89**
Total (tpa)		**105,340**	**64,870**	**8,865**	**7,594**	**1,381**	**1,176**	**2,813**

Notes:

1) NPI refers to data obtained from the NPI website.
2) PM refers to combustion particulate only and neglects particulate from crustal sources.
3) Condensate ship-loading includes that from Karratha Gas Plant, Gorgon, Wheatstone, and Pluto LNG plants and also includes WA Oil BWI Operations. Therefore the plant emissions for these facilities exclude this.

The emissions in **Table 2-7** have been obtained from the referenced sources in the second column, with the following specific comments made:

- Karratha Gas Plant with 5 LNG trains. The emission parameters were based on the emission estimates provided in the 2006 Pluto modelling assessment (SKM, 2006). Emissions of CO, PM and VOC species such as formaldehyde that were not provided were filled in based on NPI emission factors for gas turbines and flares. BTEX emissions from the AGRUs were based on the NPI emission estimates for 2009/2010 and added to the KT1430 vent emissions based on the percentage of Rsmog values from these sources in SKM (2006). The SO_2 emissions in SKM (2006) were reduced by a factor of 5 to be consistent with the latest NPI figures as it is understood that the earlier SO_2 emissions were overstated. Emissions from fugitive sources (primarily seals) were taken from the NPI reporting for fugitive (non point sources) and assigned a near surface source as per SKM (2006). The resultant emissions were compared to the latest reported NPI emissions and found to be consistent;
- Dampier Power Station. This consists of four 30 MW gas fired boilers with emissions released via two 52 m stacks. This power station is being phased out and will be decommissioned and replaced by the Yurallayi Maya power station;
- Emissions from Cape Lambert power station consisting of three 35MW boilers though with emissions from only two boilers as per normal/routine operation;
- Yurallayi Maya Power station, near the Dampier Salt facilities, with four open cycle 46 MW LM6000 gas turbines constructed with another two units approved. For modelling, the six units with total power generation of 276 MW was modelled;
- West Pilbara Power Station with two 46MW open cycle gas turbines near the Karratha light industrial area;
- Emissions from Burrup Fertilisers Pty Ltd (BFPL) ammonia plant were as supplied in the BFPL environmental assessment (EPA, 2001), though with revised emissions as per their licence (DEC, 2010). Importantly, the NO_X emissions have been reduced as BFPL have adopted low NO_X burners for the boilers subsequent to the air quality modelling. Therefore, the emissions are lower than have been used in previous modelling assessments which were based on the original 2003 approval application;
- EDL Maitland LNG plant. This is a small domestic LNG production facility that produces LNG for road shipment to sites in the Pilbara and Kimberley. This facility has three small Solar Centaur gas turbines for generating power. Emissions were sourced from the NPI with emission parameters sourced from Solar Centaur specifications;
- Data from NPI sources were obtained from the 2008/2009 emissions that was the most current at the time. Major land based sources are:
  - Telfer mine with 138 MW power station with three 47MW GE LM6000 open cycle gas turbines;
  - Cloud Break mine with 32 MW distillate fired reciprocating engines of 2MW each; and
  - Power stations at Port Hedland and Broome;
- Major over-water sources are the:
  - Floating Production Storage and Offloading (FPSO) facilities such as the Cossack Pioneer FPSO, Griffin Venture FPSO and Maersk Mgujima-Yin FPSO;
  - Oil/gas rigs such as Goodwyn Alpha and North Rankin Alpha; and
  - Island oil and gas facilities such as Varanus and Thevenard Islands.

2.3.3 Approved, Under Construction and Under Assessment Emissions

Emissions for sources approved, under construction or under assessment are summarised in **Table 2-7**. Emissions for the sources were developed from the relevant public assessment reports, such as the:

- Pluto LNG Project with 2 trains (SKM, 2006). Emissions of CO and VOC that were not provided were filled in based on NPI emission factors for gas turbines and flares;
- Wheatstone LNG project with data from SKM (2010), but with condensate shipping assumed to be equal to that for the Gorgon Gas Development plant operations, as these were not provided in SKM (2010); and
- Sino Iron project (stage 1) and Balmoral South operations with Pellet Plants and power stations. Note that stages 3, 4 and 5 with further mines and further Pellet Plants have not been included in this modelling as the Pellet plants with total production of 28 Mtpa pellets are considered very unlikely to proceed.

2.3.4 Ship Emissions

Ship engine emissions for the study have been estimated for the major ports and shipping channels in the region. These were estimated by scaling based on the relative ship numbers from a comprehensive emission estimate study for the port of Dampier.

2.3.4.1 Typical Ship Emission Parameters

Typical emission parameters for different ship "classes" in the region are summarised in **Table 2-8**.

Table 2-8 Estimated Emission Parameters from Various Ship "Classes" Used

Vessel	Engine Type [3]	Engine Size (MW)	Engine Load (MW)	Exhaust Diam. (m)	Height (m)	Exit Temp (deg C)	Exhaust Velocity (m/s)	PM (g/s)	VOC (g/s)	NO_X (g/s)	CO (g/s)	SO_2 (g/s)
Main engines												
LNG – Boiler	Boiler	25	12.5	1.8	35	150	9.4	0.13	0.10	4.9	1.8	0.03
LPG and Condensate	SS	12	6	1.5	35	400	13.3	2.5	0.54	28.6	2.4	19.3
Iron Ore	SS	15	8.25	1.5	35	400	15.8	3.44	0.64	40.1	3.2	26.0
Salt and Petroleum	SS	8	4.4	(4)	35	400	(4)	1.83	0.34	21.4	1.6	13.9
Gen Cargo (11,000 GRT)	SS	6	3.3	(4)	35	400	(4)	1.38	0.26	16.0	1.2	10.4
2000 GTn vessel	MS	4	2.2	0.8	35	400	22.3	0.92	0.34	7.4	0.1	0.14
900 GTn Vessel	MS	2.5	1.375	0.5	35	400	27.3	0.51	0.24	4.3	0.07	0.002
Tugs	MS	3.5	2.5 [1]	0.7	10	400	25.4	0.42	0.20	3.0	0.06	0.001
Auxiliary Engines												
LNG – Boiler	Boiler	-	2.5	0.8	35	150	9.5	0.03	0.02	1.0	0.37	0.006
>5000 GTn	MS	-	0.6	0.5	35	400	11.9	0.25	0.11	1.85	0.33	1.97
(1500-5000 GTn)	MS	-	0.15	0.3	35	400	8.3	0.20	0.11	1.15	0.33	1.57
(300 – 1500 GTn)	MS	-	0.075	0.25	35	400	6.6	0.03	0.05	0.52	0.16	0.01
<300 GTn anchorage	MS	-	0.03	0.15	10	400	6.6	0.01	0.01	0.24	0.16	0.0001

Notes:

1) The emission parameters are hourly averages except for the exhaust velocities of the tugs which is the value when they are operating at 2.5 MW.
2) SS is slow speed and MS medium speed reciprocating engines. For medium speeds engines two engines were assumed, so the engine size given is the total of the two.
3) All exhaust temperatures assumed to be 400 deg C except for LNG boilers.
4) Assumed as per iron ore ships to simplify number of ships being modelled, though diameter and velocity should be smaller for the smaller engine size.
5) GTn is gross tonnage. Gross Tonnage represents the internal volume of a vessel, and is the volume of all the ship's enclosed spaces (from keel to funnel) measured to the outside of the hull framing.

These are based on data from shipping at Dampier and the following assumptions:

- Emissions from all vessels greater than 5000 Gross Tonnage (GRT) were based on the NPI EET methodology (Environment Australia, 1999) assuming slow speed reciprocating engines using heavy fuel oil (HFO);
- Emissions for the ships "steaming" were determined by estimating the time per trip in shipping channels divided by the average speed. The length of travel from near the large ship anchorage points where pilots are picked up (west of Legendre Island) to the berth locations varied from 12.2 to 16.6 nautical miles to the LNG berths or to Dampier Salt. Travel speeds were estimated to be on average 9.8 knots based on data from Dampier Port Authority pilots (DPA, 2010). The lower travel speed of 7 to 8 knots as provided to and used in SKM (2003a) is only for the last 3 nautical miles before berth (where the tugs come along side) and for about 3 nautical miles near the pilot pick up at the top of the channel. For the majority of the channel (about 10 nautical miles) the ships speeds are at about 12 knots, or near cruising speed for the bulk carriers. The

average speed of 9.8 knots therefore is considered to equate to the average power demand of 55% of maximum continuous rating (MCR) of the engine;

- Typical main engine sizes as listed in **Table 2-8** are taken from the average of the data in Appendix B of SKM (2003a);
- Emissions from LNG carriers were assumed to have a main "engine" size of 25 MW with this power produced using gas fired boilers to drive steam turbines using 100% of the boil off gas from the LNG tanks as the fuel. At berth the electricity demand was taken as 3 MW which is considerably more than the default NPI Emission Estimation Technique (EET) (Environment Australia, 1999) value of 600kW for auxiliary engines in port as LNG carriers have a much larger power demand than many other ship types ;
- The sulphur content of fuel used for vessels was taken as:
    - Greater than 10,000 GRT taken as per the NPI with a sulphur content of 2.7%;
    - From 5,000 to 10,000 GRT as per the NPI manual with sulphur content of 0.5% (5000 ppm). This assumes some mixture of fuel sourced locally and from marine fuel oil sourced overseas;
    - From 1,500 to 5,000 GRT. Assumed as 500 ppm. This assumes that the majority of the ships use fuel from local sources with sulphur content of 10 ppm, but with some of these vessels travelling from other countries; and
    - Vessels less than 1500 GRT vessels were taken as 10 ppm assuming all fuel is sourced locally;
- The speciation of VOC for all shipping and tug operations was as per the heavy vehicle exhaust (DECC, NSW, 2008);
- Exhaust volumes from the condensate ship and tug engines were estimated from the power generated in MW multiplied by 5.7 to convert to exhaust flow wet at 0 deg C and 1 atmosphere (Cooper, 2000), with the temperature assumed from typical engines. Exhaust volume for the LNG ships were taken as 1.25 times the power generated as derived for the LNG boilers (Woodside, 2010); and
- Auxiliary engines were taken to operate at all times, except for vessels less than 300 GRT when berthed, as per SKM (2003a).

2.3.4.2 Dampier Port Estimates

Ship emission estimates for the port of Dampier as at 2009 and with the addition of a two train Pluto development are summarised in **Table 2-9**. These are based on:

- Vessel numbers, berthing times and anchorage times in **Table 2-9** as supplied primarily from Dampier Port Authority shipping movement data;
- The tugs operate from the south side of East Intercourse Island to service the Pilbara Iron and Dampier Salt shipping requirements and from King Bay for Woodside for the Dampier Port Authority wharves. Tugs were assumed to operate for all ships greater than 5,000 gross tonnage. Smaller ships as primarily ocean going tugs and service vessels can berth themselves. For the iron ore, LNG, and LPG condensate ship arrivals and departures, three tugs were assumed to operate, whilst for Dampier Port Authority jetties and Dampier Salt berthing, two tugs were assumed. On each berthing or departure, tugs were assumed to operate for 1 hour

guiding the ship in and out of the berths, with the tugs assumed "working" with a power output at 2500 kW for 24 minutes in the hour such that average hourly power output was 1000 kW.

Table 2-9 Estimated Shipping at the Port of Dampier

Berth	Number of Vessels	Average Gross Tonnage of Vessels in 2009 (tonnes)	Average Berthing or Anchorage Time (hrs)
Pluto LNG	75	60,000	30
Pluto Condensate	6	49,000	24
Woodside LNG	243	60,000	30
Woodside LPG	28	49,000	24
Woodside Condensate	65	57,000	44
Dampier Port Authority Public			
< 300 GRT	50	220	-
300 - 1500 GRT	103	860	18
1500 - 5000 GRT	213	2,750	32
>5000 GRT	132	11,100	36
Dampier PA Bulk Liquid Berth	28	27,000	36
King Bay and Mermaid Marine			
< 300 GRT	378	225	-
300 - 1500 GRT	879	780	18
1500 - 6550 GRT	925	2,800	32
Parker Point – Service Wharf Petroleum Import	53	29,000	36
Parker Point –Iron Ore	540	86,000	36
East Intercourse Island- Iron Ore	254	91,000	36
Dampier Salt	96	24,000	36
Total Vessels	**4068**	-	-
Anchorage Northern Anchorage	**79**	-	**216**
Anchorage <6000 GRT near King Bay	**1500**	-	**84 to168**

Notes: Based on Dampier Port Authority shipping records for 2009 and including estimates for the Pluto LNG Project (2 trains)

2.3.4.3 Ship Emissions for Other Ports in the Region

Ship emissions for other ports were estimated based on the Dampier port estimates by:

- LNG ships emissions at the five LNG Berths/Ports and in their shipping channels were based on the number of ships expected per year, with one day at port for the LNG and condensate tankers;
- For ships at berth and tug operations at Port Hedland, Cape Lambert, Port Anketell and Cape Preston, which are (or will be) predominantly bulk ore carriers, the emissions were scaled by the 2009 Dampier estimates. Dampier exported 135 Mtpa of bulk commodities in 2009, with estimates for other ports estimated at: Cape Lambert (85Mpta), proposed Cape Lambert Port B (130 Mtpa), Port Hedland with outer harbour expansion (420 Mtpa), Cape Preston (Citic and Balmoral South) (72 Mtpa), and proposed Anketell port (115 Mtpa);
- Emissions from shipping channels at these ports were based on Dampier estimated emissions but scaled by the proportion of tonnage exported and then scaled by the relative length of the

shipping channels. Note, that the emissions from anchorage and movement outside the shipping channel have been neglected in this study, due to lack of data.

The resultant annual ship emissions for the various ports are presented in **Table 2-10**.

Table 2-10 Estimated Annual Shipping Emissions at Port and Shipping Channels

Port or Berth	Export Bulk Solids (Mtpa)	Export LNG (Mtpa)	Export Condensate (Mtpa)	NOx (g/s)	CO (g/s)	SO_2 (g/s)	PM (g/s)	Paraffins (g/s)	Benzene (g/s)
Dampier	135	26	5.0	49.5	7.3	23.2	4.3	0.3	0.3
Cape Lambert (A and B)	215	0	0	28.6	4.2	16.9	2.9	0.3	0.3
Port Hedland	420	0	0	62.9	6.1	37.5	6.2	0.3	0.3
Cape Preston	72	0	0	10.8	1.1	6.4	1.1	0.0	0.0
Port Anketell	115	0	0	15.6	1.6	9.4	1.6	0.1	0.1
Wheatstone (5 trains)	0	25	2.0	4.9	0.8	1.1	0.5	0.0	0.0
Gorgon (4 trains)	0	20	1.2	2.2	0.4	0.0	0.2	0.0	0.0

Notes:

1. Tonnages from bulk solids, iron ore, salt, pellets etc.
2. Port Hedland from 180 Mtpa as indicated by 2010 figures plus 240 Mtpa outer harbour proposal.
3. Dampier based on 2009 data. Dampier emissions above do not include anchorage, whilst **Table 2-7** does.
4. Cape Preston includes the Sino Iron Ore Project (Stage 1) and the Balmoral South Iron Ore Project's iron ore and pellets exports.
5. Other smaller shipping operations such as at FPSOs have been neglected in this study.

2.3.5 Other Anthropogenic Sources

Other anthropogenic sources comprise emissions from small industry that are sub-threshold facilities for NPI reporting, small commercial sources and domestic sources. The DEC 1999 Karratha/Dampier emission inventory included motor vehicles, auto refinishing, cutback bitumen, domestic gas consumption, aircraft, garden maintenance, service station emissions, amongst other sources. Of these, motor vehicles are the major source. For this study, all towns in the Pilbara with a population greater than 200 have been included and scaled up from the Dampier/Karratha 1999 data. Karratha estimates have also been increased to a population of 26,400. These emissions have been estimated on an hourly basis using a typical daily profile, varying from minimal emissions in the early hours of the morning to maximum emissions throughout the day after DEC (2002).

2.4 Vegetation and Soil Emissions

Estimates of VOCs emissions from vegetation and NO_X from soils were determined by TAPM-CTM. These are required as inputs into the regional smog assessment (see **Section 4**).

The vegetation VOC emissions were derived from estimates of VOCs per leaf surface area for grasses and trees multiplied by the leaf area index (LAI), which is the density of vegetation matter per square metre. The VOC emissions for vegetation were parameterised as described in Cope et al. (2009) with a temperature dependence giving increasing emissions at higher temperatures. Estimates of the LAI were provided by a database developed from MODIS satellite data (Hurley, 2008) which provides LAIs on a 4km grid over Australia for each month of the year. The LAIs for the central Pilbara region are low ranging from 0.3 to 0.4 in December to 0.3 to 0.8 in April. For comparison, the estimated LAIs for the central Dampier Peninsula (north of Broome) range from 0.6 in April to 1.6 in November which are 2 to 3 times those for the central Pilbara.

2.5 Emissions from Fires

Emissions of particulate and gaseous emissions from fires used in the regional modelling were estimated by the Centre for Australian Weather & Climate Research using the methods and tools developed by Meyer et al. (2008a). This methodology provides estimates on an hourly basis and on a spatial resolution of 1 km square for Australia. The method utilises satellite data (fire-scar and hotspot data) to estimate the area burned daily. The hourly variation in a day is estimated from a fire danger meter using the meteorological output from TAPM. This results in low emissions for low wind speeds and high humidity (as generally occurs at night) with peak emissions occurring for strong winds and low humidity (as generally occurs during the day). Fuel loads are estimated by the model VAST that uses rainfall, radiation, temperature, soil moisture and vegetation class to determine the biomass or fuel load available. The fire emissions are then estimated from the fuel consumed using emission factors that relate the emission of a substance such as carbon monoxide to the amount of carbon burned.

The land area burned for the Pilbara is shown in **Figure 2-1**.

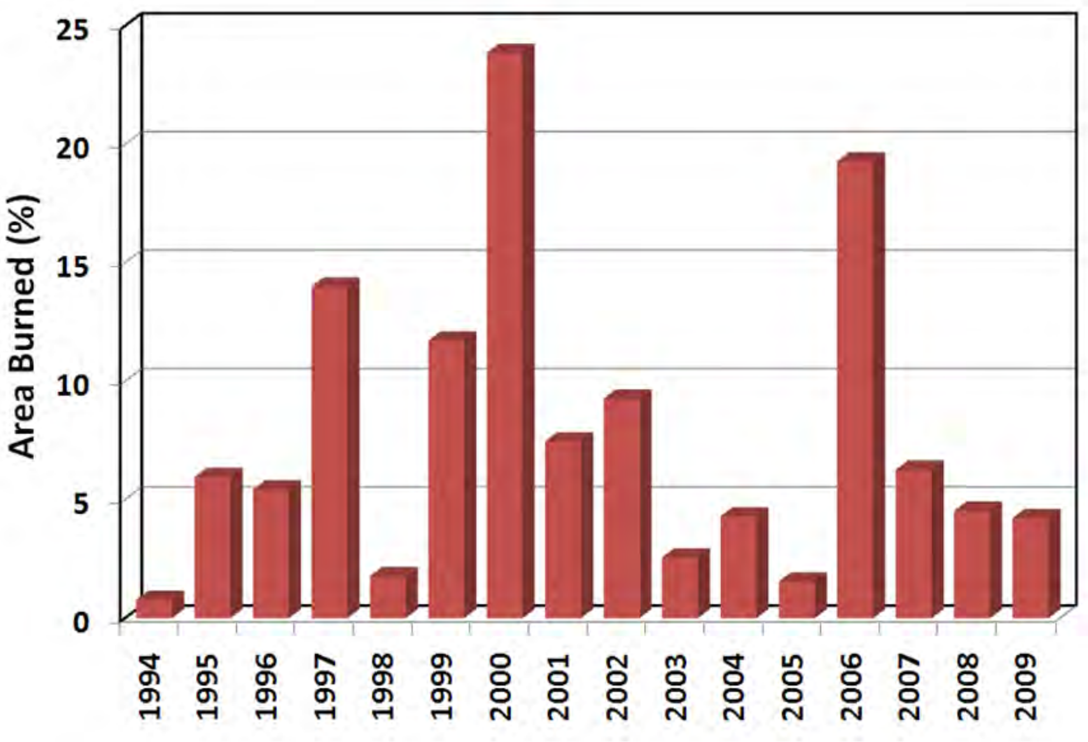

Figure 2-1 Land Area Burnt for the 1994 to 2009 (from Pitts *et al*, 2011)

2.6 Speciation of VOCs

For modelling photochemistry, the VOCs are required to be speciated into individual VOCs to account for the wide range of reactivity's that occur. For data sourced from the NPI and many of the air quality assessments, little or no data are provided on the majority of components of the VOC. Therefore, for this study, the VOCs were speciated by:

- Using the speciations as provided in (DECC, NSW, 2008) where the sources were categorised as either gas turbines, diesel fired reciprocating engines or petrol engines; and
- For emissions from the AGRU vents and condensate and oil loading, using typical composition of vent gases - this indicates that apart from the BTEX component, the VOCs are essentially all paraffins. From the typical compositions, condensate VOCs were assigned to be equal to 90% paraffin and for AGRU emissions to be 80% paraffins.

3 Impact Assessment Criteria

3.1 Ambient Air Quality Criteria

Ambient air quality criteria appropriate for the pollutants considered in this assessment are listed in **Table 3-1**. These criteria are the National Environmental Protection Measure (NEPM) standards

Table 3-1 National Environmental Protection Measure - Air Quality Standards and Goals

Pollutant	Averaging Period	Maximum Concentration		Goal
		(ppm)	($\mu g/m^3$)	
				Maximum allowable exceedances within 10 years
Carbon Monoxide	8-hour	9.0	*11,240*	1 day a year
Nitrogen Dioxide	1-hour 1-year	0.12 0.03	*246* *62*	1 day a year none
Photochemical Oxidants (as ozone)	1-hour 4-hours	0.10 0.08	*214* *171*	1 day a year 1 day a year
Sulphur Dioxide	1-hour 1-day 1-year	0.20 0.08 0.02	*572* *228* *57*	1 day a year 1 day a year none
Lead	1-year	-	0.5	None
Particles as PM_{10}	1-day	-	50	5 days a year
Advisory Reporting Standards and Goal				
Particles as $PM_{2.5}$	1-day 1-year	- -	25 $\mu g/m^3$ 8 $\mu g/m^3$	Goal is to gather sufficient data nationally to facilitate a review of the advisory Reporting standard as part of the review of this Measure scheduled to commence in 2005

Notes:

1) Concentrations of gaseous pollutants in italics have been converted from the NEPM standard quoted at 0 deg C and 101.3kPa.

3.2 Vegetation Criteria

Effects on vegetation and ecosystems can occur from the elevated pollutant concentrations directly affecting plant physiology, growth and vitality. Examples are sulphur dioxide and ozone damage to vegetation at high levels and damage due to fine particulate deposition on vegetation. These effects can be observed over days to years on the plant species. The direct effects can be described by Critical Levels - *the concentration of pollutant in the atmosphere above which adverse effects on receptors such as plants, ecosystems or materials may occur* (WHO, 2000).

Air pollutants can also affect ecosystems by adding to nutrients in the soil or acidifying the soil through dry and wet deposition. This can affect the ecosystem structure and functioning by favouring the conditions for one species over other species, with the effects normally observed after many years. These effects can be described by Critical Loads - *deposition levels below which harmful effects on specified sensitive elements in the environment do not occur* (WHO, 2000).

WHO (2000) summarises these two as:

"Critical levels provide effect thresholds for relatively short term exposures, and are not aimed at providing complete protection of all plants in all situations from adverse effects, critical loads provide the long term deposition below which we are sure that adverse affects will not occur."

Criteria for critical levels and loads have been determined for plant species and ecosystems for Europe and North America, but there is no data available for the north west of Australia. The vegetation in the north west and soil types are very different to that from which the European studies were based. As such, for the similar Gorgon Gas Development on Barrow Island in the Pilbara, the WA EPA in their assessment report (1323) stated or concluded that:

"there are no data available on the effects of these pollutants on the fauna and flora of Barrow Island. In the absence of such standards, the EPA considers that the limit for humans is the only available surrogate for mammals and the WHO deposition limits are the only available surrogate for vegetation" (EPA, 2009).

Therefore, for this study to assess the likely impact on vegetation, the WHO deposition limits have been adopted. WHO (2000) report that critical loads range between less than 250 to greater than 1,500 eq/ha/year (eq - acid equivalents), depending on the type of soil and ecosystem. Less than 250 eq/ha/year is stated for sands, granites and gravel base material of coarse texture (<18% clay content) to >1500 eq/ha/year for base material from dolomite, basalt and volcanic deposits with fine soil texture (clay content > 35%). For the sandy soils of the Barrow region and as for the Dampier Peninsula a critical load at the low end of around 200 to 500 eq/ha/year is considered appropriate. According to SKM (2008a) this equates to a sulphur load of 4 to 8 kg/ha/year or if all the sulphur is from SO_2, a critical SO_2 deposition load in the range of 8 to 16 kg/ha/year.

For nitrogen, WHO (2000) estimate that critical loads for various ecosystems range between 5 to 35 kg N/ha/year, depending on the type of soil and ecosystem. The low critical loads of 5 -10 kg N/ha occur for the most sensitive species (arctic bogs, soft water lakes, forest in humid climates) with "an average value for natural and semi natural ecosystems of 15 to 20 kg N/ha per year". For areas not covered for the categories (such as the Kimberley), the WHO (2000) document offers guidance that the values should be increased for the following factors; hot climates, wet soils, no frosts and high base cation availability. For this study critical loads toward the middle to high end would be expected and the average value "for natural and semi natural ecosystems of 15 to 20 kg N/ha per year" is considered appropriate.

4 Atmospheric Dispersion Modelling

4.1 Introduction

This section provides a summary of the important atmospheric dispersion processes that need to be modelled and the rationale for selection of the models and the model set ups.

4.2 Sources to be Modelled

The major sources and pollutants from the Gorgon Project that need to be modelled (see **Section 2.2.1**) are:

- Gas turbines with stack heights of 45 m emitting very buoyant plumes that will typically rise 200 to 400 m above ground level, with the emission of most concern being NO_X;
- AGRU with the emissions either released as a heavier-than-air gas at high velocity with pollutants of concern being BTEX and H_2S or, with the emissions being directed to a RTO where the VOC and H_2S are oxidised, the pollutants of concern being NO_X and SO_2;
- Flares with very variable emissions with pollutants of concern being NO_X, PM and VOCs. For the large flaring events, the very large amount of heat released will result in a very buoyant plume that will rise hundreds to a thousand metres above ground level;
- Ships engine emissions. These are less buoyant and under stronger winds will be subject to plume downwash due to the airflow around the superstructure of the ships. Emissions from ships at berth and in the shipping channel near the island have been considered; and
- Vapour emissions from ship loading. This occurs when the VOC rich air in the headspace in the tankers holds is displaced during ship-loading. This vapour is heavier than air and will have a tendency to descend to ground level under light winds.

Besides these sources, there are some existing small sources on Barrow Island that are released from short 3 to 8m stacks adjacent to or on building structures. To predict concentrations from these, models that can model the increased dispersion due to the airflow distortion around the buildings are needed.

4.3 Important Dispersion Processes to be Modelled

The relevant dispersion processes are dependent on the type of source, the topography, land use variations and general wind patterns. For the sources considered which are primarily elevated or highly buoyant, a coastal environment in a sub tropical region, the following meteorology and dispersion processes are important:

Plume Rise above the Stable Boundary Layer
Generally the buoyant plumes such as from the gas turbines will penetrate any low inversion and remain above the inversion. As such, at night when there are low winds, the ground level concentrations should be negligible.

Morning Fumigation

This occurs in the morning when the morning mixed layer grows to the plume height and the plumes can be mixed rapidly to the ground. In modelling by Hurley et al (2003) for the Karratha Gas Plant, this phenomenon was considered to lead to the highest concentrations for distances greater than 5 to 10 km from the sources.

Onshore Wind Fumigation

For onshore winds the temperature of the sea is often cooler than on the land during the day. In such cases, the onshore flow is relatively stable and plumes emitted into this air flow will disperse relatively slowly. When this air passes over the hotter land surface a growing region of thermal dispersion occurs (termed the Thermal Internal Boundary Layer, TIBL). The TIBL is important for tall stacks and/or very buoyant plumes as it can lead to a process of fumigation of the plume at distances of several to ten kilometres downwind, leading to higher concentrations than would otherwise occur (see **Figure 4-1**);

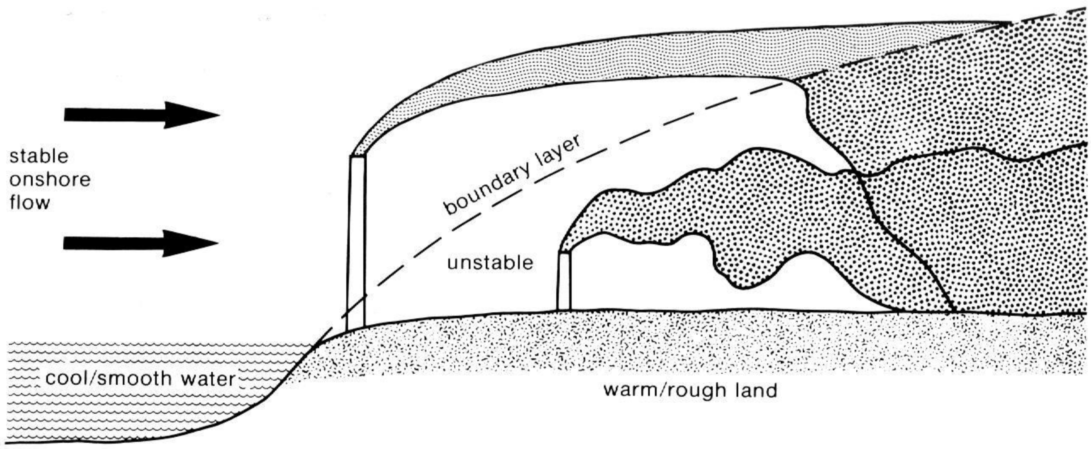

Figure 4-1 The fumigation process due to the presence of a thermal internal boundary layer (from DCE, 1982). Note the plume from the tall stack on the coast is undergoing fumigation, whilst the shorter stack inland is just trapped.

Plume Merging with Nearby Plumes

Plumes that are sufficiently close together may, in the process of rising, start to merge, resulting in an overall greater plume rise for each plume than would otherwise occur. This process is especially important when there are many, closely spaced plumes such as at power stations.

Plume Downwash due to Nearby Structures

Downwash of the plume by the turbulent eddies that develop when air flows over and around buildings. If the plume is emitted into or is caught in such an eddy, it can be brought to ground much sooner than would otherwise occur, resulting in higher ground level concentrations. This is especially important for the emissions from the ships with stacks just above their superstructures and the existing WA Oil sources.

Convective Dispersion

During the day time, the heated earth's surface will generate convective cells of rising and descending air which can bring any plume to the ground within several hundred metres of the source.

Terrain Effects on Airflow
The topography of Barrow Island is slightly undulating, with terrain gradually rising towards the centre of the island to typically to 30 to 40m above sea level with a peak height of 60 m. This topography is considered to have only a minimal impact on dispersion, apart from a tendency for some slight drainage from the inland to the sea for surface sources. For the elevated sources at the LNG plant, this is not considered applicable.

Modelling Photochemistry
Of the pollutants emitted, NO_X will react with VOCs in the presence of sunlight and create ozone and other secondary pollutants. Therefore given the significant emissions of NO_X in the region, modelling of chemical transformation is required. As maximum ozone concentrations occur two to five hours after release, the modelling must be on a regional basis and not just for the local area. With the location of the Gorgon Gas Development 135 km to the WSW of the Burrup Peninsula, it is considered that there may some contribution to the existing pollutant levels there. As there have been concerns raised regarding potential air pollution impacts there, it is considered that modelling should predict this Project's contribution at the Burrup. Therefore predicting the winds, wind fields and pollutant transport in the larger Pilbara region is important.

Modelling Deposition
Prediction of deposition has been required for the assessment of the impacts from air pollutants. As such, models that can predict deposition for the range of species required are necessary.

Modelling Heavier Than Air Releases
Emissions from the AGRU, the RTO and vapour emissions from ship loading are heavier than air releases. They therefore will have a tendency to descend and the initial plume path and dispersion can not modelled by normal regulatory air pollution models. This is discussed further in **Section 4.12**.

Inclusion of Existing Concentrations – Cumulative Assessment
For pollutants where there is a significant cumulative impact (i.e. background levels are significant), the impact assessment needs to include existing or background concentrations. If predicting crustal particulates, as in the case of mining studies, the background particulate concentrations are simply added to the predicted particulate levels. For pollutants such as NO_X, ozone and CO however, the resultant concentrations depend on chemical reactions of the emissions with the background concentrations in a complex manner. Therefore, cumulative predictions for these pollutants require models that predict the chemical reactions.

4.4 Previous Modelling for the Gorgon Gas Development

Previous modelling of the air quality impacts of the Gorgon Project has been undertaken as follows:

- Chevron (2005), two train Gorgon assessment. This used the models DISPMOD to predict the local pollutants levels and TAPM (v2.5) to predict regional ozone and acid deposition. DISPMOD is the WA DECs model for modelling coastal areas where shoreline fumigation is important. With no suitable meteorological data including the important temperature profile data for onshore winds available, the data was predicted using TAPM. Regional modelling was conducted using TAPM with the GRS photochemistry scheme. Sources included where the major regional sources at the time; Karratha Gas Plant (5 trains), Dampier Power Station and Burrup Fertilisers all on the Burrup Peninsula;

- SKM (2008a). The modelling for the three train proposal used the model TAPM (v3.07) for both local and regional modelling. Local pollutants were modelled using TAPM without photochemistry (termed tracer mode) and included emission estimates for the existing WA Oil operations. The regional modelling used TAPM with the GRS scheme and included the regional sources, Karratha Gas Plant, Dampier Power Station, Burrup Fertilisers, shipping at Dampier plus, a 2 train Pluto LNG development, with very approximate estimates of WA Oil operations. For regional modelling four cases were modelled:
    - Routine operations;
    - Non routine-1- Start-up Case;
    - Non Routine 2 - Emergency Shutdown (with very large flaring); and
    - Non Routine 3 – CO_2 venting with 3 AGRUs venting.

  The modelling results showed a possible exceedance of the NEPM NO_2 standard from the start up case and a possible exceedance of the ozone standard from the 3 AGRU venting case;

- Chevron (2011). Modelling in the Air Quality Management Plan (AQMP) was undertaken to better determine the likelihood of the predicted NEPM exceedances and the sensitivity of the model assumptions and methods used. Sensitivity modelling using the TAPM GRS scheme showed that the maximum ozone concentrations predicted were not very sensitive to the background Rsmog concentrations used. Rsmog is a pseudo variable that is a composite weighting of all the reactive VOCs. The study did review the derivation of the Rsmog emissions from the plant and found that the 2008 values were overly conservative. Model runs reducing the Rsmog emission value to more appropriate levels decreased the maximum 1-hour ozone concentrations significantly from 272 $\mu g/m^3$ to 89 $\mu g/m^3$, well below the criteria of 214 $\mu g/m^3$ (0.10 ppm).

  Modelling was also conducted using TAPM-CTM, though with only the Barrow Island sources. This model does not use Rsmog but the actual VOC concentrations and emissions. This modelling likewise predicted much lower concentrations than in the 2008 assessment with predicted maximum 1-hour ozone concentrations ranging from 140 $\mu g/m^3$ (65% of the criterion) for the base case, to 167 $\mu g/m^3$ (78% of the criterion) for the case of 3 AGRUs venting continuously. The predicted maximum 4-hour ozone concentrations ranged from 119 $\mu g/m^3$ (70% of the criterion) for the base case to 125 $\mu g/m^3$ (73% of the criterion) for the case of 3 AGRUs venting continuously.

  Maximum BTEX and H_2S ground level concentrations from the AGRU vents were predicted using the model Canary. Canary was selected as it can model all the important processes for the AGRU releases including:
    - Momentum-jet routine for the near sonic release;
    - Multi-component releases, such as CO_2 mixed with H_2S and BTEX;
    - Liquid-vapour flash;

- Aerosol formation and evaporation such as occurs with the CO_2; and
- Dense-cloud dispersion.

The results from the Canary modelling (Chevron, 2011) indicated that concentrations of BTEX and H_2S were "to remain below the relevant impact assessment criteria; therefore, ambient air quality is expected to be deemed acceptable".

4.5 Recent Modelling in the Pilbara Kimberley – TAPM-CTM

Recent modelling in the region has tended to use TAPM-CTM and to explicitly include emissions from fires. This has been used successfully to predict concentrations for the Browse LNG Precinct assessment (Air Assessments, 2010) and also in a validation study for the Pilbara region centred on Karratha/Dampier (Pitts et al, 2011).

The validation study which included the Barrow Island region found very good agreement with the observations at Karratha and Dampier with the comparison of ozone concentrations at Dampier in 1999 presented in **Figure 4-2**. The year 1999 was used as there were both available ozone data and it was a year with above average fire impacts. A comparison of the predicted to observed ozone levels are presented in **Figure 4-2** showing a slight tendency of the model to be conservative at the highest concentrations, which if anything is desirable in a model for air quality assessments.

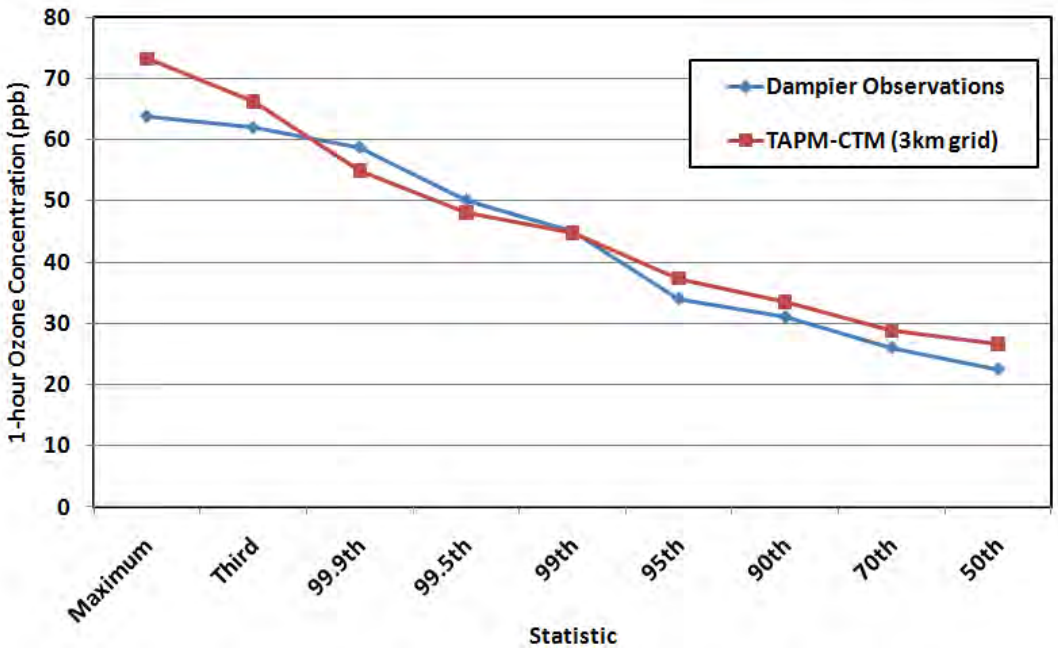

Figure 4-2 Observed and predicted ozone concentrations at Dampier North for 1999 (from Pitts et al, 2011)

A plot of the hourly ozone concentrations at Dampier for a period with fire impacts, September through to early December in 1999 is presented in **Figure 4-3**. This shows the major fire smoke plume events are all well predicted by the modelling system, though the actual day of the event may not be predicted. For example, the maximum concentrations do not occur on the correct day as the location of the ozone plume depends on the model predicting the correct wind field. Small changes in the wind field can easily lead to the plume being 50 km from the site and therefore being recorded as a missed event.

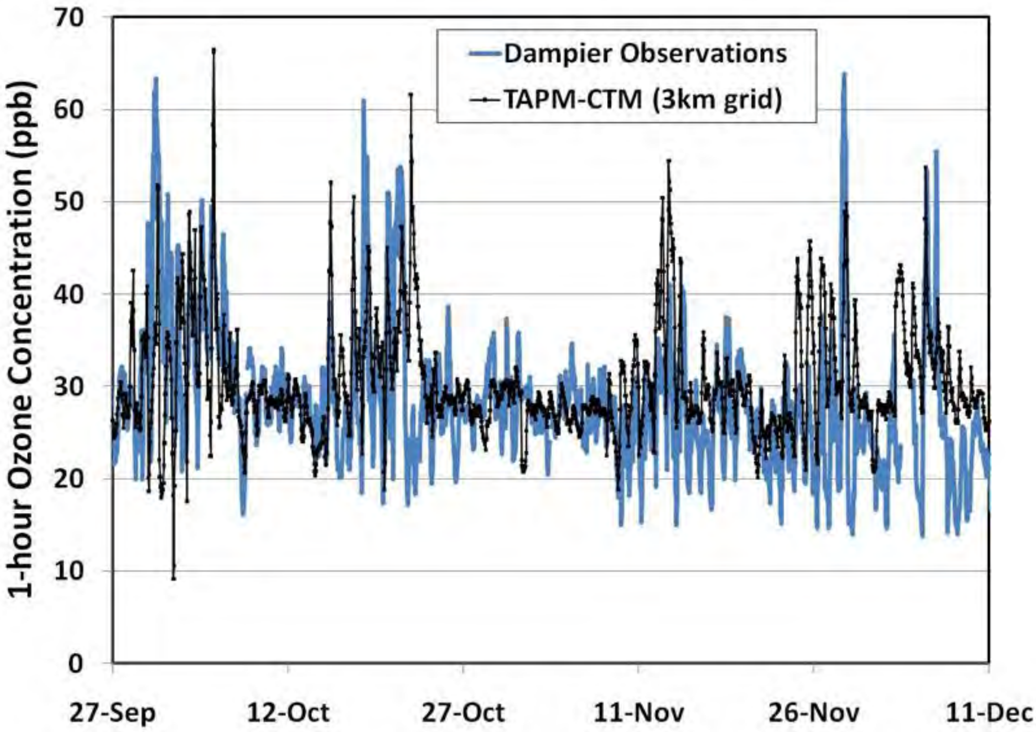

Figure 4-3 Observed and predicted ozone concentrations from the 27th September to 11th December 1999

The use of TAPM-CTM and the inclusion of fires also allow the contribution of the various sources to be determined (see **Figure 4-4**), such that a true cumulative assessment can be undertaken, as required in the DEC modelling guidelines.

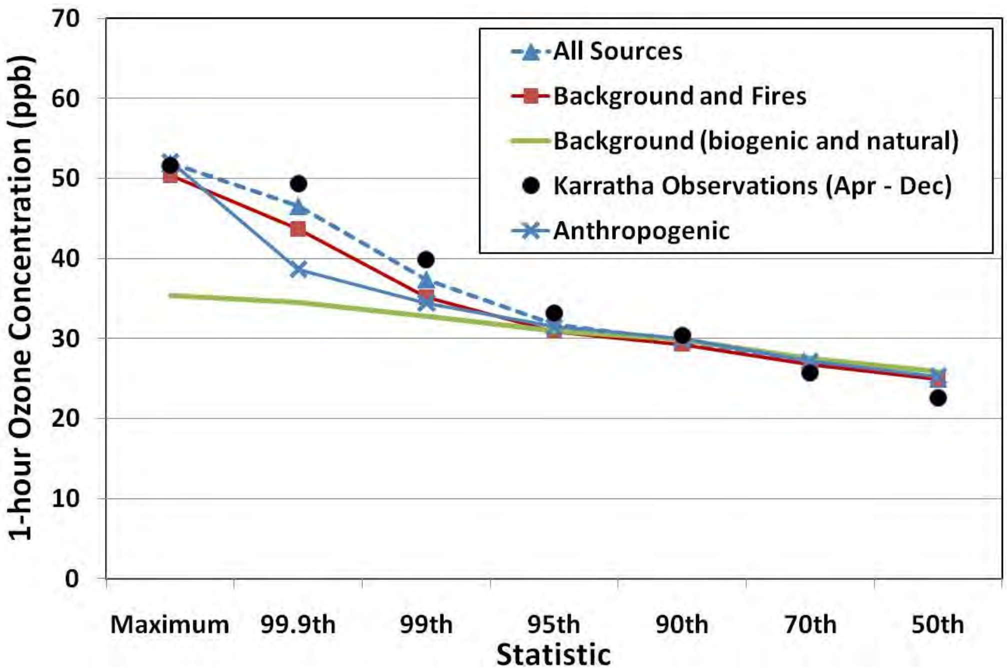

Figure 4-4 Observed and predicted ozone concentrations at the Karratha Scout Hall for April to December 2009

4.6 Model Choice – TAPM and TAPM-CTM

For the important processes described in **Section 4.3** and the sources and pollutants to be modelled in this study (NO_2, CO, SO_2, PM_{10}, $PM_{2.5}$, ozone and acid deposition), the models TAPM and TAPM-CTM have been selected.

TAPM was selected for the local modelling as it is considered the best to model the buoyant plumes and moderate stacks where plume interactions with TIBL will be important, and it models convective dispersion very well. Other models such as Aermod and Calpuff were discounted as both are not proven for modelling plume interaction with TIBLs.

For regional modelling TAPM-CTM was selected as:

- TAPM can generate the regional wind fields required for CTM. Other alternatives are to use another prognostic model or use a diagnostic model. A diagnostic method was not considered due to lack of upper air data in the region;
- CTM was selected as it is one of the best photochemistry schemes available, with the recent Pilbara validation showing very good agreement with observations (Pitts, et al, 2011) where it was shown to be superior to TAPM and the GRS scheme; and
- TAPM-CTM can include the emissions from fires as developed by CSIRO and therefore allow a true cumulative assessment to be conducted. Therefore the question as to whether industry impacts may add to already existing high levels from fires can be addressed.

4.6.1 TAPM - Description

TAPM is a prognostic meteorological and dispersion model that can predict the meteorology in the region of interest without recourse to observational data, though local observational data can be assimilated if selected. TAPM is supplied with databases of terrain, vegetation and soil types for Australia and uses the meteorological analyses from weather models to initialise the model. TAPM is especially suited for modelling the effects from tall and very buoyant sources, such as fumigation (both morning fumigation and sea breeze fumigation), generating three dimensional wind and turbulence fields. TAPM incorporates building downwash using the USEPA PRIME algorithms. It is noted that past versions of TAPM under-predicted the frequency of occurrence of low winds speeds, although this has been improved considerably in version 4. The DoE (2006) in their air quality modelling guidance, commenting on TAPM v 3 state that:

"the DoE will not accept the use of TAPM to model dispersion of low sources with zero or low buoyancy, either directly (TAPM calculating concentrations) or indirectly (TAPM- producing a meteorological file for another model) unless performance of the model(s) is demonstrated to be reliable, or there is a margin of safety in results which is demonstrably larger than model error".

In this study however, as the major sources to be modelled are not low sources with low buoyancy, this issue is not critical. Additionally, besides the issue of low winds, TAPM tends to under-predict the high winds at the surface (see **Section 5**) which is important particularly for fugitive dust assessments involving wind erosion. In this study however, as wind erosion is not being modelled, TAPM is considered to be appropriate.

In terms of the model, TAPM has undergone many upgrades in the last 10 years. Recent model validations for Collie (Rayner, 2009), has shown that even with the same initial meteorology and emissions, the results can be significantly different between different versions of the model. Therefore predicted concentrations from one version of the model, such as version 4.04 used here, will not be exactly the same as that predicted using version 2.5 as in 2005 or version 3.07 as used in 2008.

4.6.2 TAPM-CTM Description

TAPM-CTM utilises the meteorology predicted by TAPM but instead of the normal dispersion options available within TAPM, predicts the dispersion and photochemistry using the Chemical Transport Model. For regional photochemistry modelling (and deposition) TAPM-CTM with the Carbon Bond 2005 (CB05) reaction mechanism has been used. CB05 is a state of the art chemical transformation mechanism which has recently been released by the USEPA (Yarwood et al, 2005). In the modelling here, 62 gaseous and 28 aerosol species were modelled. Organic species are lumped according to their carbon-carbon bonding type. Organic species treated in CB05 include alkanes, ethene, terminal and internal-bonded alkenes, toluene, xylene, formaldehyde, higher aldehydes, isoprene and terpenes.

4.7 TAPM and TAPM–CTM Modelling Set-Up

The following set-up options within TAPM were used for the TAPM pollution modelling:

- Use of TAPM v4.04 with new surface schemes;
- Default options for turbulence and land use schemes for version 4;
- A meteorological grid with 30, 10, 3 and 1 km nested grids with 31 by 31 grid points;
- Modelling was undertaken for the year 2010 to be consistent with the 2010 meteorological data to provide for model comparison;
- Sea surface temperatures were obtained from the TAPM databases;
- 25 vertical levels;
- Soils assigned to a silty clay loan (classification 14) with land use assigned to shrub-land low sparse (classification 14) to provide a low surface roughness;
- Deep soil moisture specified as 0.15 for the year. This is higher than used in the past for Pilbara modelling and earlier versions of TAPM, but with the low soil moistures, the new version of TAPM resulted in typical latent heat fluxes of 100 w/m^2 which is not considered appropriate;
- Two spin up days for each model run to allow the meteorological fields to stabilise;
- No data assimilation of surface observations to nudge the model predictions. Data assimilation is considered to lead to sharp wind shears in the vertical at night when the winds above the number of layers used to define surface layer return to that derived by TAPM;
- Lagrangian /Eulerian dispersion mode for all point sources with change over at 900 seconds;
- Pollution modelling was conducted over a 20 by 20 km grid with a fine 250 m resolution; and
- All sources were modelled as point sources including ships.

Specific set-up options for TAPM-CTM were:

- Where possible, the model set ups as used in the model validation study of Pitts *et al* (2011), with the major exception being the grid size and domain, which was selected to better cover the area of interest;
- A larger meteorological grid with 25, 10 and 5 km with 60 by 40 grid points see **Figure 4-5**.

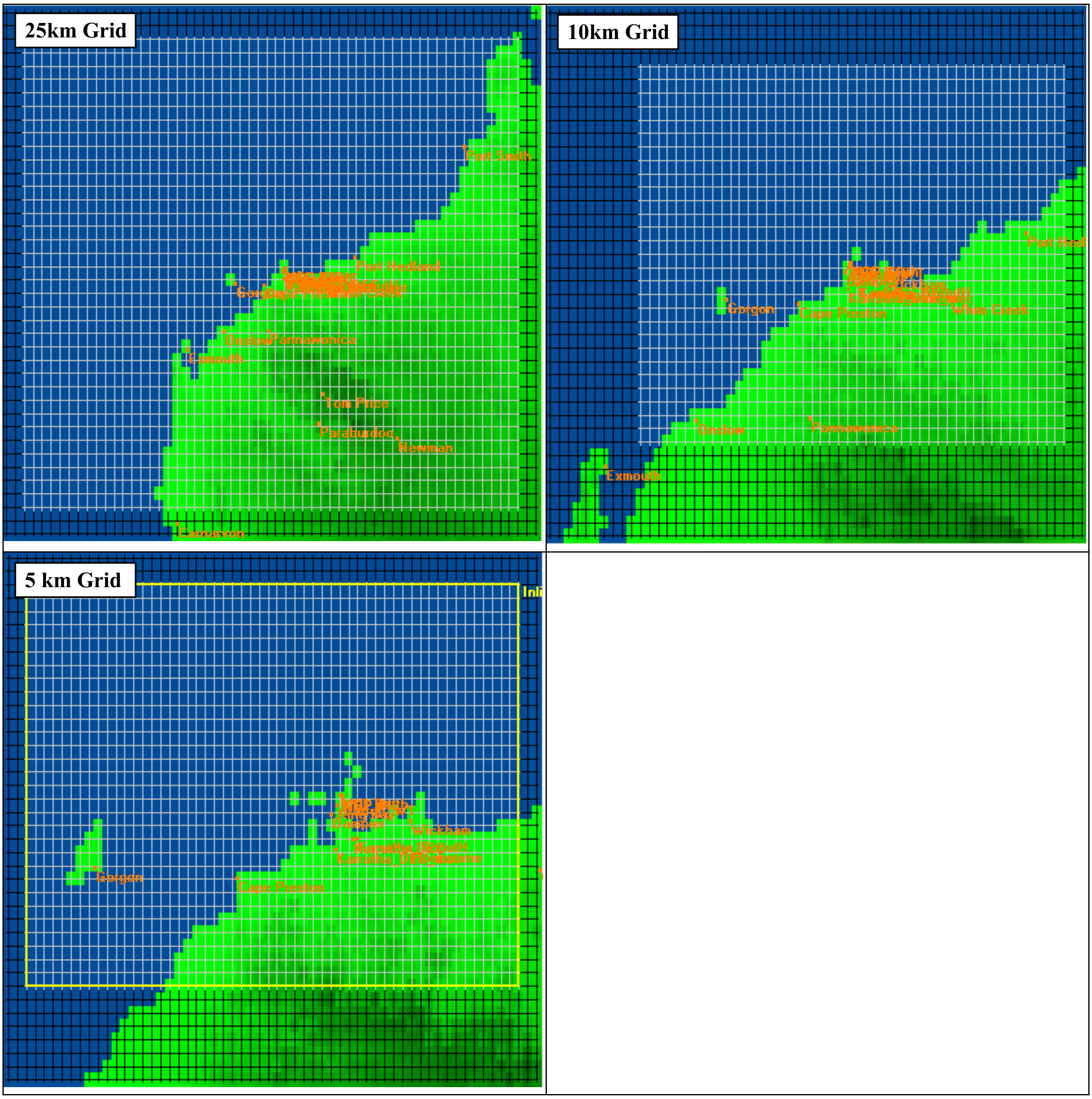

Figure 4-5 TAPM-CTM model grids. The black and white grids are the meteorological and pollution grids. The yellow box marks the extent of the inner 2.5km pollution grid.

This size was selected such that the inner pollution grid of 2.5 km (marked as the yellow box), would cover the area needed to capture the region to 100 km to the east of the Burrup Peninsula where high ozone concentrations may occur due to superimposition of Gorgon plumes with emissions from the Dampier/Karratha area. The second grid is large enough to capture sources from the Wheatstone LNG project near Onslow to the west out to Port Hedland to the east. The outer grid was set to encompass a large area of fire emissions and extended from the Dampier Peninsula near Broome to near Carnarvon. The pollution grid was selected to be also slightly in from the boundary of the meteorological grid boundary to minimise boundary effects on the pollution predictions;

- Emissions from fires were entered separately for each pollution grid. For the outer 25 km pollution grid, a 8 km emission grid was used. For the 10 km grid a 5 km emission file was used, whilst for the 5 and 2.5 km grid emissions were resolved onto a 1 km grid. This setting the fire emissions to generally no more than half the grid size was done as a balance between adequately resolving the fire (not spreading it over too wide a region), but also limiting the number of fire sources that had to be modelled. If the same 1 km emission file was used for the large 25 km outer domain, a very large number of fire sources would be required;
- For modelling the pollution within TAPM-CTM, a Eulerian dispersion scheme is used;
- 12 vertical levels for modelling pollution;
- Use of the Carbon Bond 5 mechanism;
- Emissions from biogenic sources and soils and fires are as described in **Sections 2.4** and **2.5**; and
- Initial and Boundary VOC levels developed through a literature review of available measurements including those from the Burrup rock art study and background aerosol measurements for Australian sites (Galbally et al., 2009 and references therein; Gillett and Cope 2009, Cainey et al., 2007). All species except ozone were set constant for the year with lower initial conditions as summarised in **Table 4-1**.

Table 4-1 Initial and Boundary Concentrations used in TAPM-CTM Modelling

Substance	Average Concentration (ppb)	Substance	Average Concentration (ppb)
Gaseous Species			
Benzene	0.015	Ethane	0.03
NO	0.1	Olefins	0.02
NO_2	0.6	Toluene	0.02
CO	65	Xylenes	0.01
SO_2	0.1	MEK	0.001
Formaldehyde	0.3	PAN	0.0
Aldehyde	0.0	Methane	1700
Paraffins	0.6 (0.06 ≥450m)	NH_3	0.3
Particulate Species			
Elemental Carbon < 2.5 µm	0.1 (0.001 ≥800m)	Sea Salt < 2.5 µm	0.6 (0.3 ≥600m)
Elemental Carbon 2.5 to 10 µm	0.1 (0.001 ≥800m)	Sea Salt 2.5 to 10 µm	2.0 (1.0 ≥600m)
Organic Carbon < 2.5 µm	0.1 (0.001 ≥800m)	Miscellaneous PM < 2.5 µm	0.1
Organic Carbon 2.5 to 10 µm	0.1 (0.001 ≥800m)	Miscellaneous PM 2.5 to 10 µm	0.1

Boundary conditions of ozone were varied by month as the upwind ozone levels are considered to change more than the other parameters and as ozone is an important boundary condition. The monthly values are listed in **Table 4-2**. Low values from the west are specified as this is generally very clean air. High values from the east, especially in October to November occur with the large fires to the east at this time, with higher values to the south in May to August from burn-offs to the southwest.

Table 4-2 Initial and Boundary Ozone Concentrations used in TAPM-CTM Modelling

Month	North (ppb)	East (ppb)	South (ppb)	West (ppb)
January	20 (30)	22 (30)	20 (25)	17 (25)
February	20 (30)	22 (30)	20 (25)	17 (25)
March	20 (25)	20 (25)	18 (25)	15 (22)
April	20 (25)	20 (25)	18 (25)	15 (22)
May	20 (28)	22 (30)	22 (28)	17 (25)
June	20 (28)	23 (30)	23 (30)	17 (28)
July	20 (28)	23 (30)	23 (30)	17 (28)
August	20 (28)	23 (30)	23 (30)	17 (28)
September	20 (30)	22 (32)	20 (28)	17 (25)
October	20 (30)	22 (32)	20 (28)	17 (25)
November	20 (32)	22 (32)	20 (28)	17 (25)
December	20 (30)	22 (30)	20 (25)	17 (25)

Note: Values in brackets are the 4 top levels from 1 km to 3 km

4.8 Plume Merging and Plume Rise Enhancement

Combined plume rise or plume rise enhancement is often used to account for the effect that nearby plumes will tend to merge and increase the overall plume rise of each individual plume. Plume rise enhancement has been used in the model validation for the Karratha Gas Plant plume where Physick and Blockley (2001) argue it is required to explain the observed concentrations, and was also used in the model validation in Pitts *et al* (2011). These assessments used the method of Briggs (1974) as generally used within Australia. This method defines the effective number of stacks (*Ne*) as:

$$Ne = \left[\frac{n+S}{1+S}\right] \qquad \textbf{Equation 4.1}$$

where n is the physical number of stacks, and S is a dimensionless separation factor:

$$S = 6 \cdot \left[\frac{(n-1)\cdot \Delta s}{n^{1/3} \cdot \Delta z}\right]^{3/2} \qquad \textbf{Equation 4.2}$$

where Δs is the stack separation and Δz is the plume rise for an individual plume. The rise enhancement factor E_N is then:

$$E_N = Ne^{1/3} \qquad \textbf{Equation 4.3}$$

with the enhanced plume rise Δz_E

$$\Delta z_E = E_N \cdot \Delta z \qquad \textbf{Equation 4.4}$$

Assuming buoyancy is the dominant cause of plume rise a diameter enhancement factor can be derived as:

$$D_F = Ne^{1/2}$$ **Equation 4.5**

For this study, the enhancement factors for the Gorgon stacks and other major sources have been calculated for all major groupings of stacks listed in **Table 4-3** with the average plume rise as calculated by TAPM from a model run for the month of January 2009.

Table 4-3 Estimates of Plume Enhancement

Source	Number in Row Operating	Stack Separation (m)	Diameter (m)	Average Plume Rise[1] (m)	Ne	En	D_F	Equiv. Diam (m)
Gorgon Gas Development								
Gorgon F7 GTs	2	110	4.52	196	1.36	1.11	1.17	5.27
Gorgon F9 GTGs (East/West Direction)	2	76	6.6	312	1.66	1.18	1.29	8.51
Gorgon F9 GTGs (North/South Direction)	3	92	6.6	312	1.78	1.21	1.33	8.80
Karratha Gas Plant								
GT4001 to 4006	6	25	3.96	194	3.21	1.47	1.79	7.09
GT 4007 to 4010	4	36.7	3.8	157	2.09	1.28	1.44	5.49
LNG 1 to 3 Compressors	5	37	3.8	200	2.48	1.35	1.57	5.98
LNG Train 4 to 5 Compressors	2	106	3.8	230	1.43	1.13	1.20	4.54
Domgas Compressors	3	15	1.2	170	2.59	1.37	1.61	1.93
TXU considered along with GT4001	2	37	3.36	163	1.69	1.19	1.30	4.37
Regen. Boilers	3	10	1.46	55	2.14	1.29	1.46	2.13
Other Sources								
Dampier P.S.	2	60	2.6	170	1.53	1.15	1.24	3.22
Cape Lambert P.S.	2	27	2.44	120	1.69	1.19	1.30	3.17
Wheatstone Compressors	6	50	2.66	164	2.59	1.37	1.61	4.28
Wheatstone Power generation	2	37	2.77	171	1.70	1.19	1.20	3.61
Wheatstone Power generation	3	37	2.77	171	2.01	1.26	1.42	3.92
Yurralyi Maya P. S.	6	43	3.1	199	2.33	1.33	1.53	4.73
West Pilbara P. S.	2	104	3.1	199	1.38	1.11	1.18	3.65
Sino Iron Project P. S.	2	28	3.65	85	1.55	1.16	1.25	4.55
Balmoral South P. S.	2	55	6.0	182	1.59	1.17	1.26	7.56

Notes:

1) Average plume rise derived from one month of TAPM modelling (January 2009).
2) For modelling, the equivalent diameter was used for those stacks that the plume enhancement was calculated, with the given exit temperature and velocity.

Values for the Gorgon Gas Development gas turbine generators in **Table 4-3** have been calculated for the east/west direction or the north/south direction as there are three in a row in the north/south direction and two in a row for the east/west direction. For the modelling, the value for the east/west direction as lower (more conservative) has been used. The Pluto plume merging values were based on that supplied in SKM (2006).

Besides plume merging from nearby stacks, there is a large amount of hot air released from cooling fans such as on the top of the LNG trains. This has been shown using computational fluid mechanics modelling to merge with the plumes from gas turbines, particularly during the lighter winds, but will require more verification work before it can be used in modelling.

4.9 Building Downwash

Building downwash for the LNG plant sources was not included as the stacks are generally 45m and will be subject to little effects from the buildings. Plume downwash has been omitted from past LNG plant modelling studies as it is considered not to be significant (Hurley et al, 2003). According to modelling guidance “rules of thumb” downwash should be considered when nearby structures are more than 40% of the stack height. With the height of the main structure of the LNG train about 25 m and stack heights of 45 m, this would suggest this should be considered. However the LNG structures, particularly near the top are reasonably open allowing air to pass through it and are not bluff bodies upon which the empirical down wash formula were based.

Buildings where included for the existing sources which are short stacks, where building affects are important and for the ship superstructures which were entered as a “building” to model plume downwash from ships if necessary.

4.10 Modelling Flares

The flares for the wet gas stream and dry gas stream are routed to the ground flare to the north west of the plant area. This is designed with 4 rectangular areas (two of 171 by 75m and two of 156 by 75m) that are aligned end to end in a NW to SE orientation. The total extent of the flare area including the 40m separation between the four areas is 770 by 75m. This orientation was selected to be at right angles to the prevailing wind to assist in dissipation of the heat. The four flare areas are each enclosed by a fence structure of 14 m height, which is constructed of alternately slated panels to allow air to pass through, but does not allow light spill or radiant heat out. In each flare area there are lines of burners for each of the wet and dry gas flows. Depending on the amount of gas being flared, gas is passed to the next line of burners, such that the flaring is not across the whole area unless for the maximum flaring rates. During flaring at high flare rates, there will be a very large plume of buoyant air with the combustion air being drawn into the base of the flares through the porous fence.

Plume rise from these flares was modelled using the Texas method (TCEQ, 2004) which approximates the plume rise from the flaring by considering it as a pseudo stack with an exit velocity of 20 m/s and exit temperature 1000 deg C, with 55% of the heat released contributing to buoyancy. The other heat is lost as radiant heat. Assuming the above fixed parameters, the method calculates the pseudo effective diameter that is required to create a plume with the same buoyancy of the heat released. For the routine operation, flaring the emissions were taken to occur from one of the four boxes only – that is, the other three box areas are not operational. The effective diameter is listed in **Table 4-4**. For the maximum flaring case, the gas is burnt in all four areas and as such the buoyancy and plume rise has been split across these. Computational fluid dynamic modelling indicates that plumes from the four areas will merge, especially under the lighter winds and as such this should be a conservative assumption for far field affects. For the area close in to the flare, modelling of a single large plume may be simplistic.

Table 4-4 Estimates of Pseudo Stack Parameters for Flare Releases

Flare Case	Frequency	Gas Flow (kg/s)	Heat Released (BTU/s)	Equiv Diam. (m)
Routine Operations				
Wet Gas Flare	Normal	0.17	2.98E+03	0.77
Dry Gas Flare	Normal	0.17	1.38E+04	1.67
BOG Flare	Normal	0.01	3.94E+02	0.28
Non Routine				
Wet Gas Flare - Black Start	Approx once in 5 years	136.1	6.53E+06	18.12 [1]
BOG Flare - Black Start	Approx once in 5 years	3.05	1.46E+05	6.08

Note: Equivalent diameter for one flare area. That is the heat released and buoyancy has been divided by 4 as the flare area extends over four separate flare areas.

For the BOG flare which is an enclosed flare, similar calculations were performed as listed in **Table 4-4**.

4.11 Estimating the NO_2 Fraction within NO_X for Local Modelling

To estimate the proportion of NO_X in the form of NO_2 for the local (TAPM) modelling, the ozone limiting method (OLM) as developed by Cole and Sumerhays (1979) and as specified by the USEPA and the NSW modelling regulations (DEC NSW, 2005) was used. Note in TAPM-CTM the NO_2 is explicitly calculated. This method estimates the NO_2 concentrations as:

$$[NO_2]_{total} = 0.2 \times [NO_X]_{pred} + \min\{(0.8 \times [NO_X]_{pred} \text{ or } (46/48) \times [O_3]_{bkgd}\} + [NO_2]_{bkgd} \quad \textbf{Equation 4.6}$$

Where:

- $[NO_2]_{total}$ is the resultant total concentration of NO_2 in µg/m^3;
- $[NO_X]_{pred}$ is the predicted NO_X concentration in µg/m^3;
- $[O_3]_{bkgd}$ is the background ambient ozone concentration in µg/m^3; and
- $[NO_2]_{bkgd}$ is the background NO_2 concentrations in µg/m^3.

A coefficient of 0.2 has been used in **Equation 4.6** as NO_2 emissions from gas turbines with dry low NO_X burners, which are the dominant source at this LNG plant, are around 20% of total NO_X. This percentage will be slightly conservative for boilers, where the NO_2 percentage are typically less than 10%. For the background ozone, a concentration of 26 ppb (56 µg/m^3) has been used as the 75th percentile measured of ozone at Barrow Island (see **Section 4.13**). For NO_2 a background value of 2 ppb was used as determined in **Table 4-7**.

A comparison of this relationship with the NO_2 to NO_X concentrations measured at Dampier found that this relationship was generally conservative, especially at high NO_X concentrations.

4.12 Modelling Gaseous Emissions with High Molecular Weights

Emissions from the AGRU, RTO and condensate loading from ships have significantly higher molecular weights than from normal combustion sources, as detailed in **Table 4-5**.

Table 4-5 Emissions Parameters for High Molecular Weight Releases

Source	Stack Height (m)	Stack Tip Exit Temp (deg C)	Molecular Weight (g/mol)	Apparent Temp (deg C)	Exit Volume (Am^3/s)	Flow Rate (kg/s)	Stack Tip Radius (m)	Exit Velocity (m/s)
AGRU	56	49	43.4	-42	40.5	66.5	0.224	257
RTO	50	122	39.3	19	71.6	86.8	0.7505	40
Condensate Loading Vent Riser	6m above ship deck	41	40	-45	1.389	2.34	0.1205	30

Normal combustion sources have a similar molecular weight to that of ambient air and as such the difference in molecular weight is neglected in the plume rise calculations of regulatory models, such as Ausplume, Aermod and TAPM.

For modelling these three sources the following was undertaken:

- RTO. As the RTO has a high exit temperature, it was modelled conventionally within TAPM and TAPM-CTM but with the temperature of release adjusted to an apparent temperature of 19 deg C. The apparent temperature is the temperature that would result in the same buoyancy as the gas stream at its actual temperature and if it had the molecular weight of ambient air or typical combustion air. The correction is made by multiplying the emission temperature in Kelvin by the ratio of the molecular weight of ambient air and exhaust air (approximated as 29g/mole) to that of the gas stream. The use of the apparent temperature will therefore decrease the buoyancy and momentum of the plume as regulatory models use the plume temperature in both calculations. In reality the momentum of the plume should increase with higher molecular weight and therefore the above approximation will understate the momentum plume rise. For the RTO plume, the buoyancy term is, however, the dominant term and the approximation is reasonable if slightly conservative;
- Ship-loading condensate emissions. Modelling of this source in this study is only required for the regional assessment. This source due to the high molecular weight and low temperature will have some tendency to slump if released from the older style vent riser, though this may be minimised if released through the new style relief valve with exit velocity greater than 30 m/s. In either case, the other major impact on the dispersion will be the airflow distortion around the ships structure with it considered that the plume will generally be down-washed into the lee of the ship. As such, in the TAPM-CTM regional modelling, which does not model building effects, the sources was approximated as a release at vent height (approximately 17m) with no plume rise. For regional predictions where the plume is initially mixed within the 2.5 by 2.5 km Eulerian grid cell, this is considered adequate;
- AGRU plume with heavier than air release at near sonic velocity. Impacts from this source have been modelled using the model Canary (Chevron, 2011). The predicted final plume heights are typically about 65 to 150m (**see Table 4-6**), which is much higher than that predicted with models such as SLAB and DEGADIS that predict the plume would slump, as these do not account for factors such as phase changes.

Table 4-6 Final Centreline Plume Height (m) from the AGRU as predicted by the model Canary

Stability Class	Wind Speed @ 10m (m/s)				
	0.5	**1.5**	**3.0**	**5.0**	**7.0**
A	114	77	66	-	-
B	112	77	66	62	-
C	134	86	71	65	62
D	155	96	77	69	65
E	191	118	90	77	-
F	175	109	86	74	-

In the regional modelling the AGRU source was approximated using the given emission characteristics except with an exit velocity of 50 m/s as this results in the best agreement with the Canary predictions. In the 2010 TAPM-CTM modelling as detailed in Chevron (2011) the final plume height from the AGRU was approximated as the release height as the Canary model results were not available then. Therefore there will be some differences expected in the regional modelling results.

4.13 Background Concentrations Used in Modelling

Ongoing ambient air quality measurements have been conducted on Barrow Island. Measurements include NO_X, NO_2, ozone and $PM_{10.}$ A number of local sources affect this collected data such that it is affected by local sources, including an adjacent car park and a pumping station.

To determine background NO_X and ozone for use in modelling, the local source has been removed in the 10-minute and 1-hourly averaged data based on the direction to the source and the wind direction at the time. The resultant background data for NO_2 and ozone is presented in **Table 4-7**. For SO_2, CO as there are no Barrow Island measurements and for PM_{10} and $PM_{2.5}$ where the data is more significantly affected by local sources, Pilbara background statistics have been used which are summarised in **Table 4-7**.

Table 4-7 Expected Background Concentrations at Barrow Island

Pollutant	Ave. Period	Units	Average	75th Percentile	Maximum	Source of Estimate
Nitrogen Dioxide	1-hour 1-year	(ppb) (ppb)	- 2 (0.5)	2 (1.5) -	32 -	2010 Barrow Island Measurements
Sulphur Dioxide	1 hour 24-hour Annual	(ppb) (ppb) (ppb)	- - Negl	Negl - -	Negl - -	Dampier Measurements
Ozone	1-hour	(ppb)	21 (20-25)	26 (25)	48 (62)	2010 Barrow Island Measurements
Carbon Monoxide	8-hour Annual	(ppb) (ppb)	- 65	100 -	300 - 1000 -	Dampier Measurements
PM_{10}	24-hour Annual	($\mu g/m^3$) ($\mu g/m^3$)	- 23	27 -	>50 Bushfire smoke	Pilbara measurements (2)
$PM_{2.5}$	24-hour Annual	($\mu g/m^3$) ($\mu g/m^3$)	- 5	6 -	>25 Bushfire smoke	Pilbara measurements (2)

Notes:

1) Values in round brackets from Pilbara Dampier monitoring (DoE, 2004).
2) Pilbara measurements from Pitt (2011) and Pilbara townsite values. Non townsite values away from man made sources will be somewhat lower.

For modelling, the 75th percentile background concentrations has been used. This percentile is based on the Victorian EPA (Victoria Government Gazette, 2001) who recommend the use of the 70th percentile measured concentration as the background value.

4.14 Modelling Area Sources and Shipping in TAPM-CTM

Emissions from motor vehicles, domestic activities etc at the various towns were combined into one source file with the emissions varied by hour of day according to the motor vehicle variation determined for Karratha (DEP, 2002). This resulted in hourly emissions for the period 9am to 3pm being 8.5% of the daily emissions, whilst for the hour ending at 2am, the emissions were only 0.2% of the daily emissions. The use of the motor vehicle profile to scale all area sources is considered acceptable given that motor vehicle are the dominant source and that many of the other sources follow a similar pattern.

Ships were modelled as point sources with emissions at berth and tugs operating were estimated on an hourly basis based on the frequency of times ships were berthed according to the shipping data in **Table 2-9**. This provides actual hourly emissions rather than constant emissions throughout the year. As a simplification, emissions from shipping channels were assumed continuous which will therefore understate some hourly average concentrations but the annual averages will be correct.

4.15 Modelling WA Oil tanker Terminal Pump

The tanker terminal pumps only operate when loading ships with condensate from the tanker terminal tanks. This typically is about 7 times per year for about 20 hours each. In 2010 the total time was about 160 hours or 1.8% of the year. In modelling the pumps impacts, the tanker terminal run times for 2010 were used to provide realistic impacts from this source.

4.16 Predicting Deposition Rates

Deposition of nitrogen and sulphur occurs through gaseous, particulate and wet deposition. This includes:

- Gaseous deposition through species such as NO_2, SO_2, nitric acid (HNO_3) and ammonia (NH_3);
- Particulate deposition of N and S in particulate species; and
- Wet deposition in rainwater of species such as ammonium ions (NH_4^+), nitrate ions (NO_3^-) and sulphates.

"Measurements" of deposition in the region have been made as part of the Burrup Rock Art Monitoring Management Committee (BRAMMC) study which measured the gaseous and aqueous phases by measuring:

- Gaseous deposition of nitrogen species; NH_3, NO_2 and HNO_3 and for sulphur species, SO_2. These were inferred as the product of the monthly average concentrations measured using the diffusion tubes and an estimated annual deposition velocity calculated from a model; and
- Wet deposition in rainwater of species such as NH_4^+, NO_3^- and non sea salt sulphate.

Dry particulate deposition was not measured due to analysis issues with the deposition measurements with Gillett stating that this pathway was considered to be small compared to the other two pathways (Gillett, 2010).

The conclusions of the BRAMMC study were that deposition rates in the region are low with:

- Wet deposition only accounting for a small fraction of the total deposition due to the low rainfall rates in the region, with dry deposition accounting for 69 to 85% of the total deposition at each site; and
- For dry deposition, NH_3 gas was the largest contributor at background sites, but at sites closer to the Karratha Gas Plant, NO_2 and NH_3 were approximately equivalent, with HNO_3 deposition around half of these.

Modelled deposition rates in the Pilbara have been made using primarily TAPM for the Burrup Peninsula area and Barrow Island and for the gaseous deposition of NO_2 and SO_2. Therefore these studies have not estimated the total deposition, particularly total N deposition. TAPM-CTM has been used in unpublished work also in the Pilbara and for the Browse LNG Project in the Kimberly (Air Assessments, 2010). TAPM-CTM unlike TAPM can estimate deposition for all three pathways, dry, wet and gaseous and for a wider range of gaseous species, NO, NO_2, nitrous acid (HONO), HNO_3, NH_3, NH_4, the deposition through nitrate aerosols and the wet deposition of these species·.

A comparison of model predictions and the "measured" values is, however, problematic. A comparison of TAPM-CTM model predictions in the Dampier region showed similar levels to those predicted by SKM (2009a) which predicted a similar shape with maxima of 35 mg/m^2/year or 0.35 kg/ha/year.

These predictions are, however, about a factor of 10 lower than the BRAMMC "measurements". The maximum predicted deposition on land is 0.35 kg/ha/yr with the predictions at the monitoring sites nearer the Karratha Gas Plant being about 0.13 kg/ha/year, compared to the "monitored" BRAMMC values of 2.4 to 3.4 kg/ha/year. The reasons for the much lower predictions over land by TAPM-CTM and TAPM in SKM (2009a) compared to the earlier modelling (SKM, 2003b) and the BRAMMC "measurements" is considered due possibly to two factors (Cope, 2010):

1. That the BRAMMC values were based on annual average deposition velocities and monthly average concentrations. Use of the product of long term (monthly to annual) deposition and concentration parameters to estimate deposition can lead to over estimates of the deposition when the short term (hourly) concentration peaks are out of phase with the peaks in the dry deposition velocity. Modelling of this effect for a location on the Burrup Peninsula using TAPM-CTM suggested that the magnitude of this effect is about a factor of two; and
2. The calculated deposition velocities to the surface are very dependent on the intake (or deposition) by vegetation. It is thought that the BRAMMC deposition values may have been based on estimates for unstressed vegetation which are around a factor of 5 times higher than that used in the TAPM and TAPM-CTM that uses lower vegetation coverage and accounts for vegetation stress.

For over-water deposition, there is no measured data available. In terms of comparing modelling predictions near Dampier, the TAPM-CTM predictions over-water were much lower than from TAPM.

In this study to provide deposition estimates on the regional scale and locally, TAPM-CTM has been used as:

- It can importantly model a wider range of N and S species and both gaseous and aerosol species that TAPM does not include; and
- It is considered to more accurately predict theses species than TAPM has having more rigorous chemistry module.

It is noted that from the above brief review that deposition modelling is to a degree uncertain and therefore should be used only as indicative predictions.

5 Model Validation against Meteorology

5.1 Overview

The ability of TAPM to predict meteorological variables has been verified at numerous sites around the world (Hurley et al, 2004 and 2008). For the Dampier and Karratha region, TAPM has also been the subject of numerous validations as described in Physick and Blockley (2001), Hurley, et al, (2003) and Hurley et al, (2004). For this study, the model predictions have been compared against Barrow Island data and to upper air data at Karratha to verify the ability of the model to accurately predict winds and temperatures.

5.2 Comparison at Barrow Island

Good quality meteorological measurements available at Barrow Island are summarised in **Table 5-1.**

Table 5-1 Meteorological Monitoring on Barrow Island

Monitoring Site	Easting [1] GDA94 (m)	Northing [1] GDA94 (m)	Elevation (m ahd)	Averaging Period	Comments	Parameters Measured	Period
WA Oil Base	Central Location	Central Location	~60	10 min	Robust wind sensors but not Air Quality Grade	WS and WD at 10m,	1980s to Aug 2002 [3]
BoM Airport	~334,340	~7,691,940	6	10 min every 30 minutes	Robust wind sensors but not Air Quality Grade	WS and WD at 10m, AT, RH, BP, Rainfall	From 1996
Gorgon Project Met Station	335,886	7,701,424	33	10 min	Air Quality Grade Instrumentation	WS and WD at 10m, AT at 2 and 10m, RH, BP, SR, Rainfall	16 Dec 2009 onwards

Notes:

1) Co-ordinates Zone 50.
2) WS-wind speed; WD-wind direction; AT-air temperature; RH-relative humidity; BP-barometric pressure; SR-solar radiation.
3) WA Oil base data from March 1999 to decommissioning in August 2002 was very patchy.

The Bureau of Meteorology (BoM) measurements are part of the national system of automatic weather stations and was installed at Barrow Island in late 1996. Of most importance for air quality, the surface (10m) wind data is collected using a Synchrotac 706 wind sensor, which though appropriate for measuring typical and strong winds, has a reasonably high stalling speed of 0.7 to 1.0 m/s. Therefore, the sensor overstates the frequency of calm winds. The wind sensor is also only several hundred metres from the coast and therefore for easterly winds, reflect somewhat over-water wind speeds. The wind measurements at the site do, however, provide data over a long period which can be used to assess the annual variation of winds.

The Gorgon meteorological station was installed in December 2009 specifically for air quality modelling and includes instrumentation that is more sensitive. In particular, the wind sensors (Climatronics F460) have very low stalling thresholds of 0.22 m/s and the temperature measurements at 2 and 10m are undertaken using aspirated shields. The WA Oil site was located at their base in the middle of the island and also consists of a Synchrotac anemometer. As such, it is a designed for moderate to extreme measurements.

Therefore, for comparison to winds and temperature, it is considered that the air quality grade measurements collected for Gorgon are the best available. A comparison of the 10m wind data observed and predicted at the Gorgon monitoring site for 2010 is presented in **Figure 5-1** and **Figure 5-2**.

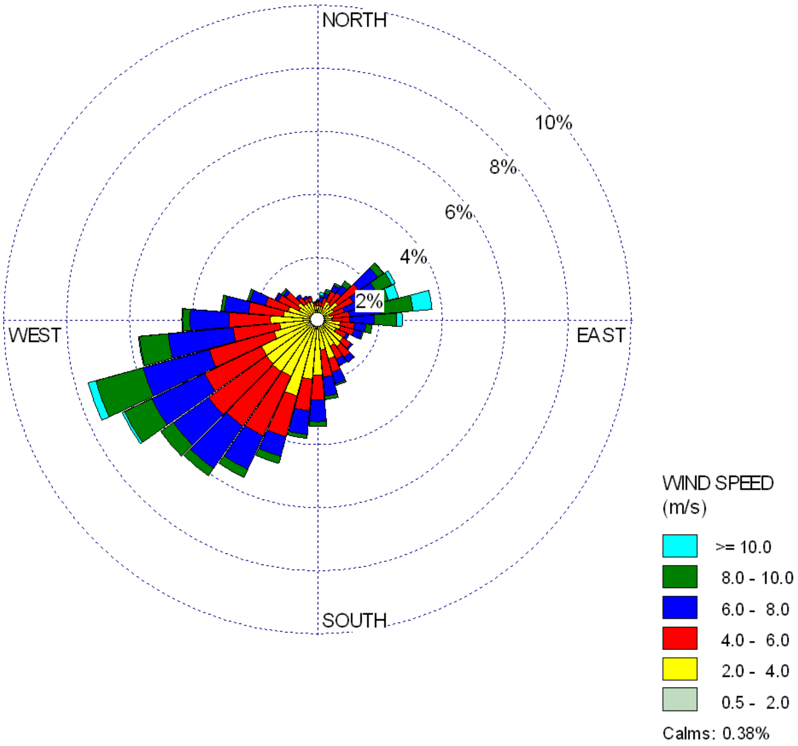

Figure 5-1 Annual (1 Jan to 21 Dec 2010) Wind Rose for the Gorgon Site

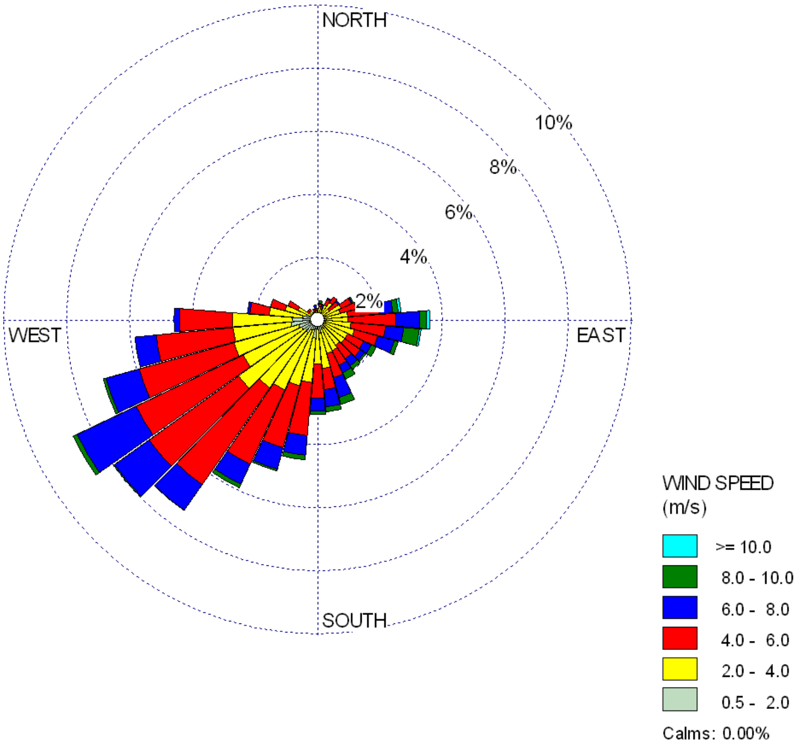

Figure 5-2 Annual (1 Jan to 21 Dec 2010) Wind Rose Predicted by TAPM for the Gorgon Site

Figure 5-1 and **Figure 5-2** show overall good agreement in the wind directions, though TAPM under-predicts the strength of the winds at this site at 10m. This is further illustrated in **Figure 5-3**.

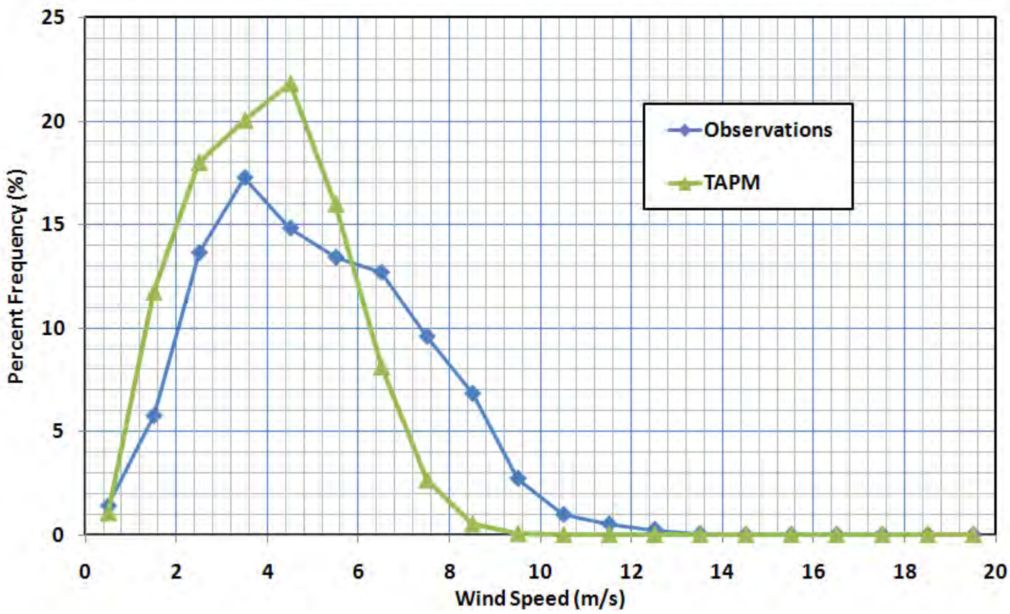

Figure 5-3 Annual wind speed histogram observed and predicted at the Gorgon site for 2010

Ambient air temperatures which are less important in terms of dispersion from the very buoyant plumes are reasonably well predicted by TAPM as indicated by the temperature scatter plot in **Figure 5-4**.

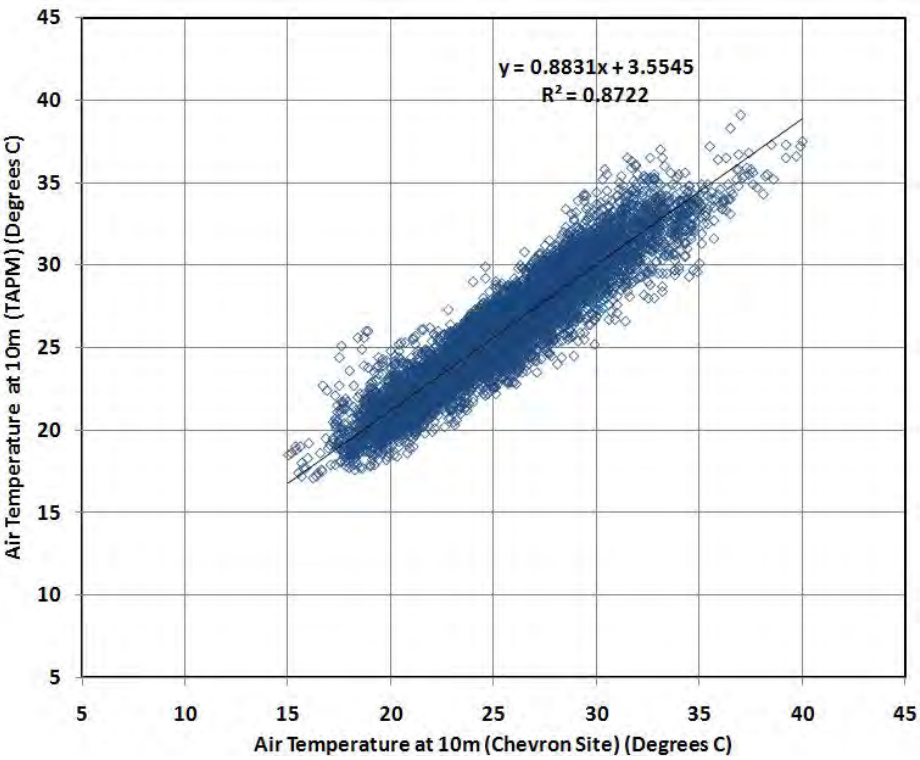

Figure 5-4 Observed and Predicted Air temperatures at 10m at Barrow Island – Gorgon site for 2010

5.2.1 Comparison of Karratha Upper Winds

The under-prediction of the stronger winds at the surface is a common feature of TAPM for areas with low surface roughness. TAPM does however, predict the winds at greater height above ground level where the plumes from the LNG plant will be primarily advected and dispersed, well. A comparison of the wind speeds at the "Karratha" DEC monitoring site which had a wind sounding system (SODAR) is presented in **Figure 5-5**. This indicates under-prediction at 10m whilst showing good agreement for the available winds at100 and 200 m. Therefore it is considered that though TAPM has a tendency to under-predict the surface winds for areas of low surface roughness but it performs reasonably well at higher heights which are important for the sources modelled in this study.

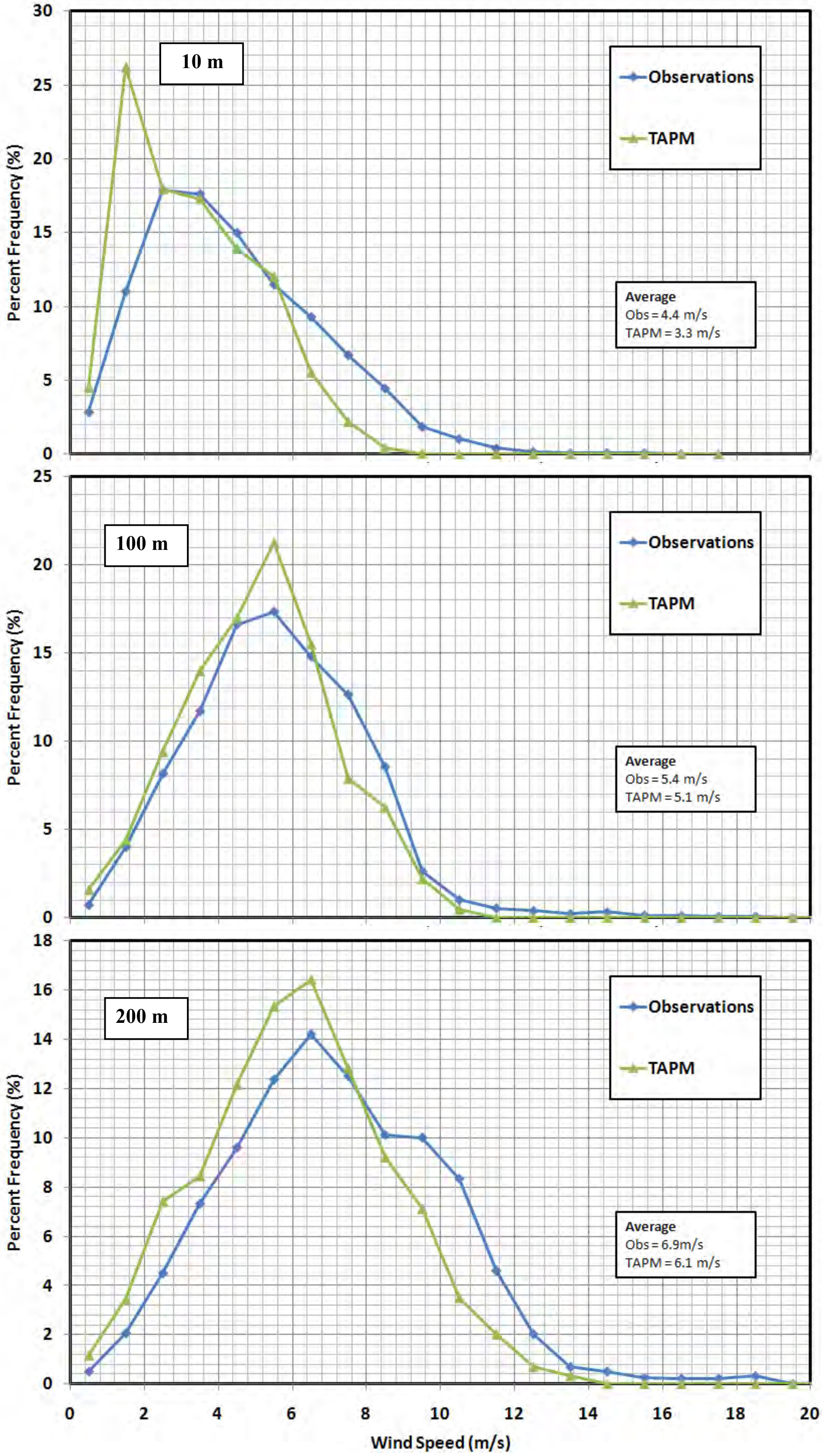

Figure 5-5 Observed and Predicted Annual Wind Speeds at the "Karratha" DECs monitoring site for 1999

6 Predicted Local Concentrations

6.1 Introduction

The following sections present the predicted local concentrations of NO_2, CO, SO_2, PM_{10} and $PM_{2.5}$ using the model TAPM.

The results from modelling the Project's emissions in isolation, such that it is easier to see the Project's contribution, are presented in **Section 6.2**. The predicted maximum concentrations that occur anywhere on the model grid are summarised in **Table 2-1**, followed by concentration contours of the species closest to their respective criteria for:

- Foundation Project (Scenario 1);
- Fourth Train Proposal - routine operations (Scenarios 2a/2b[2] and 2c); and
- Fourth Train Proposal - non-routine operations – Scenario 4. Scenario 3 is not required as the emissions of the pollutants modelled are the same as for Scenario 1.

The results from modelling the Project's emissions with the addition of existing concentrations in order to present the cumulative concentrations are presented in **Section 6.3**.

In this local modelling, "local" is defined as within 10 km of the plant where the maximum concentrations of these pollutants occur. (Concentrations of ozone are presented in **Section 7** using TAPM-CTM to predict concentrations on the regional scale to include the interaction with regional sources, as the peak concentrations may occur up to 100 km away from the source).

Other local pollutants such as BTEX and H_2S are not addressed in this assessment as the major sources from the Gorgon Gas Development are from heavier than air releases and in some cases, near sonic releases. These have been addressed for the Foundation Project using models such as Canary (Chevron, 2011).

For the particulate predictions, fugitive particulate such as from vehicular activity are not included in the predictions. Fugitive particulate is instead addressed through the Gorgon Gas Development dust monitoring program as this will provide actual concentrations. (The estimation of particulate emissions from fugitive sources for modelling purposes is difficult).

6.2 Predictions from the Project Alone

6.2.1 Summary of Maximum Predicted Concentrations

Predicted maximum concentrations that occur anywhere on the model grid for NO_2, CO, SO_2, PM_{10} and $PM_{2.5}$ are presented in **Table 6-1** and as a percentage of the criteria are presented in **Table 6-2**.

[2] Scenario 2b has the same emissions of NO_X, SO_2, CO and PM as Scenario 2a.

Table 6-1 Predicted Maximum Concentrations Anywhere from the Gorgon Project

Pollutant	Ave. Period	Conc. Statistic	Criteria Value	Units	Foundation Project (Scenario 1)	Fourth Train Proposal		
						Routine no RTO (Scenario 2a/b)	Routine with RTO (Scenario 2c)	Black Start (Scenario 4)
CO	8-hour	Max	9000	ppb	29.5	29.5	29.5	35
NO_2	1-hour	Max	120	ppb	33.4	35.2	35.2	37
	1-year	Ave	30	ppb	1.55	1.56	1.56	NA
SO_2	1-hour	Max	200	ppb	24	24	74	24
	1-day	Max	80	ppb	4.2	4.2	16	4.2
	1-year	Ave	20	ppb	0.13	0.13	1.8	NA
PM_{10}	1-day	Max	50	µg/m^3	0.16	1.6	1.6	2.3
$PM_{2.5}$	1-day	Max	25	µg/m^3	1.6	1.6	1.6	2.3
	1-year	Ave	8	µg/m^3	0.15	0.15	0.15	NA

Notes:
1) Gaseous pollutants converted from µg/m^3 using at 0 deg Celsius and 1 atmosphere.
2) $PM_{2.5}$ have been conservatively assumed equivalent to PM_{10} as the sources are primarily gas fired gas turbines and boilers where the particulate is predominantly less than 2.5 µm.
3) NA, not applicable as most of the modelled start up emissions will only occur for a maximum of 8 hours. The 24-hour estimates have been provided for indicative purposes, but will be overestimates.
4) Excludes existing sources and background levels.

Table 6-2 Predicted Maximum Values Anywhere from the Gorgon Project (Percent of Criteria)

Pollutant	Ave. Period	Conc. Statistic	Criteria	Foundation Project (Scenario 1) (%)	Fourth Train Proposal		
					Routine no RTO (Scenario 2a/b) (%)	Routine with RTO (Scenario 2c) (%)	Black Start (Scenario 4) (%)
CO	8-hour	Max	9000 ppb	0.3	0.3	0.3	0.4
NO_2	1-hour	Max	120 ppb	28	29	29	31
	1-year	Ave	30 ppb	5	5	5	NA
SO_2	1-hour	Max	200 ppb	12	12	37	12
	1-day	Max	80 ppb	5	5	20	5
	1-year	Ave	20 ppb	0.7	0.7	9	NA
PM_{10}	1-day	Max	50 µg/m^3	3	3	3	5
$PM_{2.5}$	1-day	Max	25 µg/m^3	6	6	6	9
	1-year	Ave	8 µg/m^3	2	2	2	NA

Notes:
1) Gaseous pollutants converted from µg/m^3 using at 0 deg Celsius and 1 atmosphere.
2) $PM_{2.5}$ have been conservatively assumed equivalent to PM_{10} as the sources are primarily gas fired gas turbines and boilers where the particulate is predominantly less than 2.5 µm.
3) NA, not applicable as most of the modelled start up emissions will only occur for a maximum of 8 hours. The 24-hour estimates have been provided for indicative purposes, but will be overestimates.
4) Excludes existing sources and background levels.

6.2.2 Foundation Project (Scenario 1)

Figure 6-1 to **Figure 6-7** present the concentration contours of the species closest to their respective criteria.

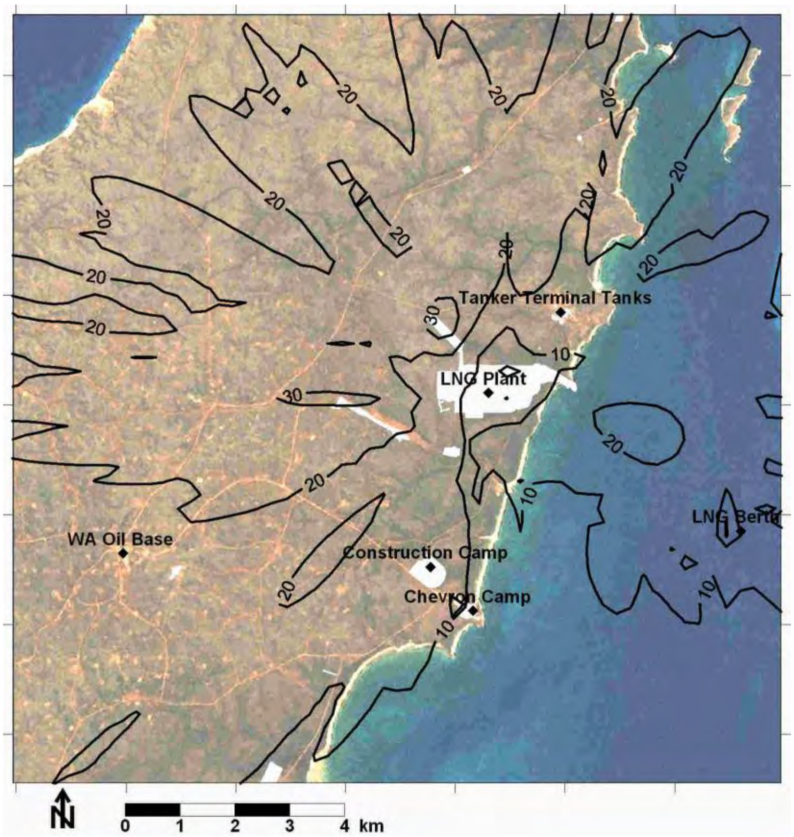

Figure 6-1 Predicted maximum 1-hour NO_2 concentrations (ppb) from the Foundation Project Routine operations

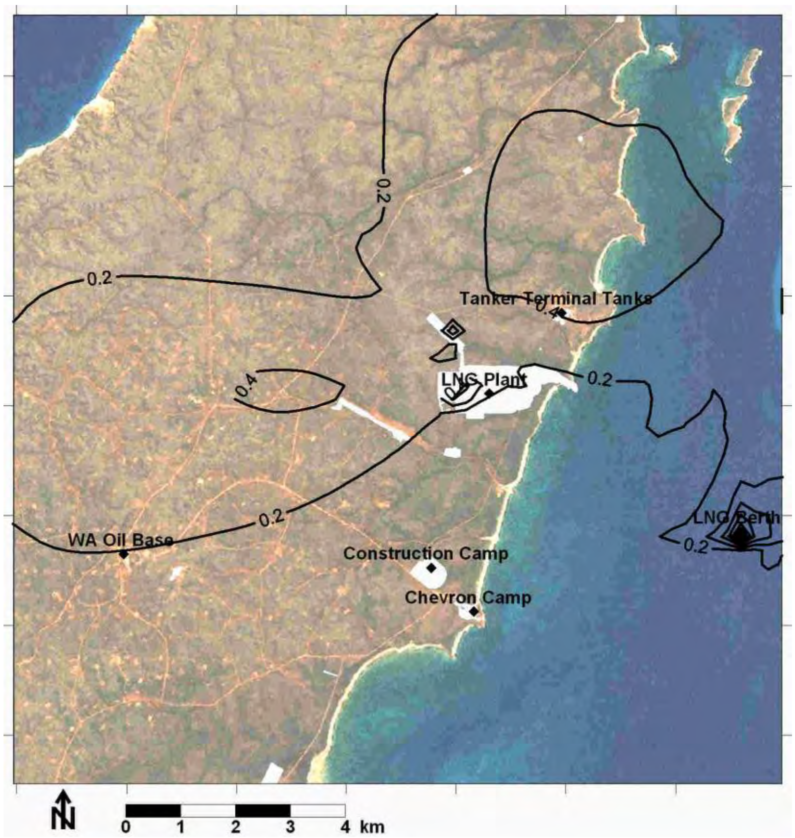

Figure 6-2 Predicted maximum annual average NO_2 concentrations (ppb) from the Foundation Project – Routine operations

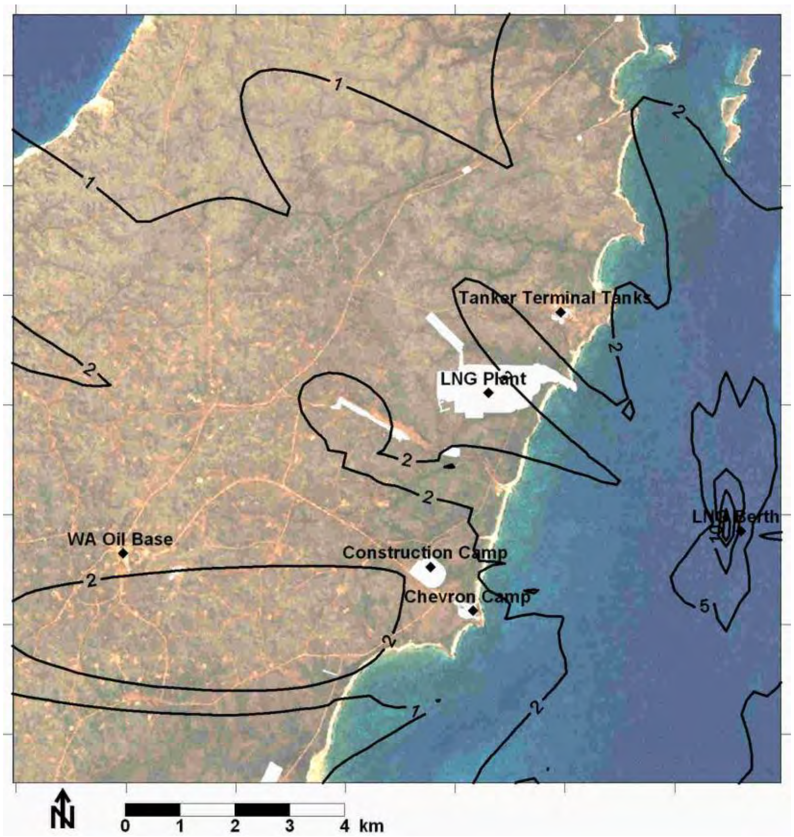

Figure 6-3 Predicted maximum 1-hour SO_2 concentrations (ppb) from the Foundation Project – Routine operations

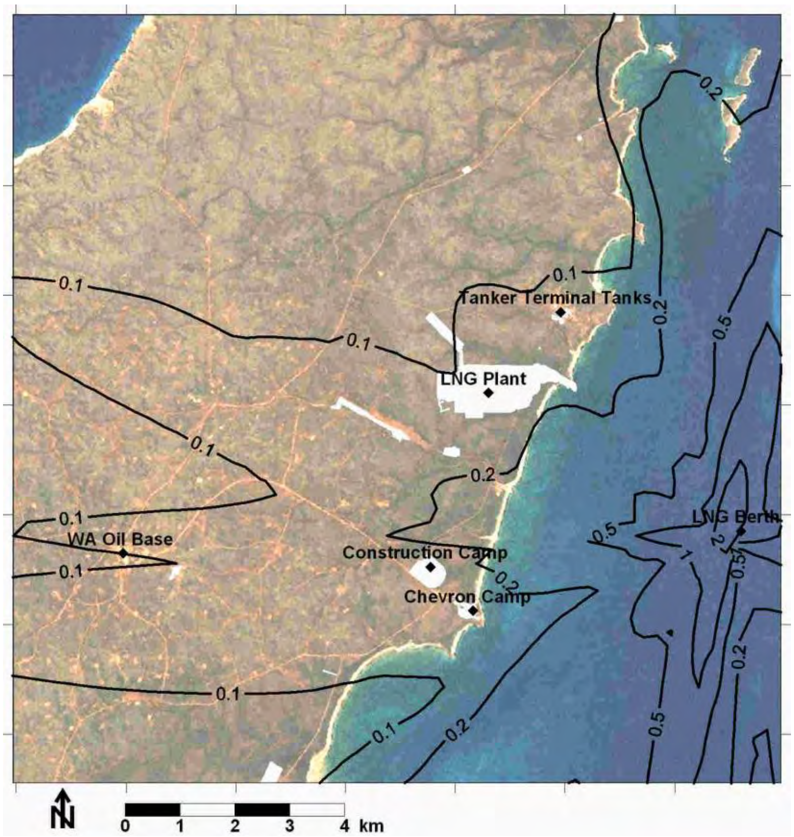

Figure 6-4 Predicted maximum 24-hour SO_2 concentrations (ppb) from the Foundation Project – Routine operations

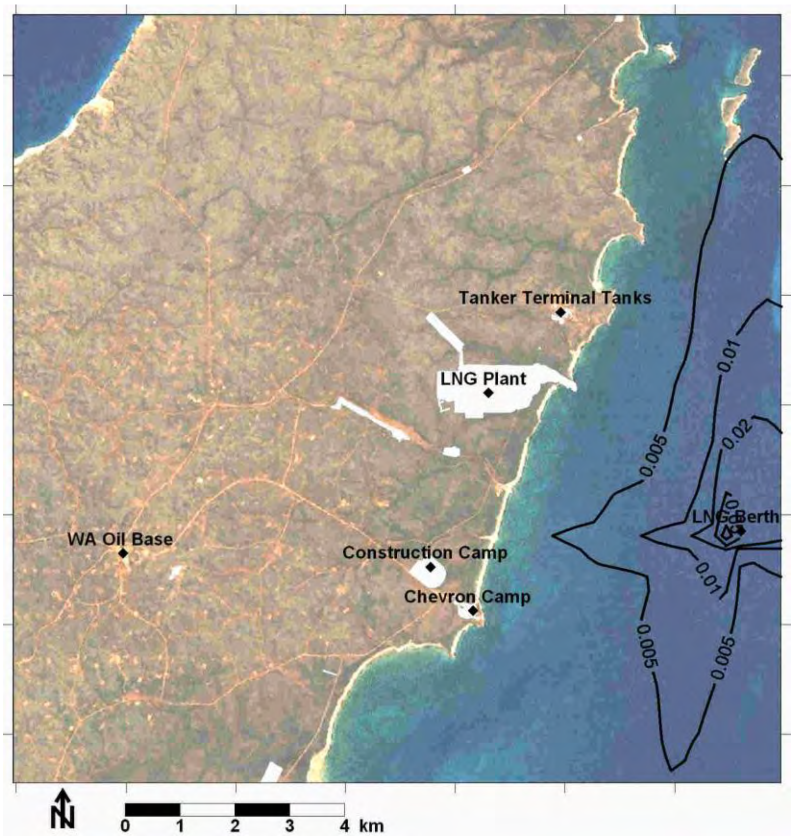

Figure 6-5 Predicted annual average SO_2 concentrations (ppb) from the Foundation Project – Routine operations

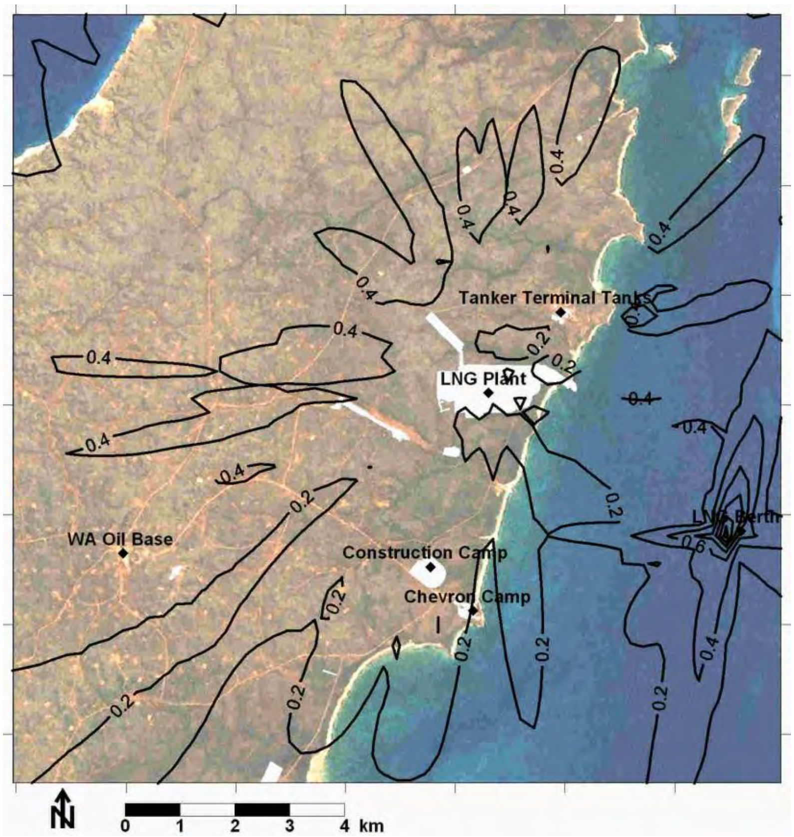

Figure 6-6 Predicted maximum 24-hour PM_{10} (or $PM_{2.5}$) concentrations (µg/m^3) from the Gorgon Gas Development – Routine operations

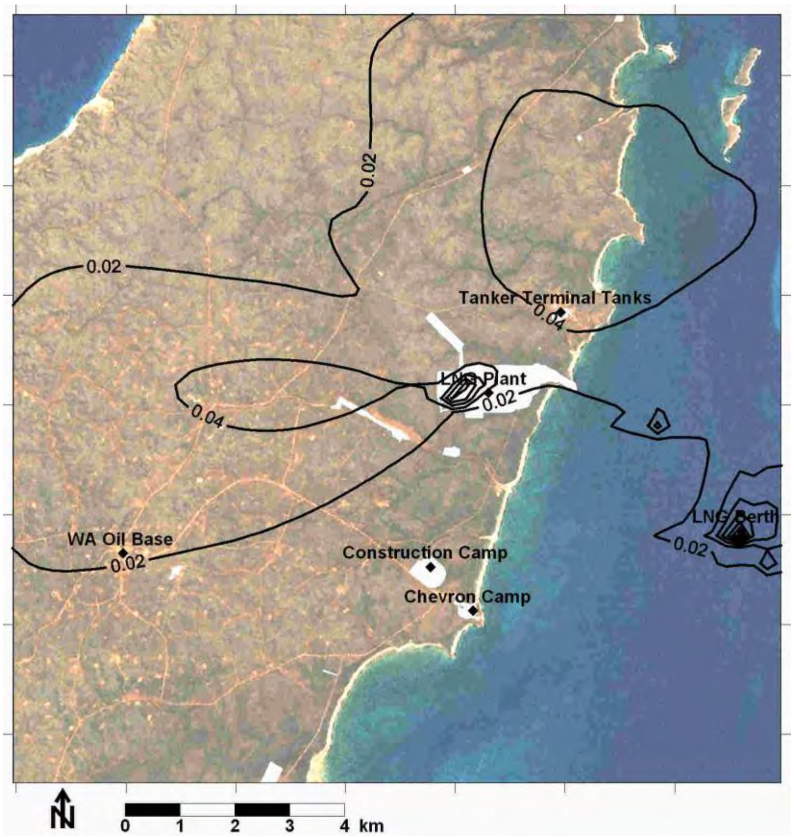

Figure 6-7 Predicted annual average PM_{10} (or $PM_{2.5}$) concentrations (µg/m^3) from the Gorgon Gas Development – Routine operations

Table 6-1 and **Table 6-2** and **Figure 6-1** to **Figure 6-7** indicate that for the Foundation Project's routine operations:

- All pollutants will be well below their respective criteria;
- Of the pollutants, NO_2 is closest to its criteria (28% of the 1-hour maximum) with the major source being the LNG plant;
- SO_2 concentrations are low, contributing at most 12% of the 1-hour criteria, this occurring over-water near the shipping berths, with the major source predicted to be the condensate ships that can use high sulphur fuels (heavy fuel oil). LNG tankers operate on boil-off gas from the LNG tanks and have negligible SO_2 emissions;
- Predicted particulate concentrations are low at 6 and 2 % of the NEPM $PM_{2.5}$ 24-hour and annual reporting standards respectively; and
- The predicted CO concentrations are very low, at most 0.3% of the criterion.

Note that the maximum 1-hour plots do not show a significant relationship to the prevailing wind as individual maxima can occur in any direction. Annual and 24-hour plots however, show the prevalence of prevailing winds with highest concentrations to the north east of the sources.

As a comparison, the concentrations predicted here can be compared to those presented in 2008 (see SKM, 2008a). These will show differences as the modelling system (the model set up, land uses and the year used), the model version (TAPM v4) as well as the emissions for some of the sources have changed. The results noting these changes indicate that:

- The local species NO_2, SO_2 and PM_{10} are all predicted in this study to be higher than predicted in 2008; and
- The only significant difference between this study and the 2008 study for other scenarios was the cold start-up case, where the 2008 study predicted much higher NO_2 concentrations than any of the cases presented here. The higher concentrations are considered to be due to the 2008 cold start up case including a large amount of gas flaring, where it is considered that the impacts from the flaring were overstated by use of a smaller than realistic equivalent diameter of 2.5 m. This small diameter resulted in the buoyancy and plume rise being underestimated.

6.2.3 Fourth Train Proposal - Routine Operation without a RTO on Train 4 (Scenarios 2a/2b)

Predicted maximum concentrations of NO_2, CO, SO_2, PM_{10} and $PM_{2.5}$ anywhere for the Fourth Train Proposal were summarised earlier in **Table 6-1** and **Table 6-2**. Plots of the pollutants nearest the criteria are presented in **Figure 6-8** to **Figure 6-14**.

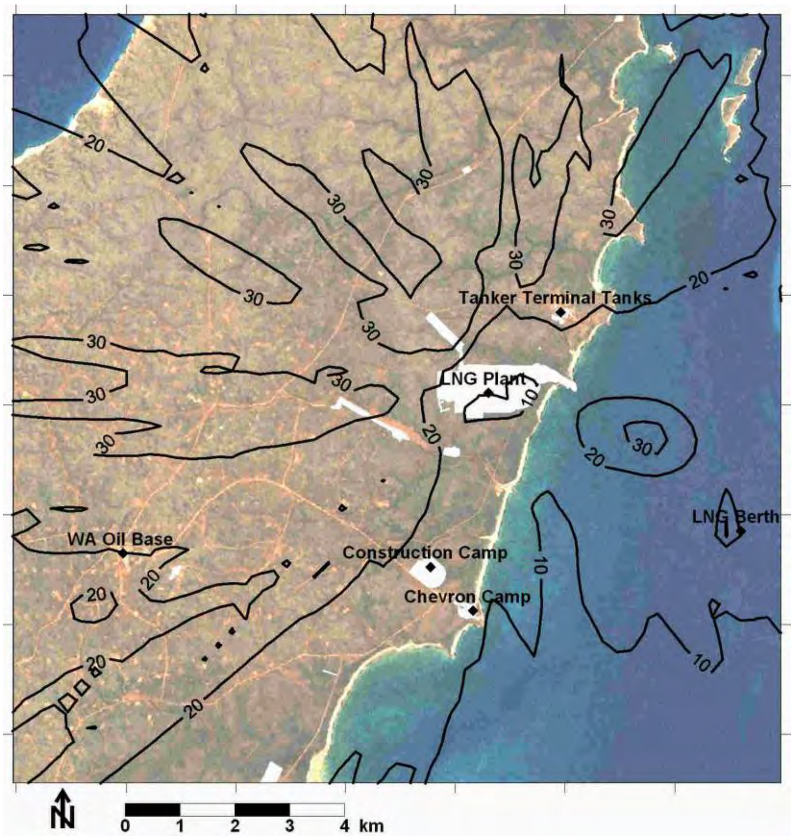

Figure 6-8 Predicted maximum 1-hour NO_2 concentrations (ppb) from the Fourth Train Proposal – Routine operations with no RTO

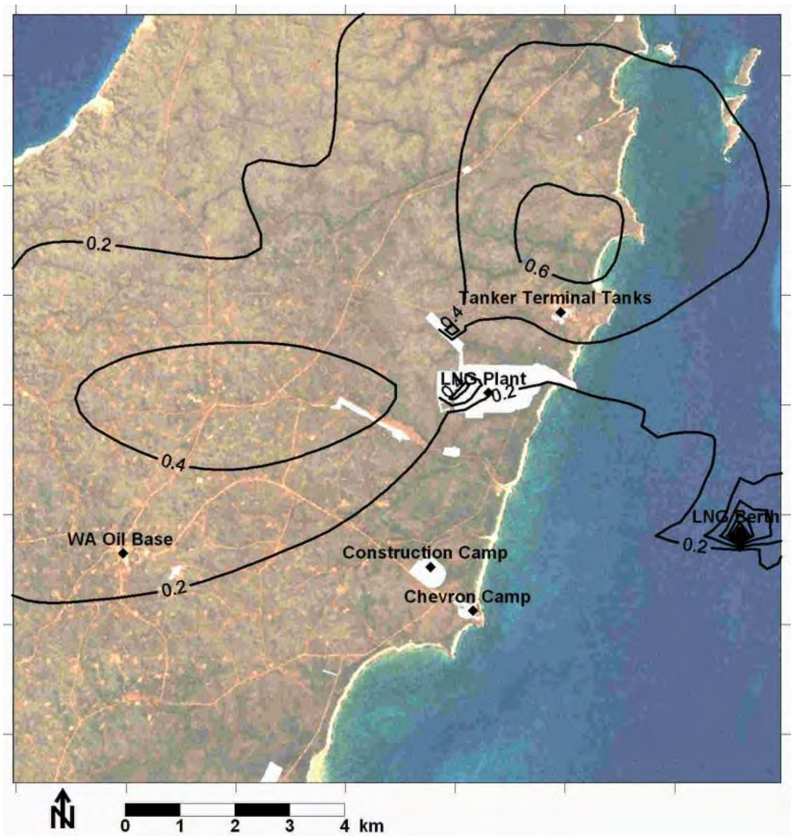

Figure 6-9 Predicted maximum annual average NO_2 concentrations (ppb) from the Fourth Train Proposal – Routine operations with no RTO

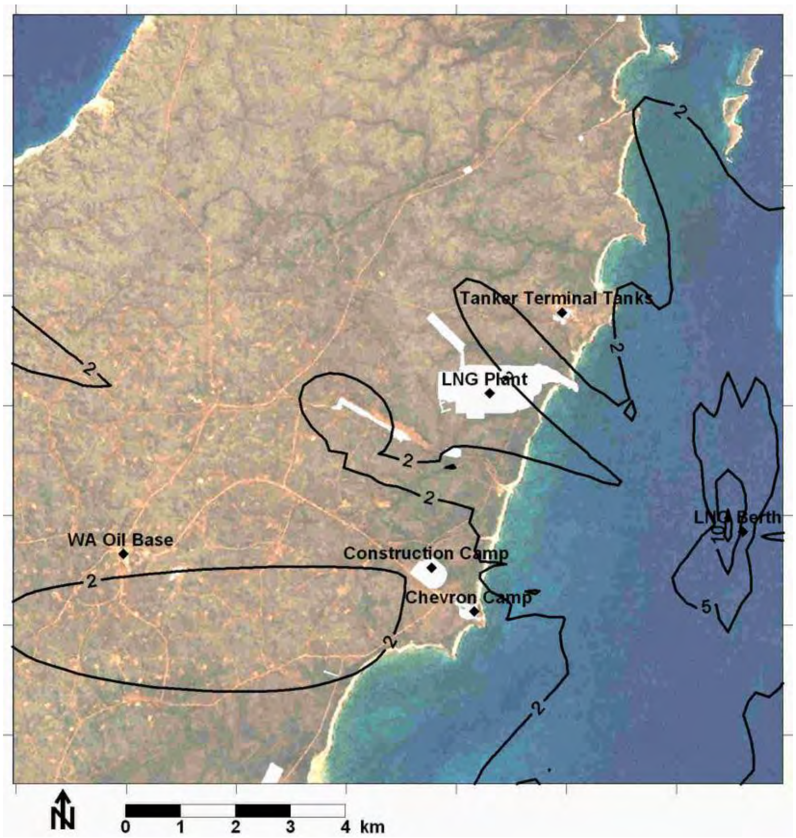

Figure 6-10 Predicted maximum 1-hour SO_2 concentrations (ppb) from the Fourth Train Proposal – Routine operations with no RTO

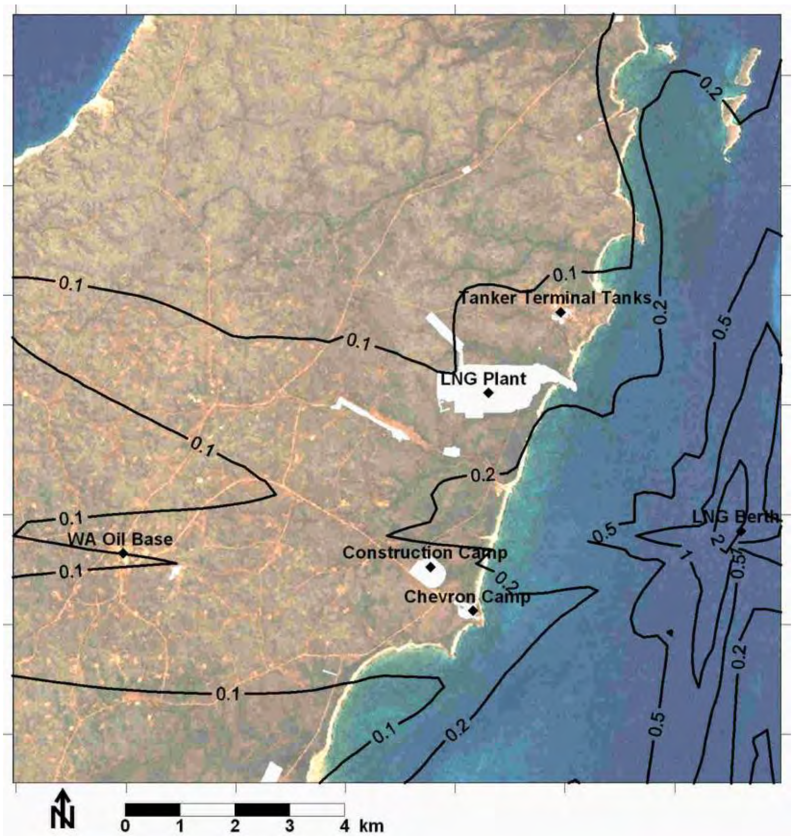

Figure 6-11 Predicted maximum 24-hour SO_2 concentrations (ppb) from the Fourth Train Proposal – Routine operations with no RTO

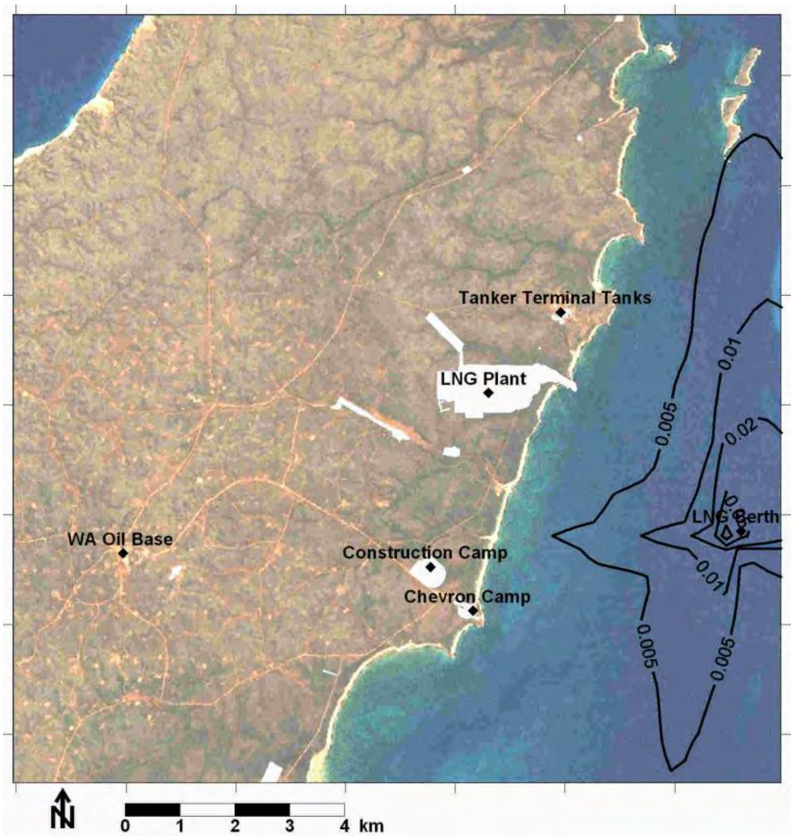

Figure 6-12 Predicted annual average SO_2 concentrations (ppb) from the Fourth Train Proposal – Routine operations with no RTO

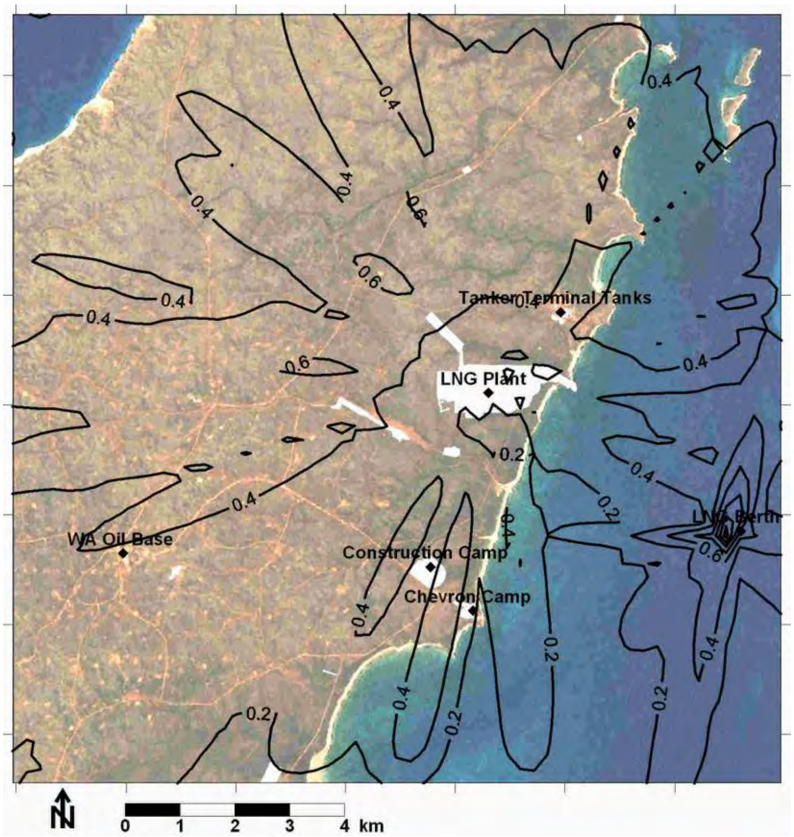

Figure 6-13 Predicted maximum 24-hour PM_{10} (or $PM_{2.5}$) concentrations (µg/m^3) from the Fourth Train Proposal – Routine operations with no RTO

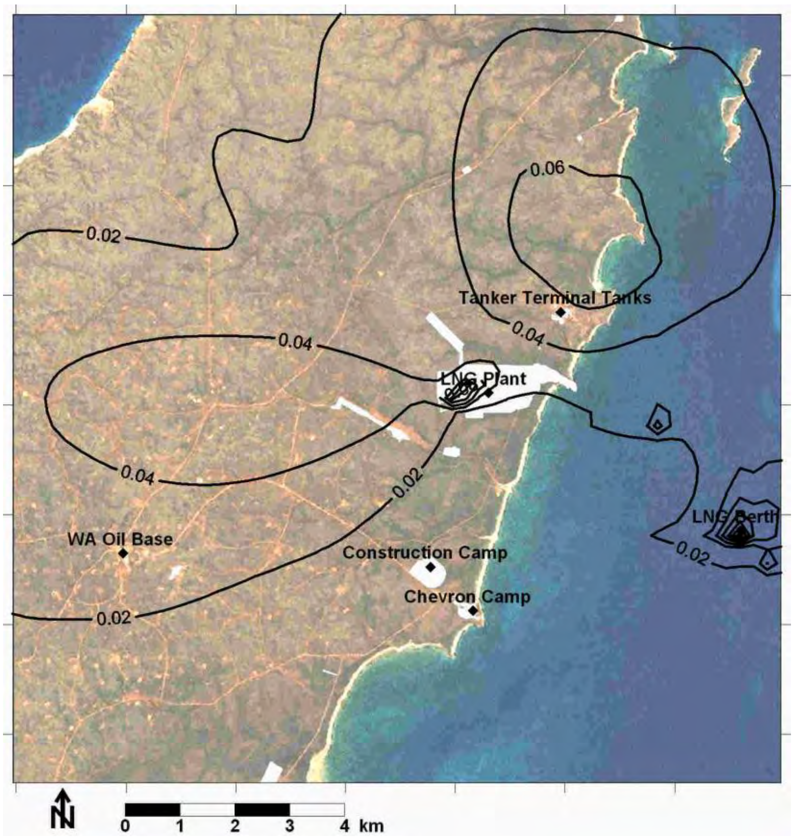

Figure 6-14 Predicted annual average PM_{10} (or $PM_{2.5}$) concentrations (µg/m^3) from the Fourth Train Proposal – Routine operations with no RTO

Table 6-1 and **Table 6-2** and **Figure 6-8** to **Figure 6-14** show that under routine operations, there will be negligible changes in the pollutant concentrations except for the 1-hour NO_2 concentrations which increase from 28 to 29% of the criteria. The change is small because emissions of SO_2, CO and PM, from the new gas turbines will add little to existing emissions.

6.2.4 Fourth Train Proposal - Routine Operation with a RTO on Train 4 (Scenario 2c)

Predicted maximum concentrations with a RTO installed to treat the AGRU emissions for the proposed Fourth Train are summarised in **Table 6-1** and **Table 6-2**. This shows negligible change to the concentrations predicted without an RTO except for the SO_2 concentrations. Contour plots of SO_2 presented in **Figure 6-15** to **Figure 6-17**.

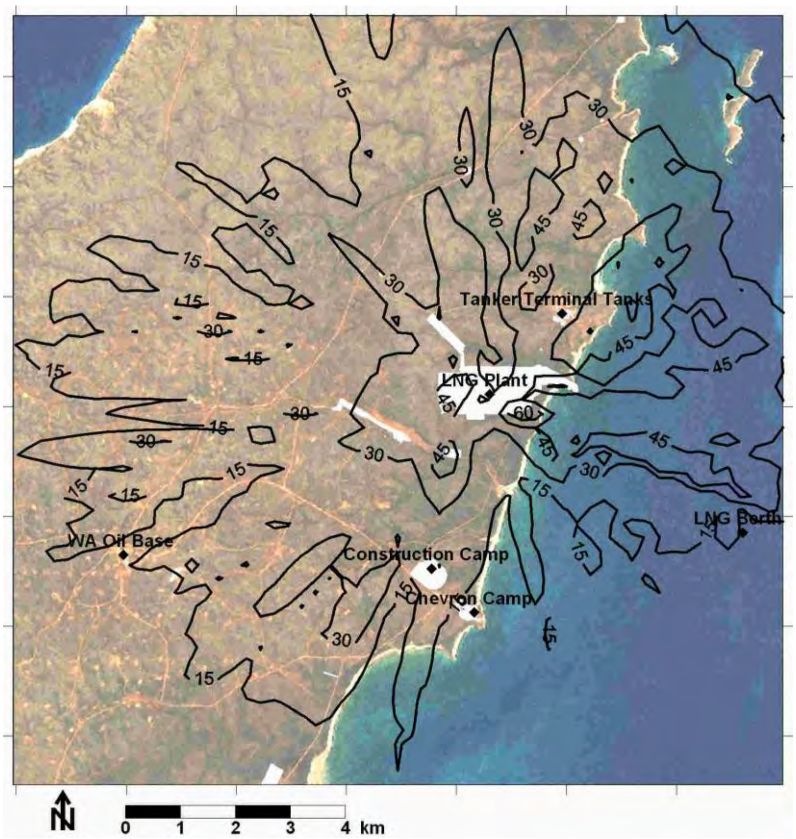

Figure 6-15 Predicted maximum 1-hour SO_2 concentrations (ppb) from the Fourth Train Proposal with an RTO for train 4

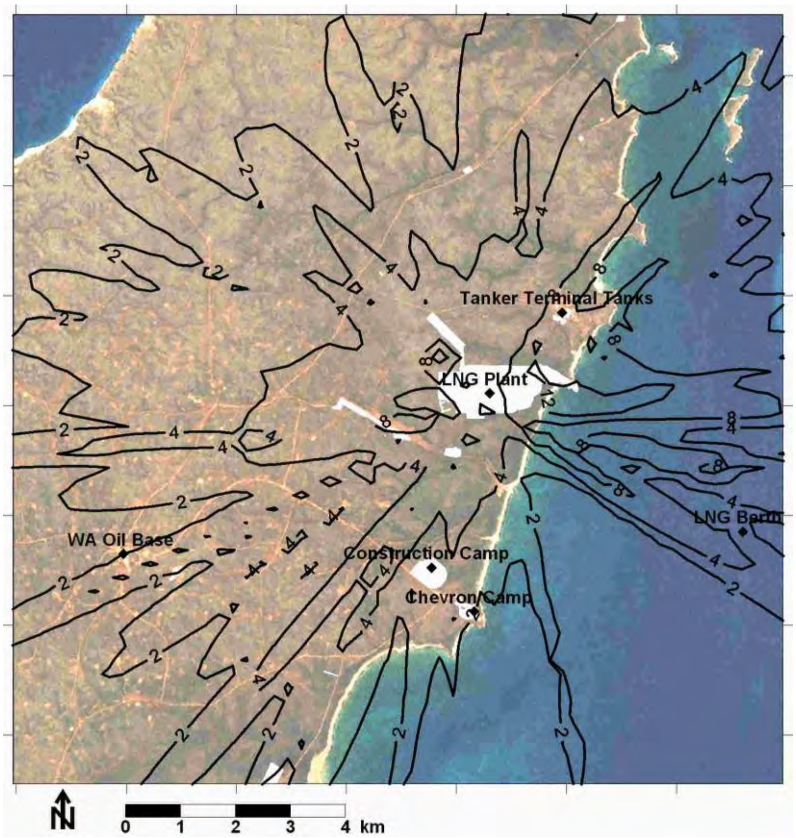

Figure 6-16 Predicted maximum 24-hour SO_2 concentrations (ppb) from the Fourth Train Proposal with an RTO for train 4

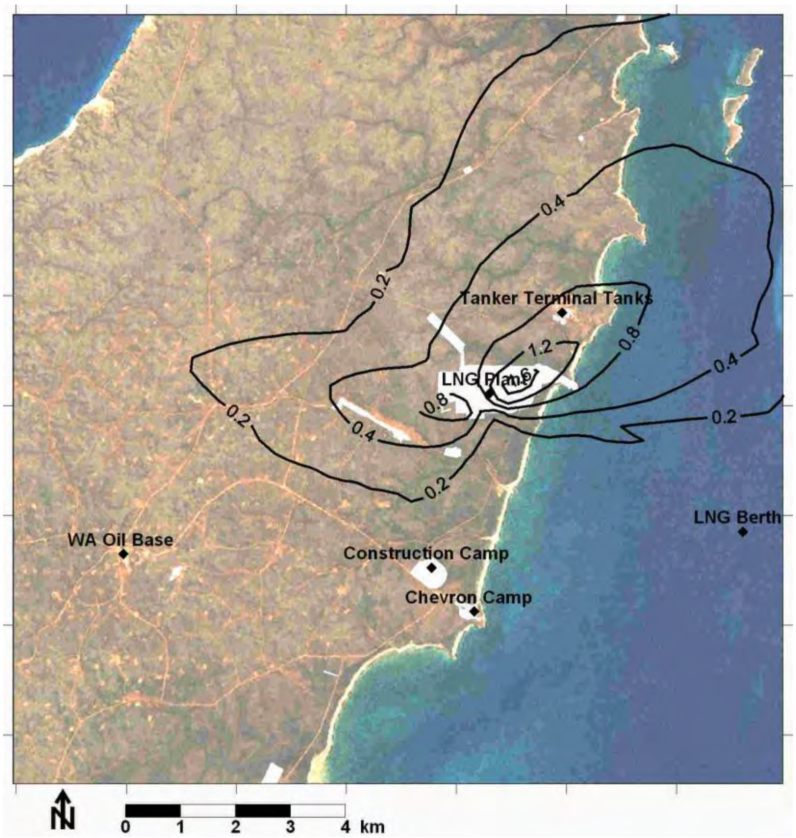

Figure 6-17 Predicted annual average SO_2 concentrations (ppb) from the Fourth Train Proposal with an RTO for train 4

Table 6-1 and **Table 6-2** and **Figure 6-15** to **Figure 6-17** indicate that with a RTO, the SO_2 concentrations will increase to 37, 20 and 9% of the NEPM 1-hour, 24-hour and annual standards respectively. This large increase occurs because the RTO is the largest source of SO_2 at the LNG plant as it oxidizes the H_2S in the AGRU gas stream to SO_2.

6.2.5 Fourth Train Proposal - Non Routine Operation – Black Start (Scenario 4)

Predicted maximum concentrations for a black start, modelled as if it occurred continuously for the whole year were presented earlier in **Table 6-1** and **Table 6-2**. This assumption of continuous operation is very conservative and will provide the maximum likely 1-hour concentrations that could occur.

The results summarised in **Table 6-1** and **Table 6-2** indicated that the black start will result in a small increase in the maximum CO, NO_2, PM_{10} and $PM_{2.5}$ concentrations over that from routine operations. The maximum 1-hour NO_2 concentration increases from 29 to 31% of the NEPM standard whilst the maximum 8-hour CO concentration increases from 0.3 to 0.4% of its NEPM standard. Contour plots of the maximum 1-hour NO_2 concentrations are presented in **Figure 6-18**. This minor change occurs as although the flaring associated with the black start is a large source of NO_X, CO etc, the very large amount of heat released is predicted to result in very large plume rise, typically of 500 to 1000 m such that the plume is not mixed to the ground.

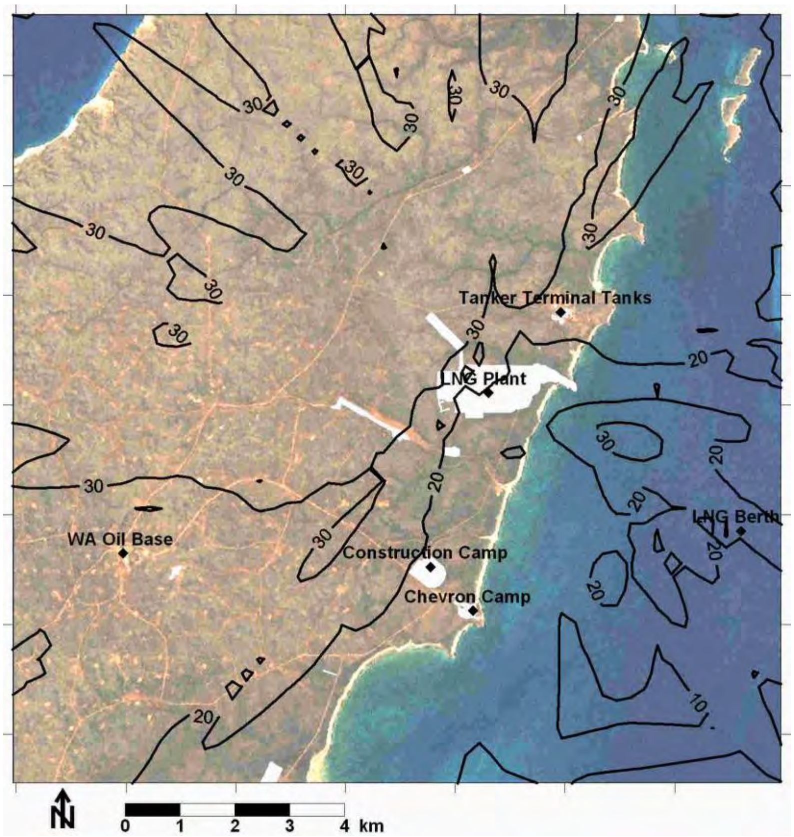

Figure 6-18 Predicted maximum 1-hour NO_2 concentrations (ppb) from the Fourth Train Proposal – Non Routine Operation - Black Start

Contour plots of the maximum 24-hour PM_{10} (or $PM_{2.5}$) concentrations are presented in **Figure 6-19**, though it is emphasised that this will overstate the concentrations as the black start scenario modelled will only last for up to 8-hours.

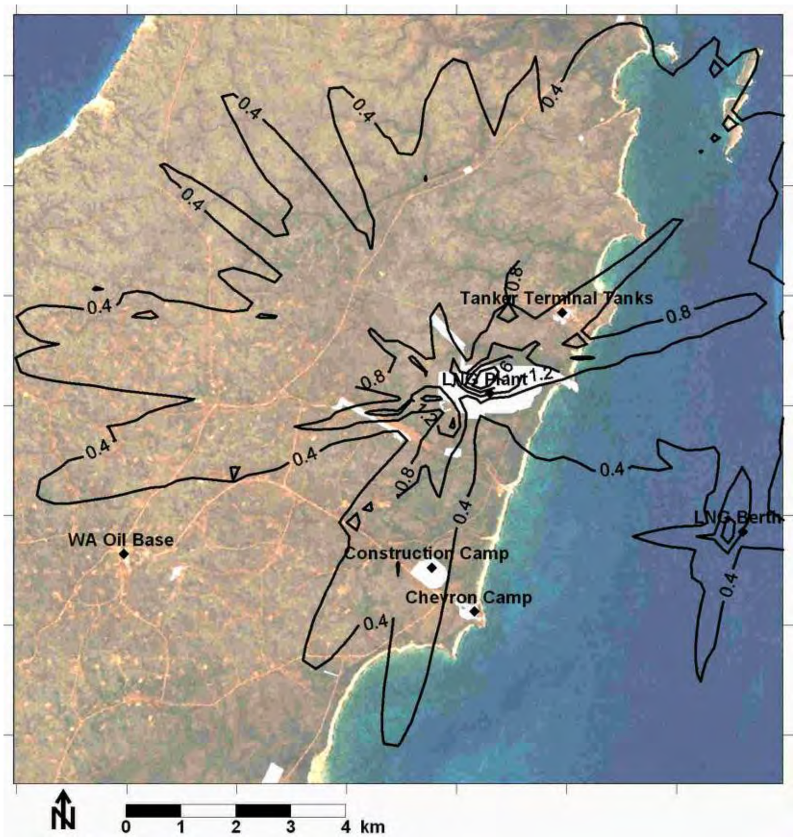

Figure 6-19 Predicted maximum 24-hour PM_{10} (or $PM_{2.5}$) concentrations (µg/m^3) from the Fourth Train Proposal – Non Routine Operation - Black Start

Figure 6-19 indicates that the maximum occurs on site (and therefore strictly should not be compared to the NEPM), though even on site the levels are very low. The source of this additional particulate is considered to be the heater medium heaters used during the start up process.

6.3 Predicted Concentrations with Existing Sources

6.3.1 Summary of Maximum Predicted Concentrations

As detailed in **Section 2.3.1**, existing emission sources on Barrow Island at the time of the Fourth Train Proposal commencement will be the CPS, tanker terminal pump station, tanker terminal diesel generator and the two ground flares. Predicted concentration contours from NO_2 and PM (the pollutants closest to their respective criteria) are summarised in this section with the maximum concentrations at any location on the model grid presented in **Table 6-3** and **Table 6-4**. Contour plots of relevant pollutants and further comments are presented in the following Sections.

The existing concentrations as per the Fourth Train Proposal modelling are predicted using a 250 m grid. This is considered fine enough to resolve the Fourth Train Proposals peak impact. For the existing low stacks subject to building influences, maximum concentration will occur close in to these stacks, most likely within about 20m from the sources and therefore on the WA Oil leases. To model these near-source impacts more accurately, a much finer grid resolution would be required. Such a fine grid is not feasible over the large domain of 14 by 14 km required in the local modelling.

Table 6-3 Predicted Maximum Concentrations from the Fourth Train Proposal and Existing Sources

Pollutant	Ave. Period	Conc. Statistic	Criteria Value	Units	Back-ground	Existing and Bckgnd	Existing and Bckgnd with Foundation Project (S. 1)	Existing and Bckgnd. with Fourth Train Proposal		
								Routine no RTO (S. 2a/2b)	Routine with RTO (S. 2c)	Plant Restart (S. 4)
CO	8-hour	Max	9000	ppb	100	466	467	467	467	466
NO_2	1-hour	Max	120	ppb	2	65	65	65	65	65
	1-year	Ave	30	ppb	1	27	27	27	27	27
SO_2	1-hour	Max	200	ppb	0	0	24	24	74	24
	1-day	Max	80	ppb	0	0	4.2	4.2	16	4.2
	1-year	Ave	20	ppb	0	0	0.13	0.13	1.8	NA
PM_{10}	1-day	Max	50	µg/m^3	27	32.3	32.4	32.4	32.4	32.4
$PM_{2.5}$	1-day	Max	25	µg/m^3	6	11.3	11.4	11.4	11.4	11.4
	1-year	Ave	8	µg/m^3	5	6.8	6.9	6.9	6.9	6.9

Note: Includes background concentrations. These are defined in **Section 4.13** with a 75th percentile value used for the maximum short term predictions and an annual average measured value used for the annual average predictions.

Table 6-4 Predicted Maximum Values (Percent of Criteria) from the Gorgon Project and Existing Sources

Pollutant	Ave. Period	Conc. Statistic	Criteria Value	Units	Back-ground (%)	Existing and back-ground (%)	Existing and Back-ground with Foundation Project (%)	Fourth Train Proposal		
								Routine no RTO (%)	Routine with RTO (%)	Plant Restart (%)
CO	8-hour	Max	9000	ppb	1.1	5.2	5.2	5.2	5.2	5.2
NO_2	1-hour	Max	120	ppb	1.7	54	54	54	54	54
	1-year	Ave	30	ppb	3.3	90	90	90	90	90
SO_2	1-hour	Max	200	ppb	0	0	12	12	37	12
	1-day	Max	80	ppb	0	0	5	5	20	5
	1-year	Ave	20	ppb	0	0	0.7	0.7	9	NA
PM_{10}	1-day	Max	50	µg/m^3	54	65	65	65	65	65
$PM_{2.5}$	1-day	Max	25	µg/m^3	24	45	46	46	46	46
	1-year	Ave	8	µg/m^3	62	85	86	86	86	86

Note: Includes background concentrations. These are defined in **Section 4.13** with a 75th percentile value used for the maximum short term predictions and an annual average measured value used for the annual average predictions.

6.3.2 Existing Sources

A summary of the major pollutants is listed in **Table 6-3** and **Table 6-4** with **Figure 6-20** to **Figure 6-23** presenting the pollutants closest to their criteria, NO_2, PM_{10} and $PM_{2.5}$.

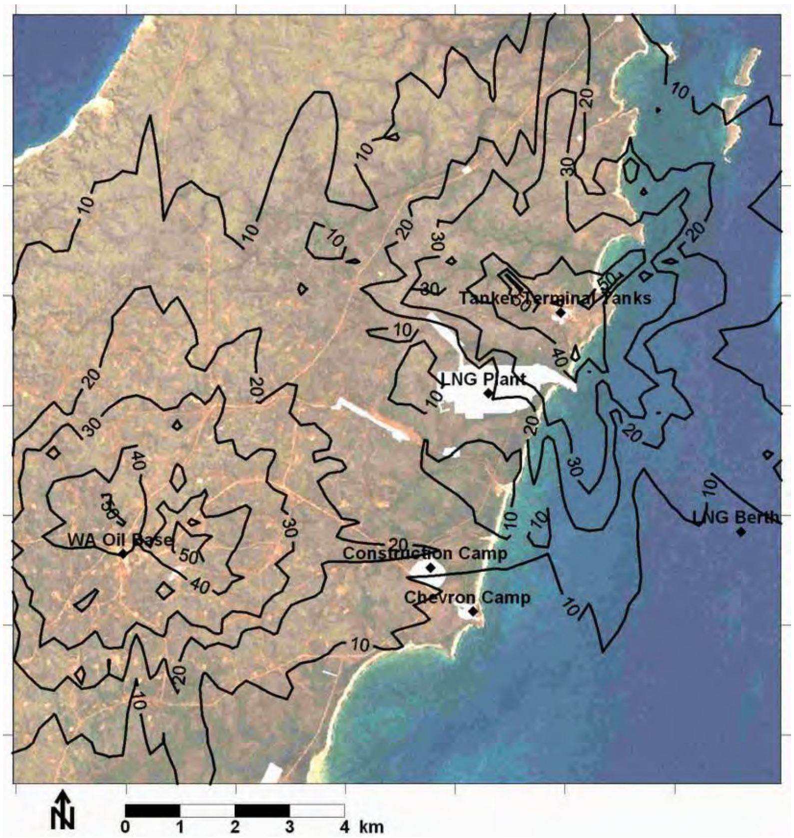

Figure 6-20 Predicted maximum 1-hour NO_2 concentrations (ppb) from WA Oil Sources (excluding background levels)

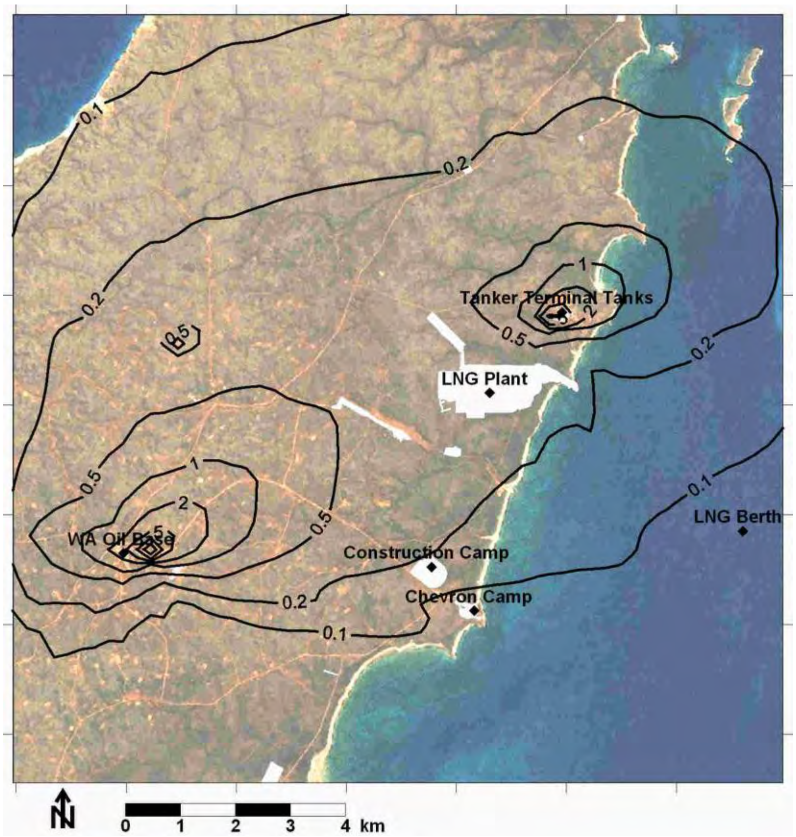

Figure 6-21 Predicted maximum annual average NO_2 concentrations (ppb) from WA Oil Sources (excluding background levels)

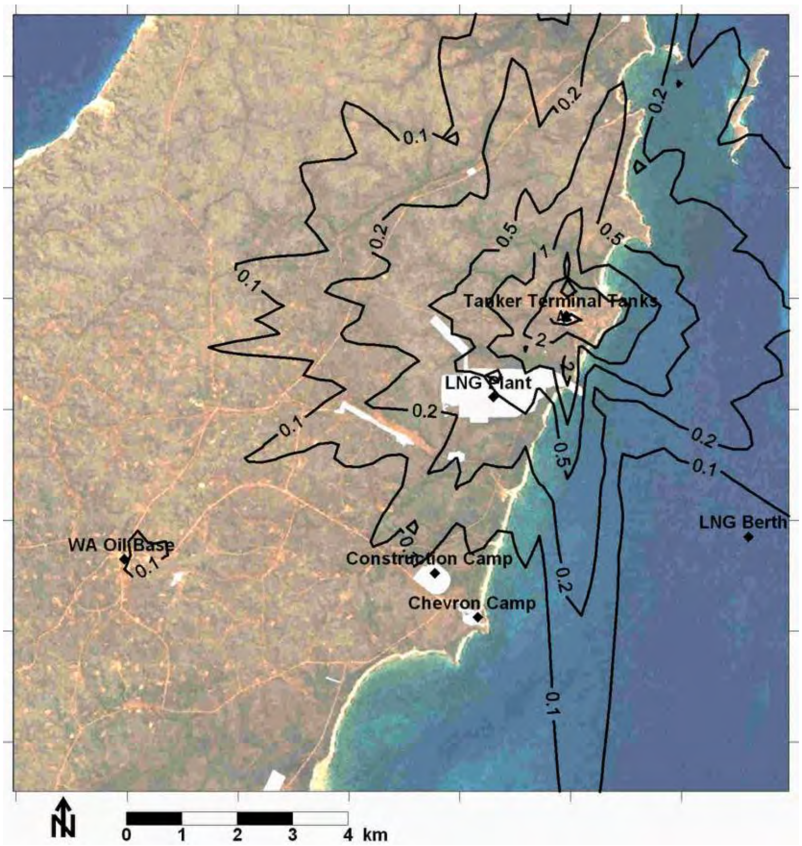

Figure 6-22 Predicted maximum 24-hour PM_{10} (or $PM_{2.5}$) concentrations (µg/m^3) from WA Oil Sources (excluding background levels)

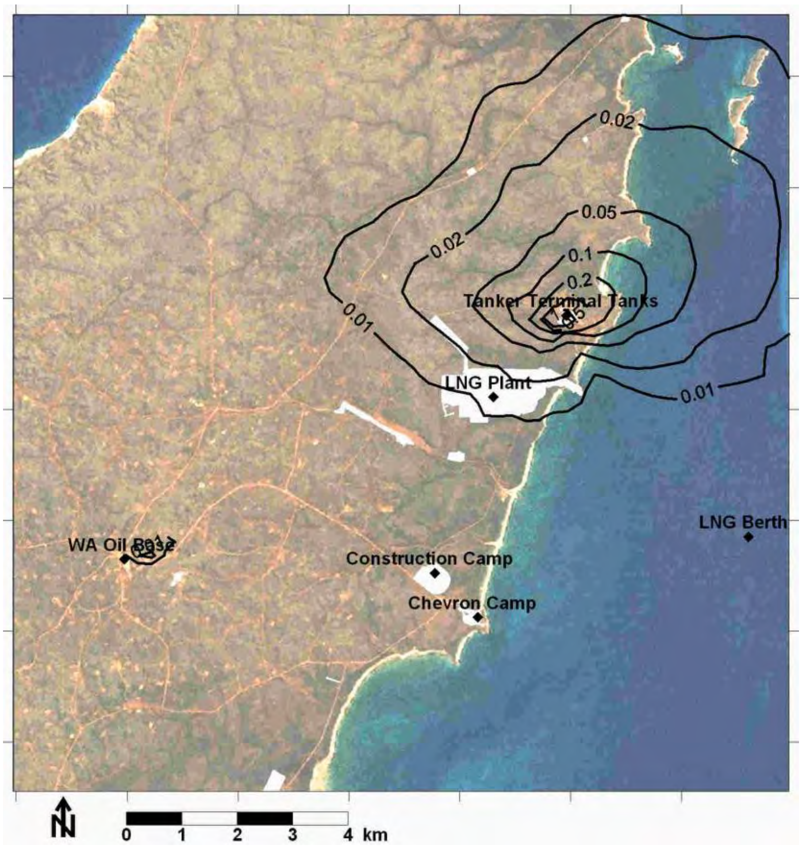

Figure 6-23 Predicted annual average PM_{10} (or $PM_{2.5}$) concentrations (µg/m^3) from WA Oil Sources (excluding background levels)

Table 6-3 and **Table 6-4** and **Figure 6-20** to **Figure 6-23** and indicates that for the existing sources:

- The predicted existing NO_2 concentrations are relatively high at 54% of the 1-hour and 86% of the annual average standards, with these occurring adjacent to the Tanker Terminal sources and the CPS. These high concentrations are therefore predicted to occur for a very small area near these sources; and
- The PM concentrations are also relatively high at 65% of the NEPM PM_{10} standard (using the maximum to compare to the goal) and 85% of the NEPM $PM_{2.5}$ annual reporting standard. This is predicted to occur next to the tanker terminal diesel generator though the majority of the predicted levels is due to background levels.

6.3.3 Foundation Project with Existing Sources

Cumulative concentrations of NO_2 and $PM_{2.5}$ from the Foundation Project's emissions together with the contribution from existing sources including the background are summarised in **Table 6-3** and **Table 6-4** with plots of NO_2 and $PM_{2.5}$ presented in **Figure 6-24** to **Figure 6-27**.

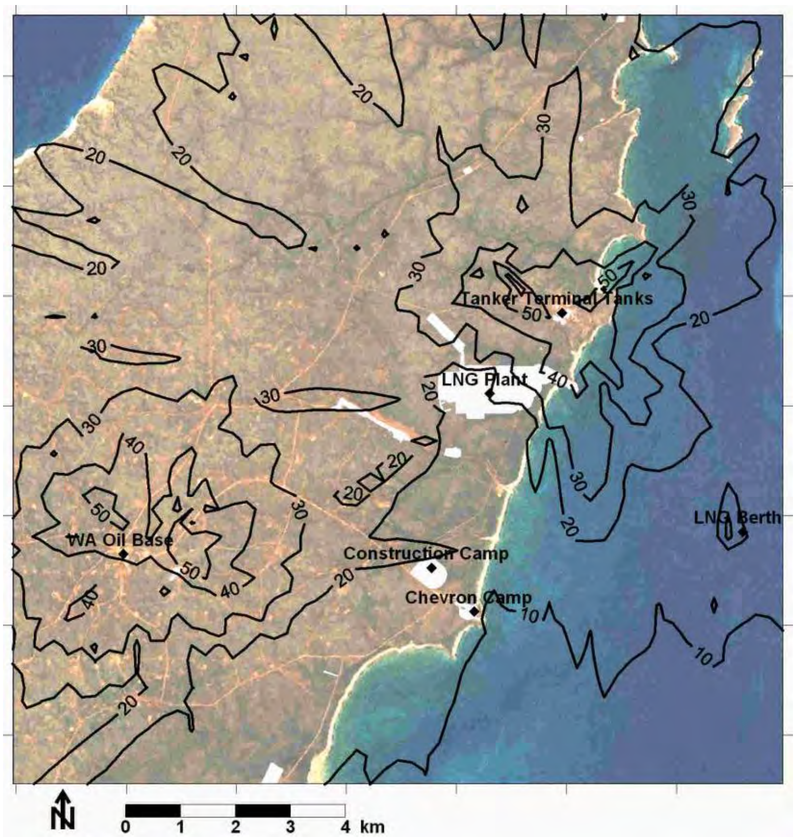

Figure 6-24 Predicted maximum 1-hour NO_2 concentrations (ppb) including existing sources, background levels and the Foundation Project

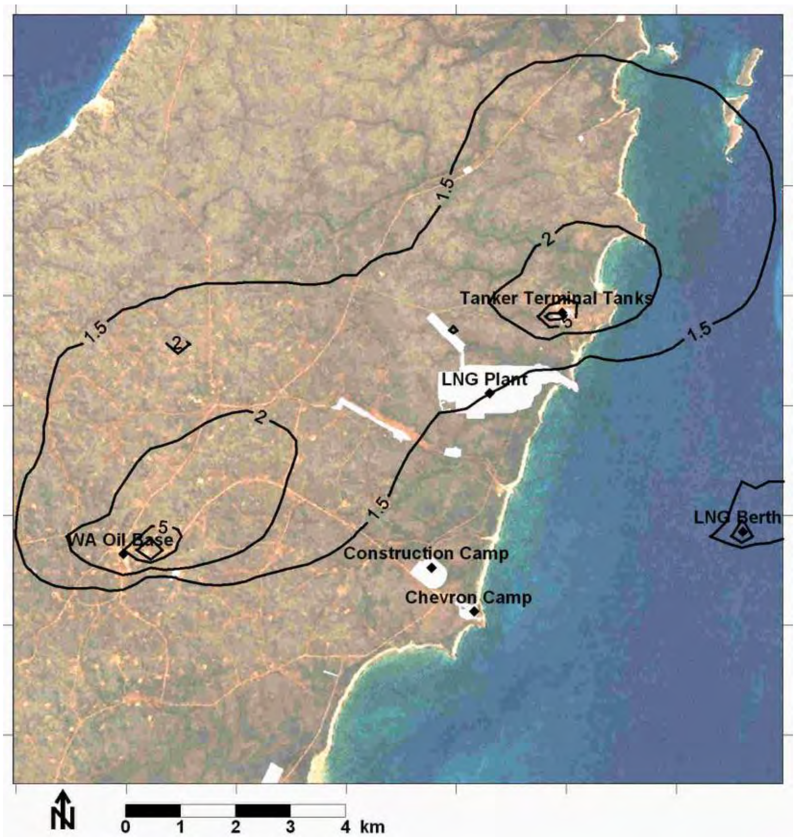

Figure 6-25 Predicted maximum annual average NO_2 concentrations (ppb) including existing sources, background levels and the Foundation Project

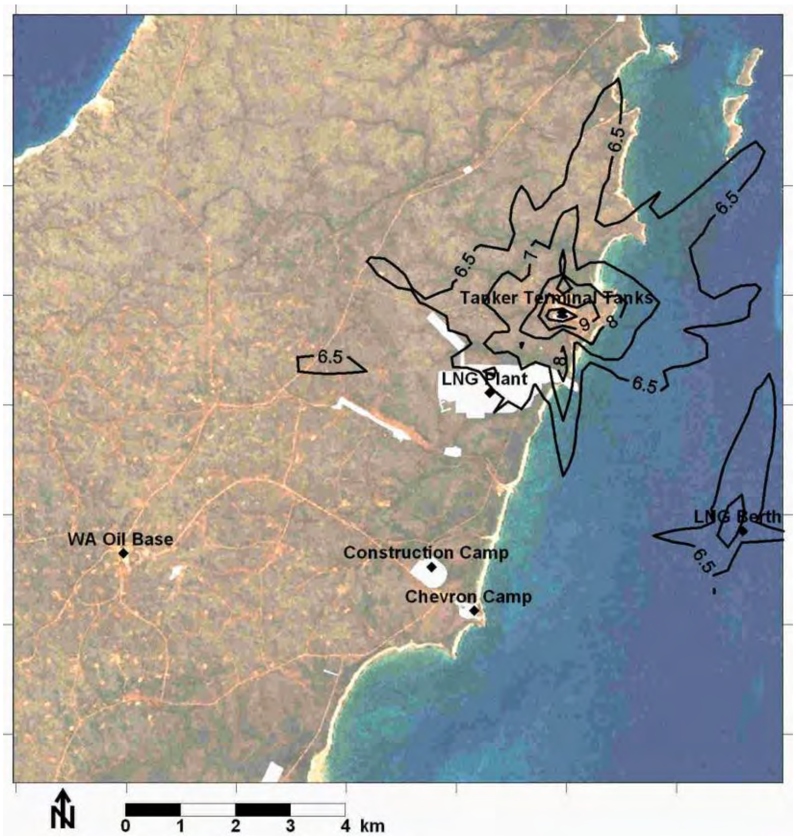

Figure 6-26 Predicted maximum 24-hour $PM_{2.5}$ concentrations ($\mu g/m^3$) including existing sources, background levels and the Foundation Project

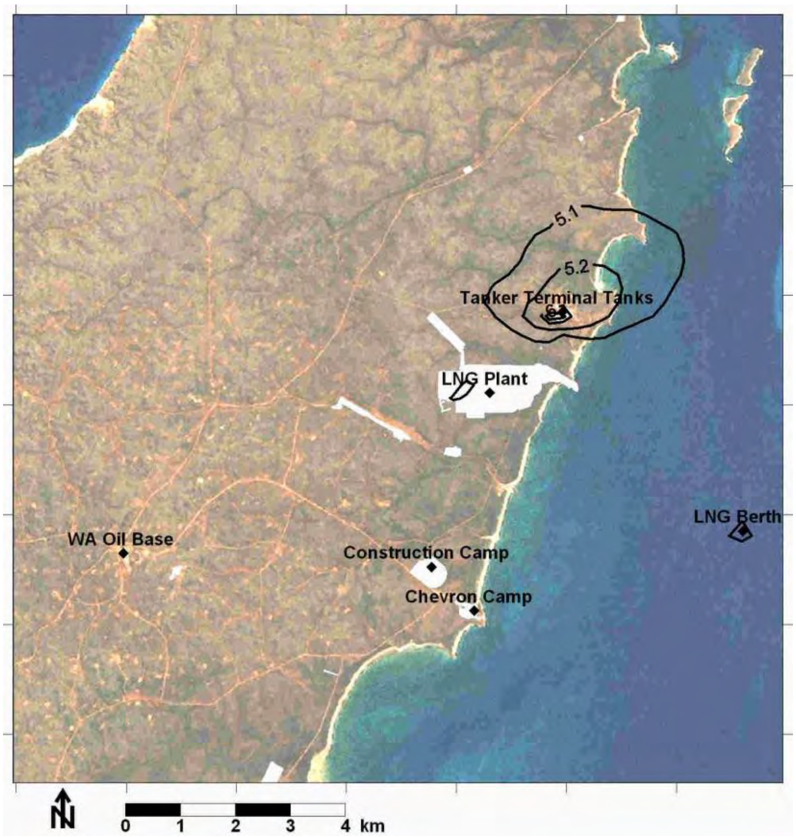

Figure 6-27 Predicted annual average $PM_{2.5}$ concentrations (µg/m^3) including existing sources, background levels and the Foundation Project

Table 6-3 and **Table 6-4** indicate that the maximum cumulative concentrations of all substances apart from SO_2 essentially remain unchanged. This is due to the highest level of NO_2 and PM occurring near the existing facilities, with the contribution from the Foundation Project being relatively minor there. The only pollutant with a significant contribution from the Foundation Project is SO_2, with this predicted to increase to 12% of the 1-hour standard. This is predicted to occur near the shipping berth due to the assumption that they use high sulphur content heavy fuel oils for the condensate tankers. Plots of the cumulative contribution are those presented earlier in **Figure 6-3** and **Figure 6-4** for emissions from the Foundation Project in isolation, as the existing sources have negligible emissions.

6.3.4 Fourth Train Proposal with Existing Sources - Routine Operation without a RTO on Train 4 (Scenarios 2a and 2b)

The predicted maximum pollutant levels for the Fourth Train Proposal without a RTO (the train 4 AGRU emissions are either vented directly to air or reinjected) are summarised in **Table 6-3** and **Table 6-4**. Contour plots of the NO_2 concentrations are also presented in **Figure 6-28** and **Figure 6-29**. Plots for other emissions are not presented as they show no change from the Foundation Project in isolation.

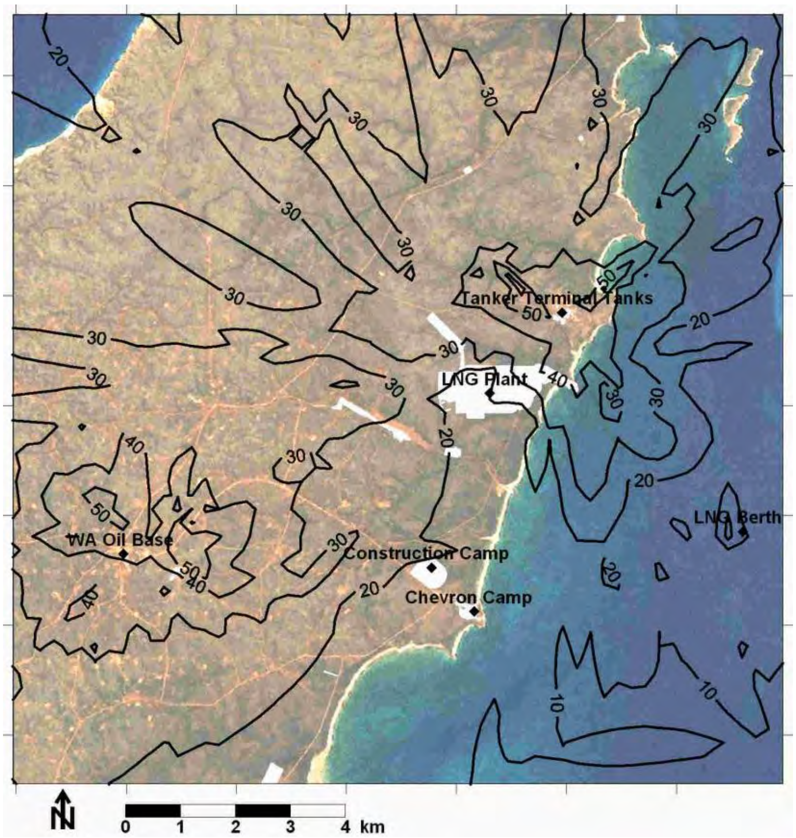

Figure 6-28 Predicted maximum 1-hour NO_2 concentrations (ppb) including existing sources, background levels and the Fourth Train Proposal without a RTO on Train 4

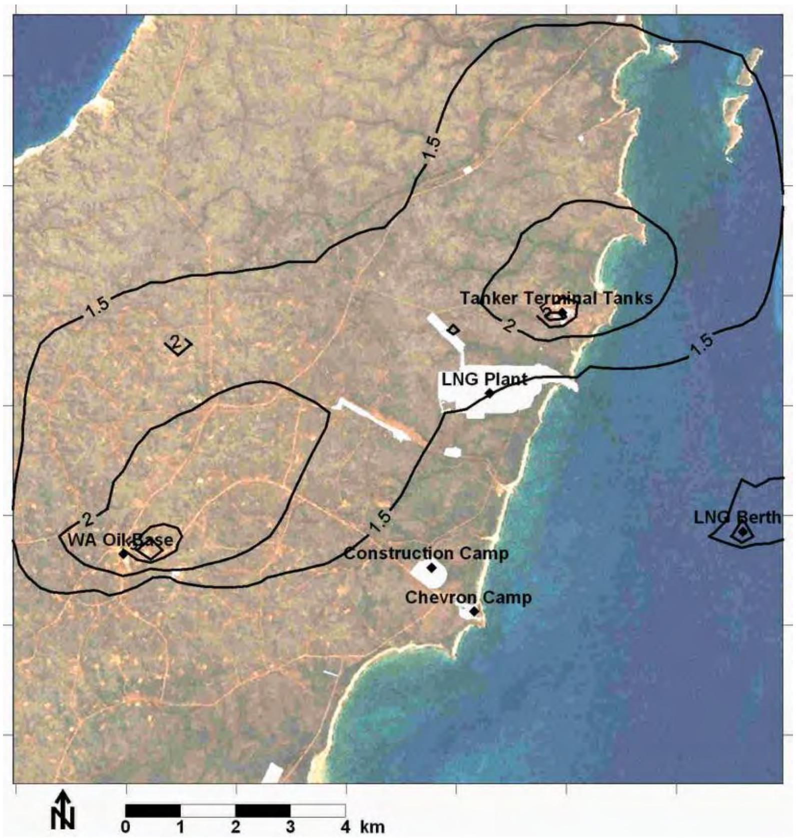

Figure 6-29 Predicted maximum annual average NO_2 concentrations (ppb) including existing sources, background levels and the Fourth Train Proposal without RTO on Train 4

Table 6-3 and **Table 6-4** show no change in the maximum cumulative concentrations for the Fourth Train Proposal. **Figure 6-28** and **Figure 6-29** shows only minor changes in the shape of the contours away from the existing sources where the maximums occur.

6.3.5 Fourth Train Proposal with Existing Sources - Routine Operation with a RTO on Train 4 (Scenario 2c)

The predicted maximum pollutant levels with the Fourth Train Proposal with a RTO are summarised in **Table 6-3** and **Table 6-4**. Contour plots of predicted NO_2 concentrations are also presented in **Figure 6-30** and **Figure 6-31**. Plots for other substances not presented as they show no change from the Foundation Project in isolation.

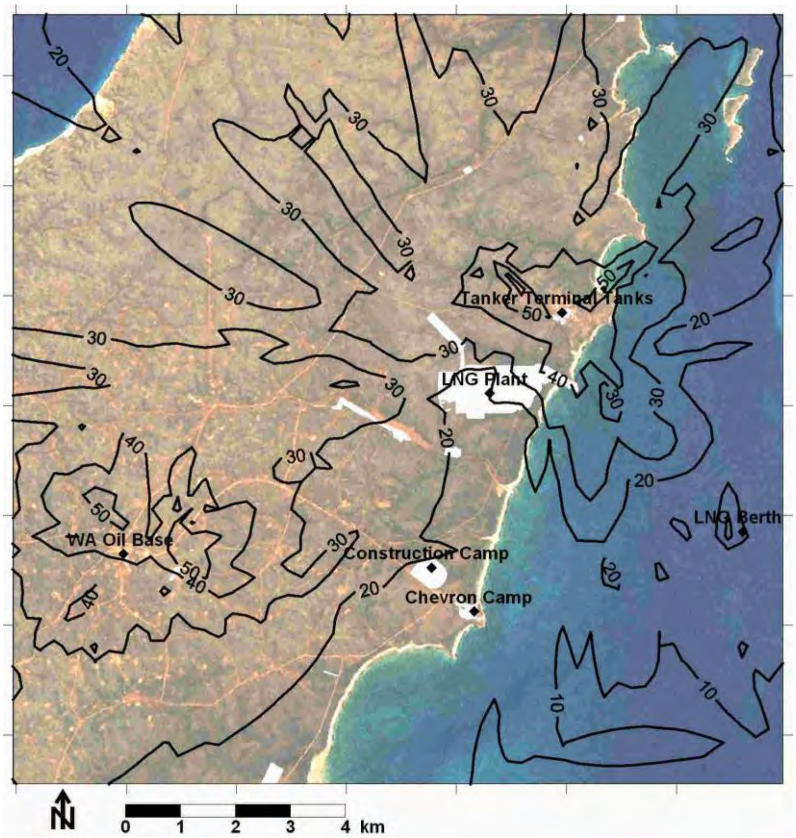

Figure 6-30 Predicted maximum 1-hour NO_2 concentrations (ppb) including existing sources, background levels and the Fourth Train Proposal with a RTO on Train 4

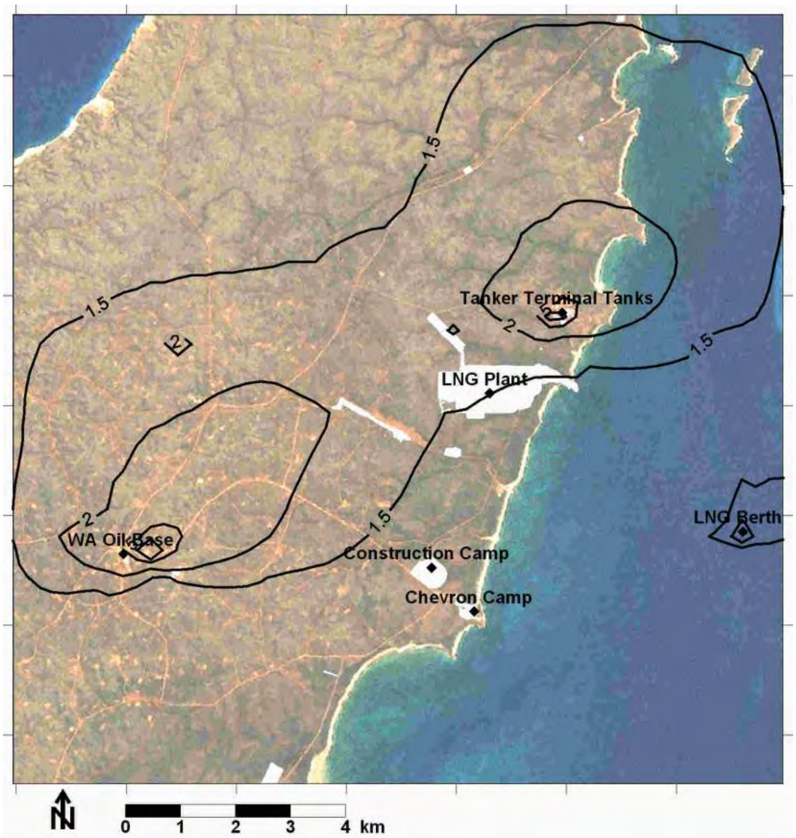

Figure 6-31 Predicted maximum annual average NO_2 concentrations (ppb) including existing sources, background levels and the Fourth Train Proposal with a RTO on Train 4

Table 6-3 and **Table 6-4** show no change in the maximum cumulative concentrations for the Fourth Train Proposal. **Figure 6-30** and **Figure 6-31** shows only minor changes in the shape of the contours away from the existing sources where the maximums occur.

6.3.6 Fourth Train Proposal with Existing Sources - Non Routine Operation – Black Start (Scenario 4)

The predicted maximum cumulative pollutant levels with the Fourth Train Proposal for the Black Start (Scenario 4) are summarised in **Table 6-3** and **Table 6-4**. Contour plots of predicted NO_2 concentrations are also presented in **Figure 6-32** and **Figure 6-33**. Plots for other substances are not presented as they show no change from the Foundation Project in isolation.

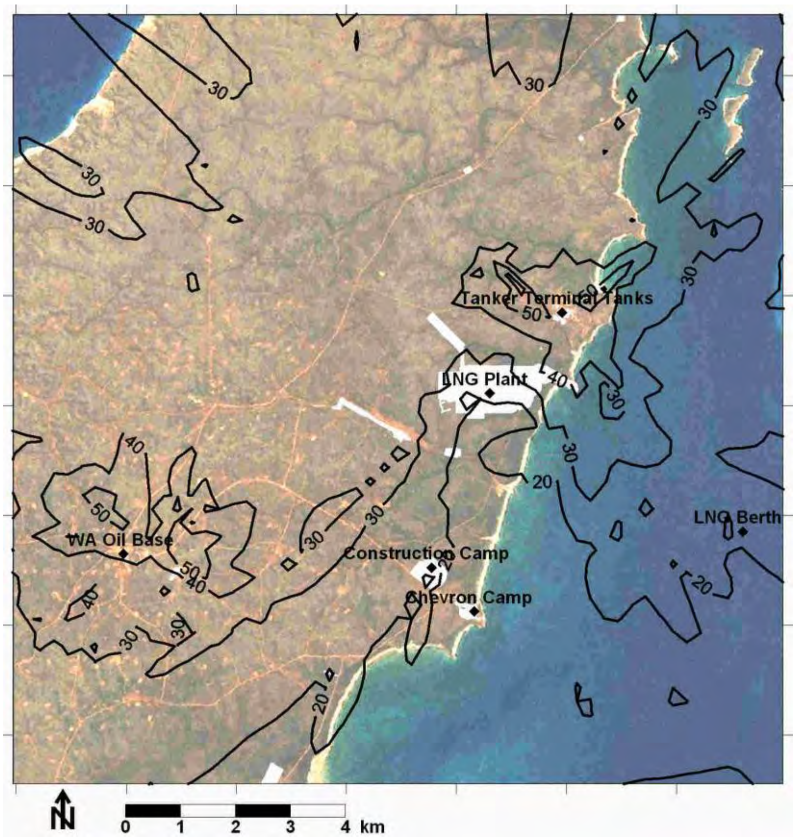

Figure 6-32 Predicted maximum 1-hour NO_2 concentrations (ppb) including existing sources, background levels with a Black Start

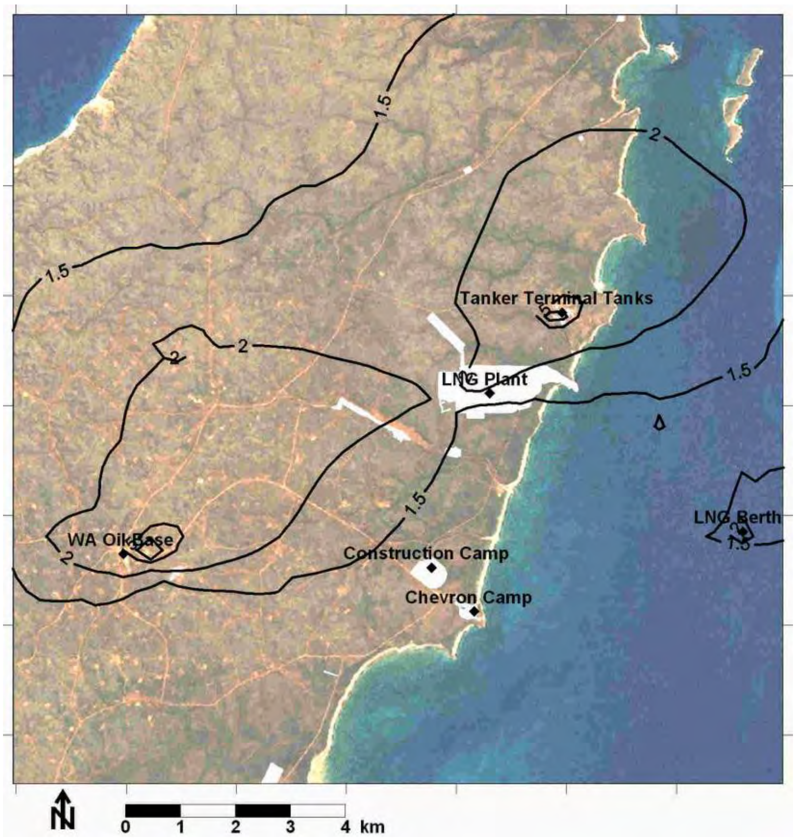

Figure 6-33 Predicted maximum annual average NO_2 concentrations (ppb) including existing sources, background levels with a Black Start

The predicted maximum pollutant levels with the Fourth Train Proposal undergoing a Black Start (**Table 6-3** and **Table 6-4** and **Figure 6-32** and **Figure 6-33**) indicate no change in the maximum concentrations, though there are predicted changes in the concentrations further away from these sources. This occurs because the predicted maxima from existing sources are larger than the contributions there from the Fourth Train Proposal and therefore do not allow the contribution from the Fourth Train Proposal to be easily gauged.

7 Predicted Regional Concentrations

7.1 Introduction

The following section presents the predicted regional concentrations of ozone and NO_2. These have been predicted using the model TAPM-CTM as it has been shown to provide good agreement with observations in the Pilbara (see **Section 4.5**), and allows for all sources (including bush fires) to be modelled, such that a true cumulative assessment can be conducted.

A summary of the predicted concentrations are presented in **Table 7-1** and as a percentage of the adopted criteria in **Table 7-2**. The following sections provide descriptions of the results along with contour plots.

Table 7-1 Predicted Maximum Concentrations (ppb) of Ozone and NO_2 Anywhere on the Model Grid

Pollutant	Ave. Period	Statistic Used	Criteria Value	Predicted Concentration (ppb)							
				Natural	Existing 2009	Future with GFP (S. 1)	Future with FTP and Train 4 AGRU Venting (S.2a)	Future with FTP and Train 4 AGRU Injected (S.2b)	Future with FTP and Train 4 AGRU to RTO (S.2c)	Future with FTP Non Routine Pigging (S.3)	Future with FTP Non Routine Black Start (S.4)
Nitrogen Dioxide	1-hour	Max	120[1]	42	47	48.5	50.6	49.6	51	48.7	48.8
	1-hour	2nd	120	39	45	47	47	47	47	47	47
	1-year	Ave	30	0.5	8.9	9.5	9.8	9.8	9.8	9.8	9.8
Ozone	1-hour	Max	100[1]	70	71	84	101	81	82	93	75
	1-hour	2nd	100	70	70.5	73	73	69	68	76.5	68
	4-hour	Max	80[1]	70	70	70	70.5	69	73	69	70
	4-hour	2nd	80	69	69.6	69	67	68	67	68.4	67

Notes:

1) NEPM 1-hour values actually allow for not more than one exceedance per year.
2) "Existing 2009" is all natural and anthropogenic sources at 2009. "Future" is existing and all approved and proposed projects as defined in **Section 2**. GFP is Gorgon Foundation Project and FTP is the Fourth Train Proposal.

Table 7-2 Predicted Maximum Concentrations of Ozone and NO_2 Anywhere on the Model Grid as a Percentage of the Criteria

Pollutant	Ave. Period	Statistic Used	Criteria Value	Predicted Concentration as a Percentage of Respective Criteria (%)							
				Natural	Existing 2009	Future with GFP	Future with FTP and Train 4 AGRU venting	Future with FTP and Train 4 AGRU injected	Future with FTP and Train 4 AGRU to RTO	Future With FTP Non Routine Pigging	Future With FTP Non Routine Black Start
Nitrogen Dioxide	1-hour	Max	120[1]	35	39	40	46	41	43	41	41
	1-hour	2nd	120	33	38	39	39	39	39	39	39
	1-year	Ave	30	2	30	32	33	33	33	33	33
Ozone	1-hour	Max	100[1]	70	71	84	101	81	82	93	75
	1-hour	2nd	100	70	70.5	73	73	69	68	77	68
	4-hour	Max	80[1]	88	88	88	88	86	91	86	88
	4-hour	2nd	80	86	87	86	84	85	84	86	84

Notes:

1) NEPM 1-hour values actually allow for not more than one exceedance.
2) "Existing 2009" is all natural and anthropogenic sources at 2009. "Future" is existing and all approved and proposed projects as defined in **Section 2**. GFP is Gorgon Foundation Project and FTP is the Fourth Train Proposal.

7.2 Existing and Approved Sources

7.2.1 Natural Sources Only

The predicted concentrations from natural sources, including from all fires (irrespective of how they were started), emissions from soils and biogenic sources are presented in **Table 7-1** and are presented as a percentage of the adopted criteria in **Table 7-2**.

The second highest concentration has also been included in **Table 7-1** and **Table 7-2** for comparisons to the NEPM criteria, as the modelling includes all natural sources for which the NEPM goal of no more than one day of exceedance is appropriate.

Table 7-1 and **Table 7-2** indicate that by themselves, natural sources make a large contribution to the ozone levels in the region with predicted maximum levels that are 70% and 88% of the NEPM 1-hour and 4-hour standards. The predicted second highest 1-hour concentrations, which are more comparable to the standard, are very similar at 70 and 86% of the standard. These maximums are predicted to occur over water (see **Figure 7-3** and **Figure 7-5**), whilst the maximum NO_2 concentrations are predicted to occur inland, associated with the regions of large fires for that year.

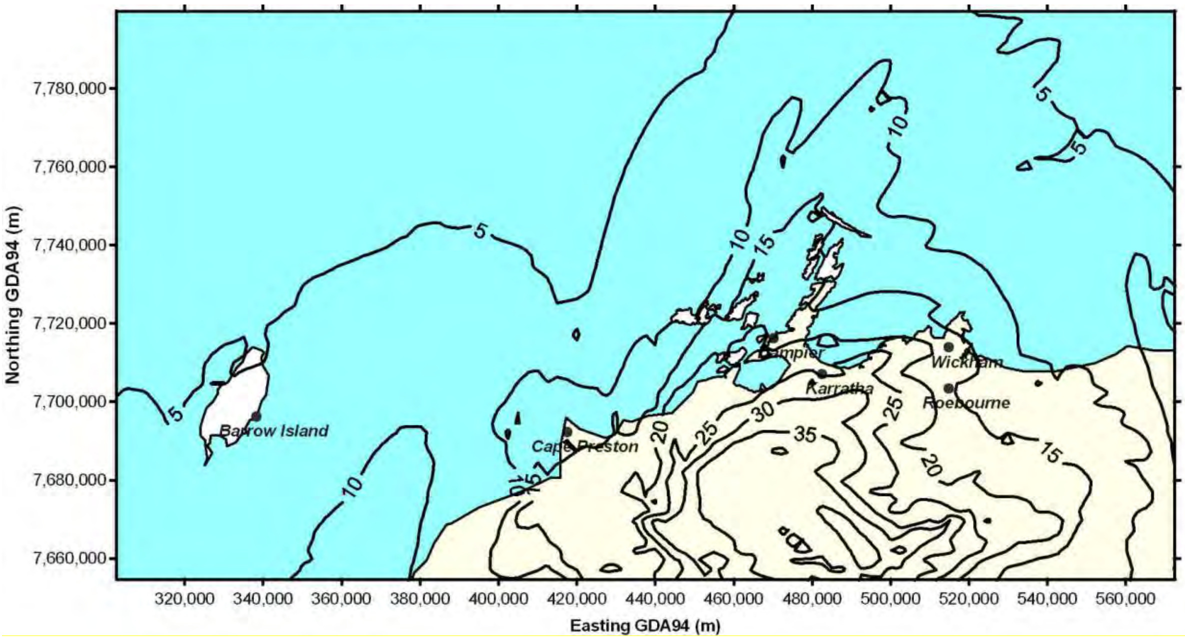

Figure 7-1 Predicted maximum 1-hour NO_2 concentrations (ppb) from "natural" sources

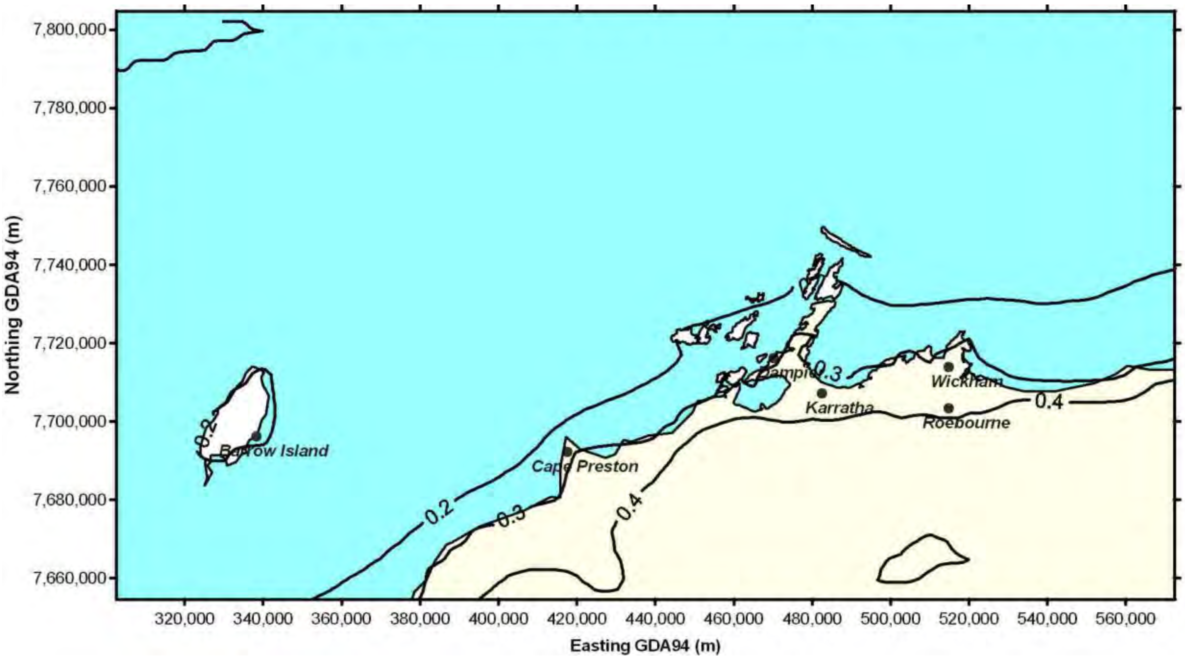

Figure 7-2 Predicted annual average NO_2 concentrations (ppb) from "natural" sources

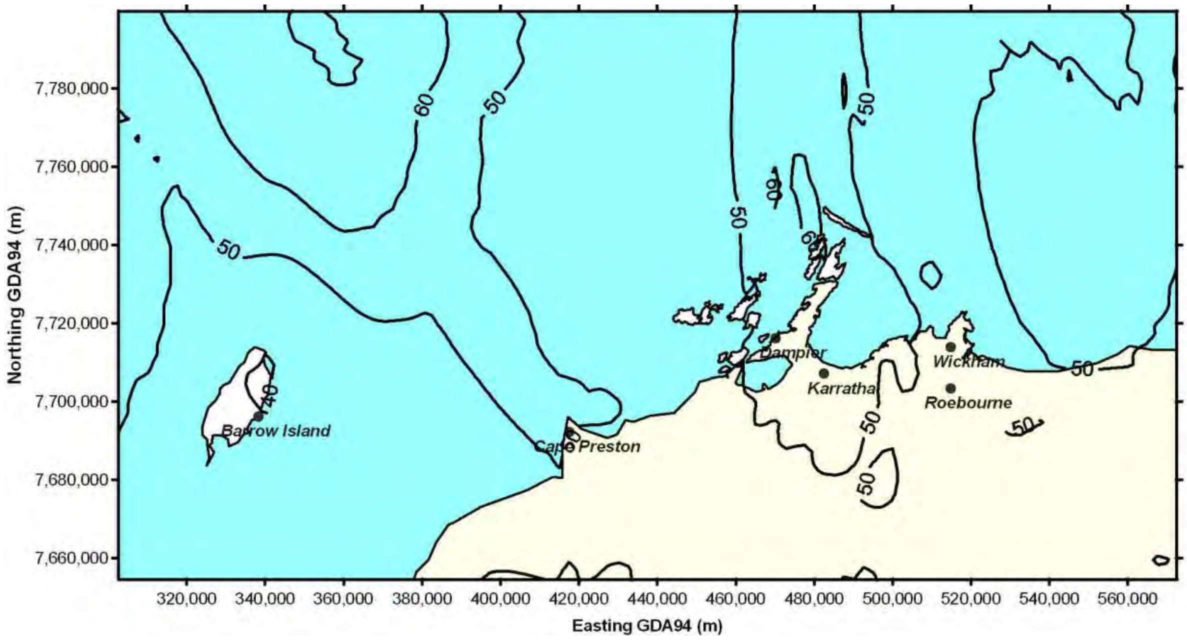

Figure 7-3 Predicted maximum 1-hour O_3 concentrations (ppb) from "natural" sources

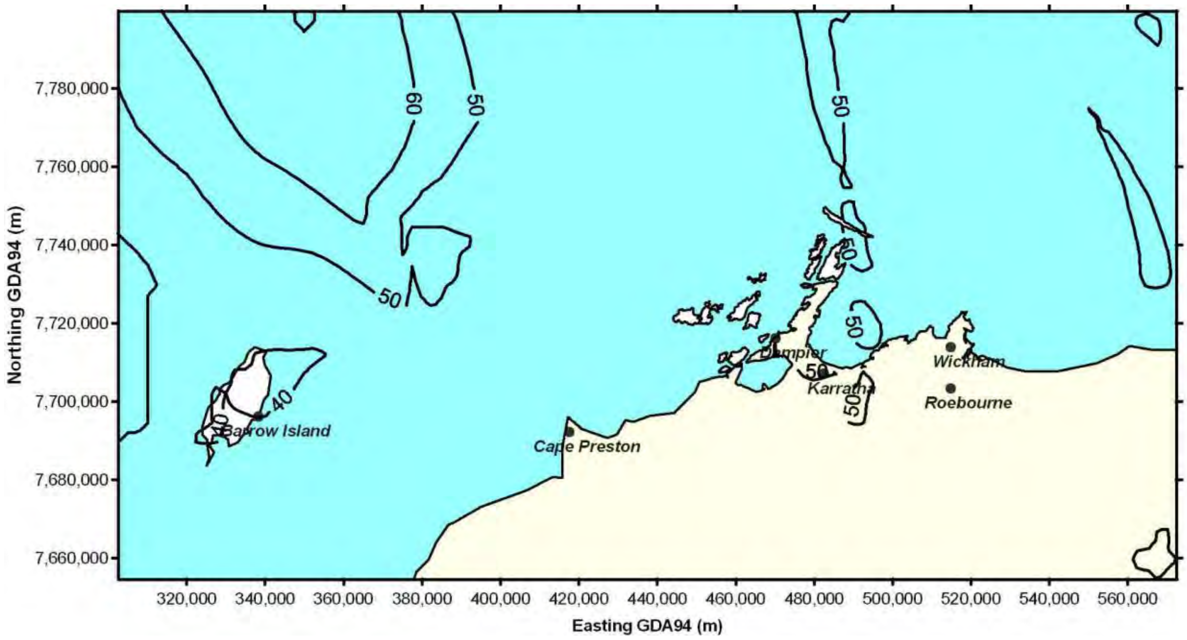

Figure 7-4 Predicted second highest 1-hour O_3 concentrations (ppb) from "natural" sources

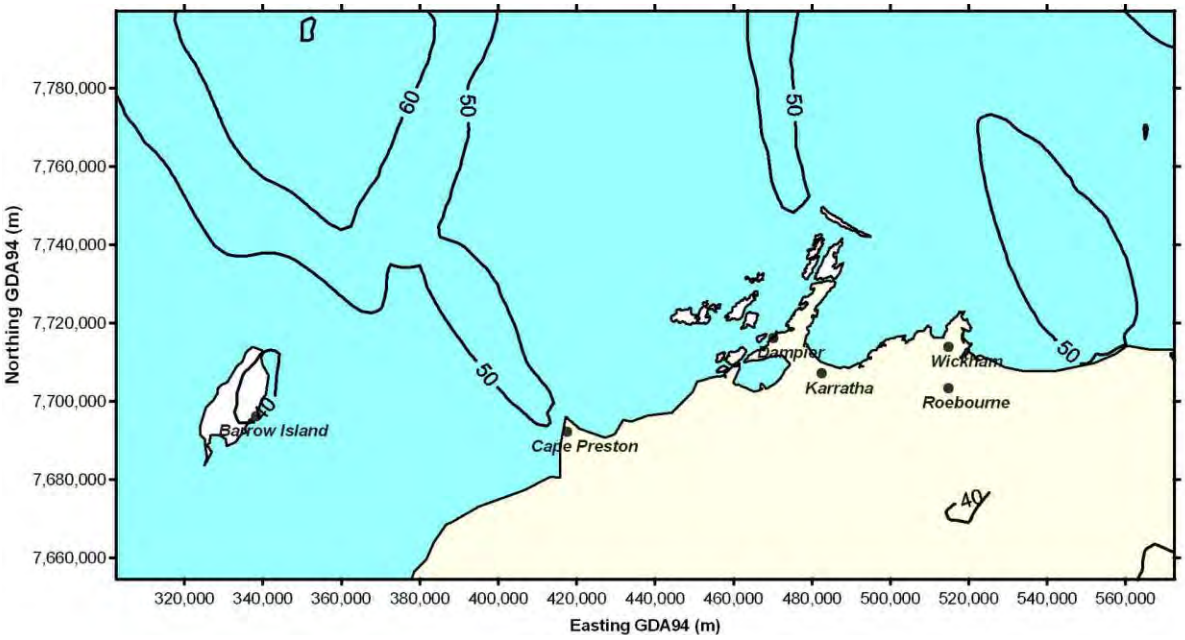

Figure 7-5 Predicted maximum 4-hour O_3 concentrations (ppb) from "natural" sources

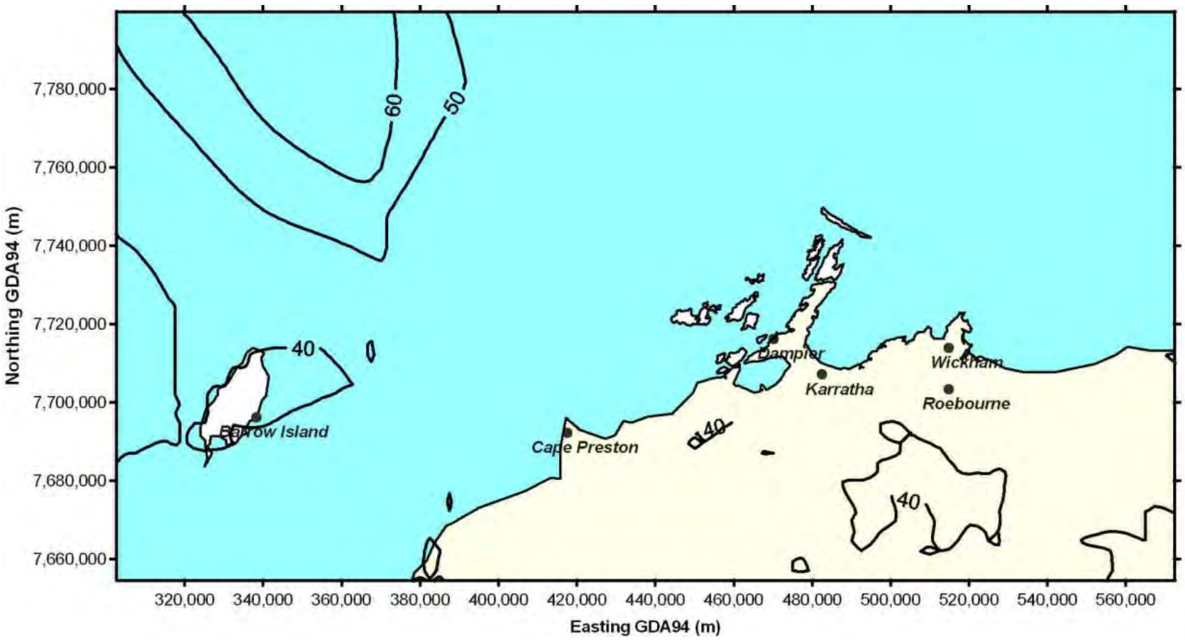

Figure 7-6 Predicted second highest 4-hour O_3 concentrations (ppb) from "natural" sources

7.2.2 Existing Sources at 2009

The predicted maximum concentrations anywhere from existing 2009 sources (natural and anthropogenic) are presented in **Table 7-1** and **Table 7-2** with plots presented in **Figure 7-7** to **Figure 7-12**.

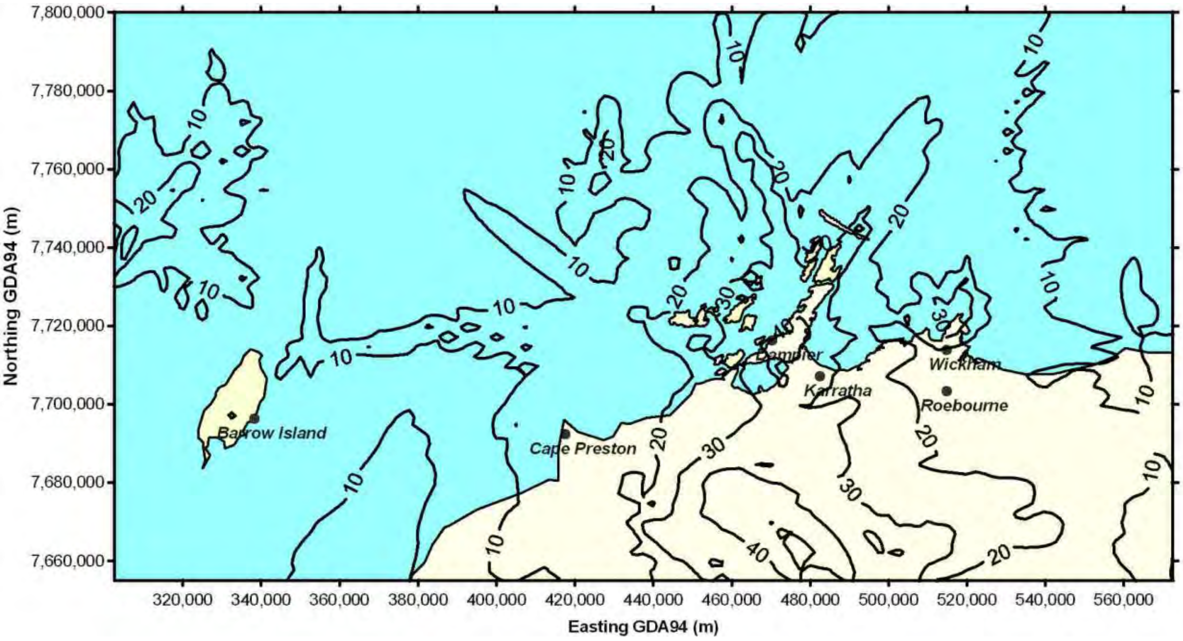

Figure 7-7 Predicted maximum 1-hour NO_2 concentrations (ppb) from existing 2009 sources

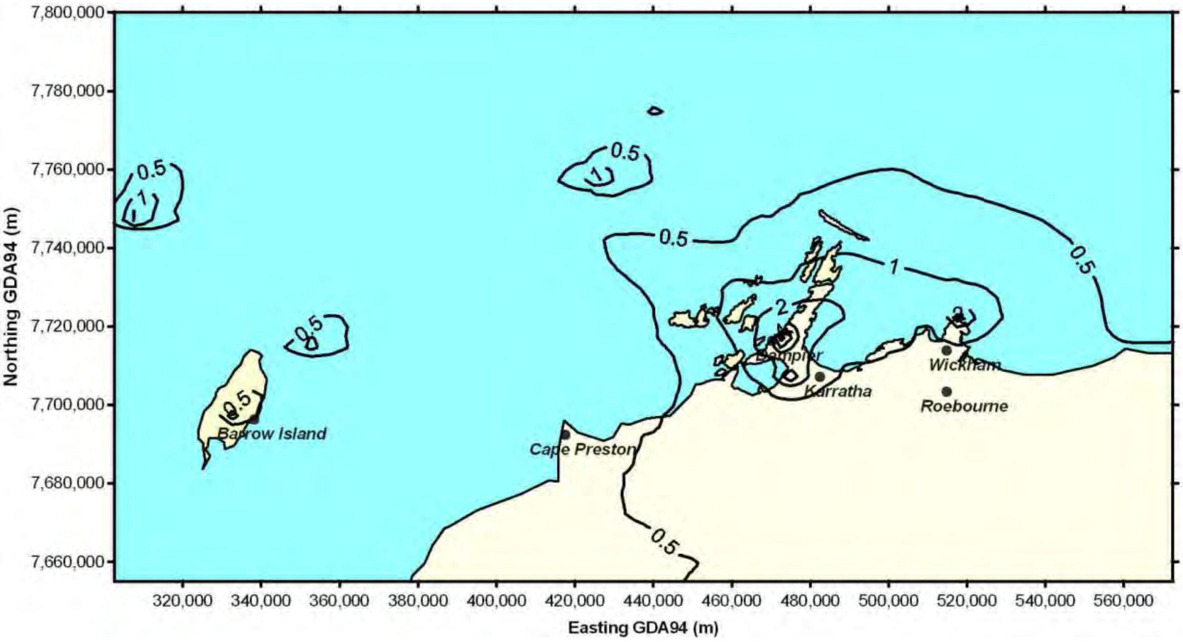

Figure 7-8 Predicted annual average NO_2 concentrations (ppb) from existing 2009 sources

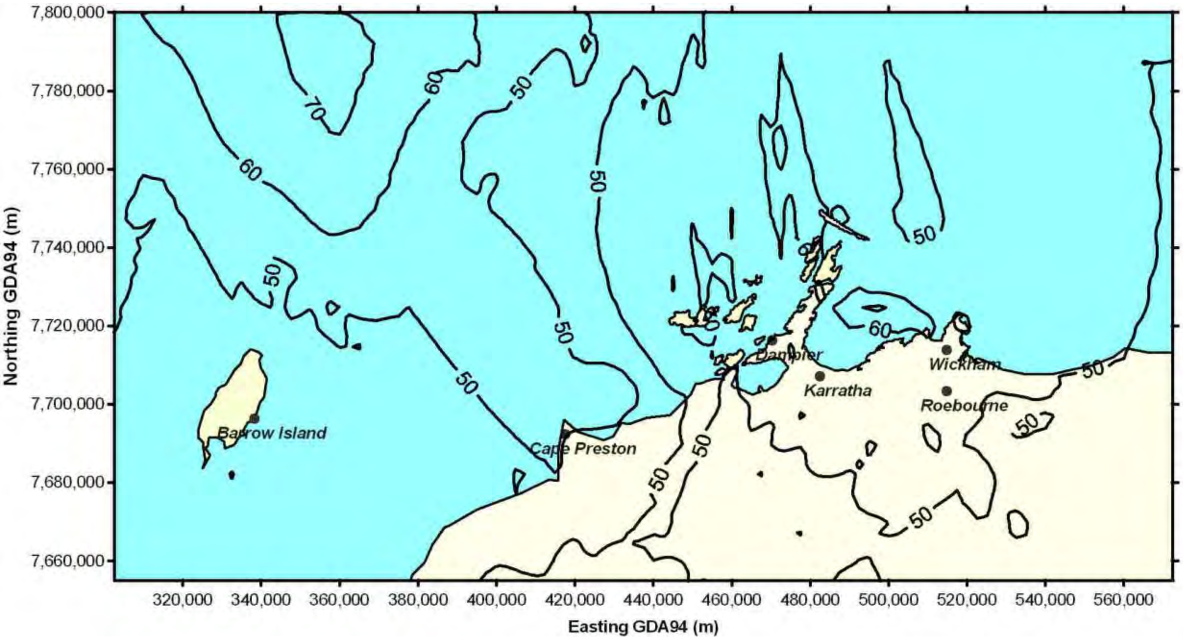

Figure 7-9 Predicted maximum 1-hour O_3 concentrations (ppb) from existing 2009 sources

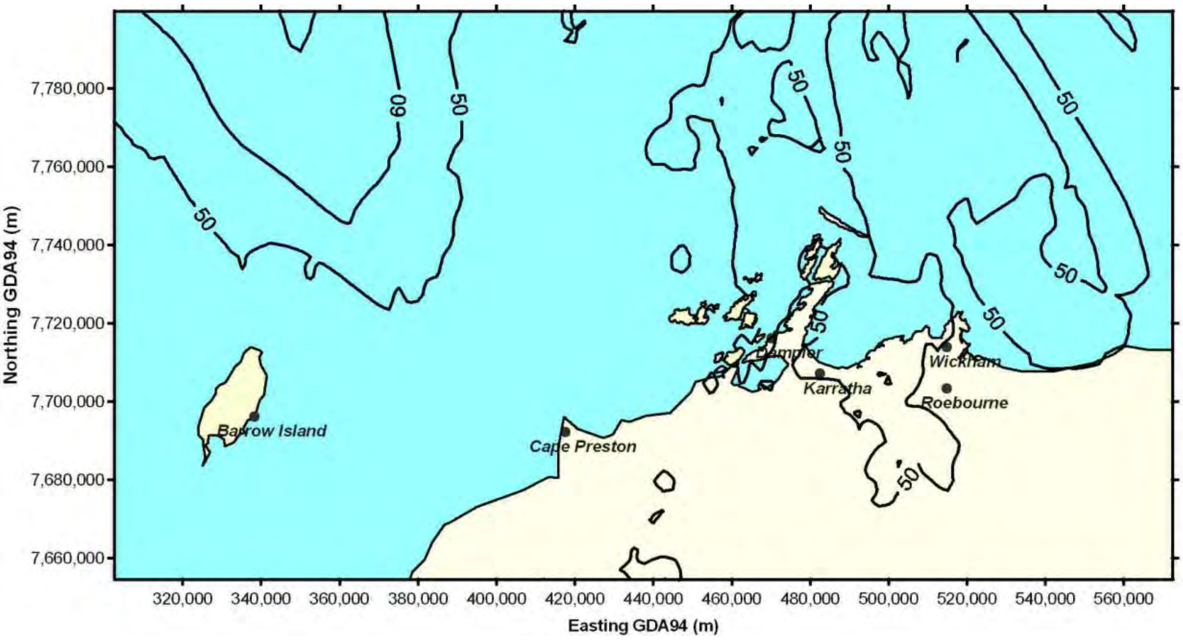

Figure 7-10 Predicted second highest 1-hour O_3 concentrations (ppb) from existing 2009 sources

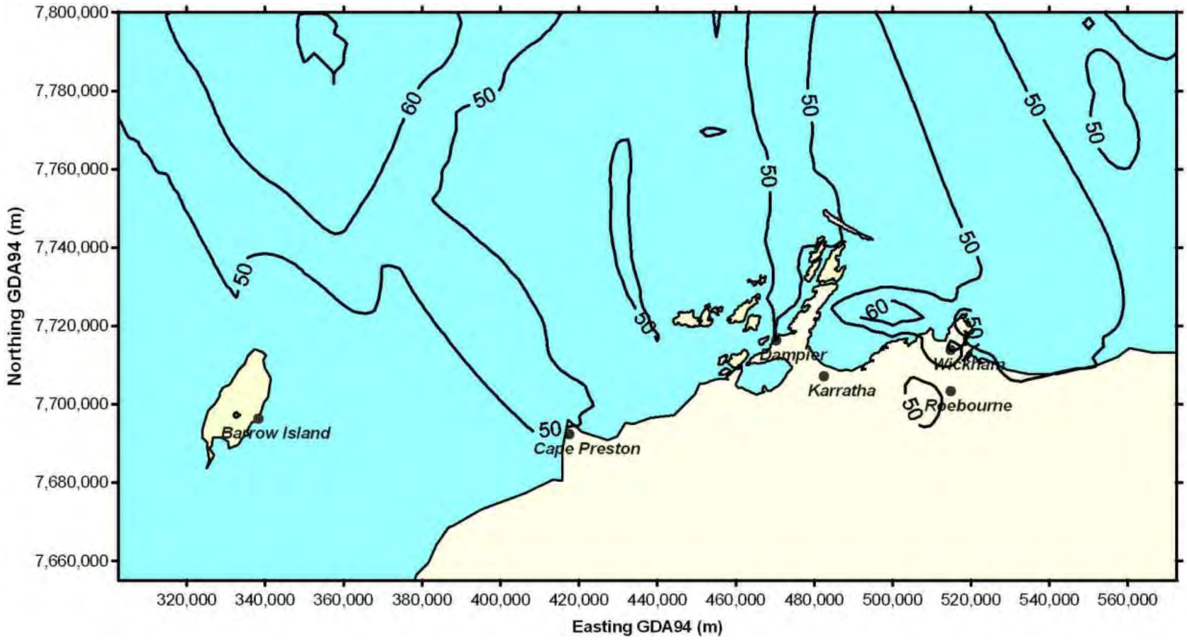

Figure 7-11 Predicted maximum 4-hour O_3 concentrations (ppb) from existing 2009 sources

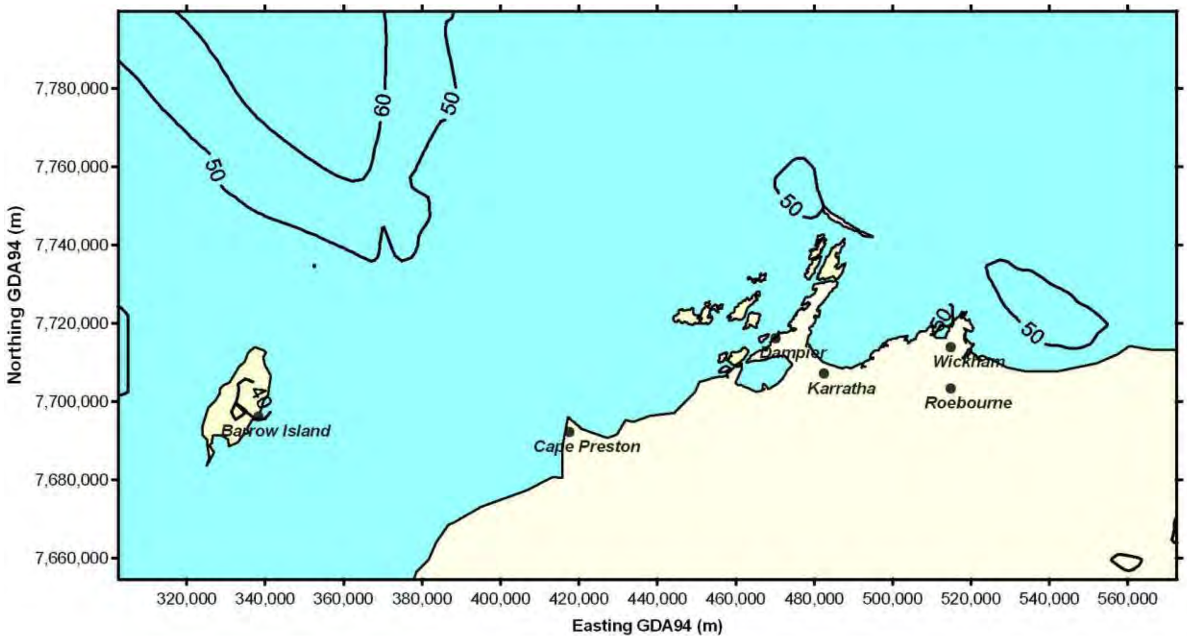

Figure 7-12 Predicted second highest 4-hour O_3 concentrations (ppb) from existing 2009 sources

Table 7-1 and **Table 7-2** and **Figure 7-7** to **Figure 7-12** indicate that the existing (2009) industry only add a small contribution to the maximum concentrations. This is primarily due to the large contribution that the fires make to existing levels.

7.2.3 Existing and Future Sources Including the Foundation Project – Scenario 1

The predicted maximum ozone and NO_2 concentrations from natural sources, existing, approved and proposed sources and the Foundation Project are listed in **Table 7-1** and **Table 7-2** with concentration plots presented in **Figure 7-13** to **Figure 7-18**.

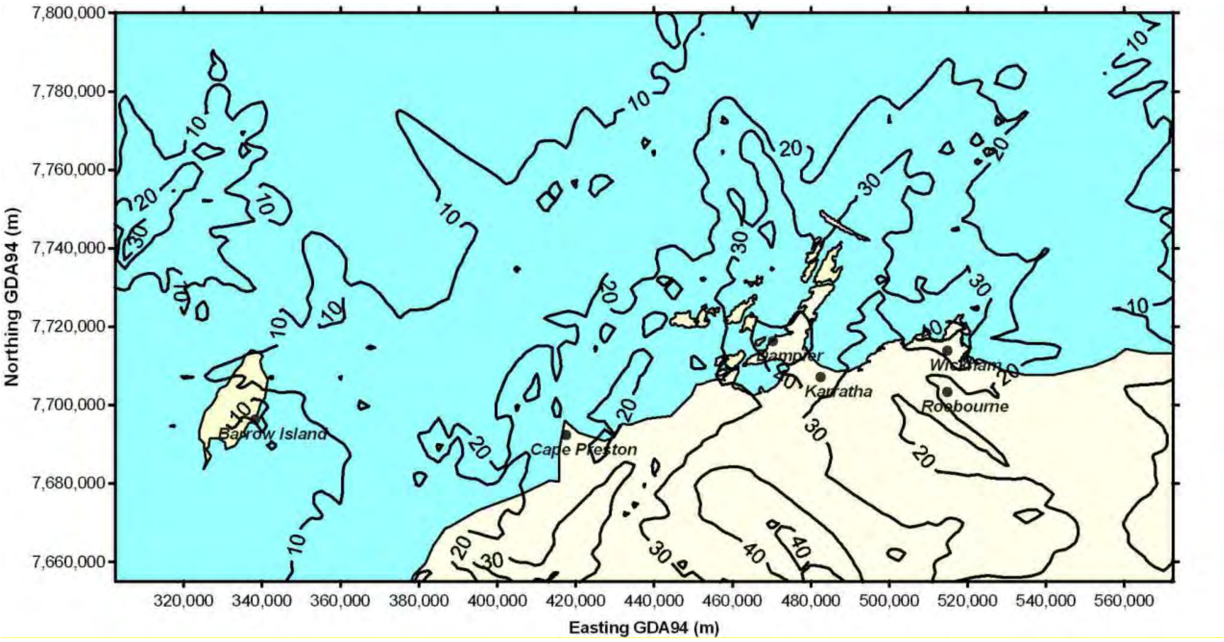

Figure 7-13 Predicted maximum 1-hour NO_2 concentrations (ppb) from existing and future sources including the Foundation Project

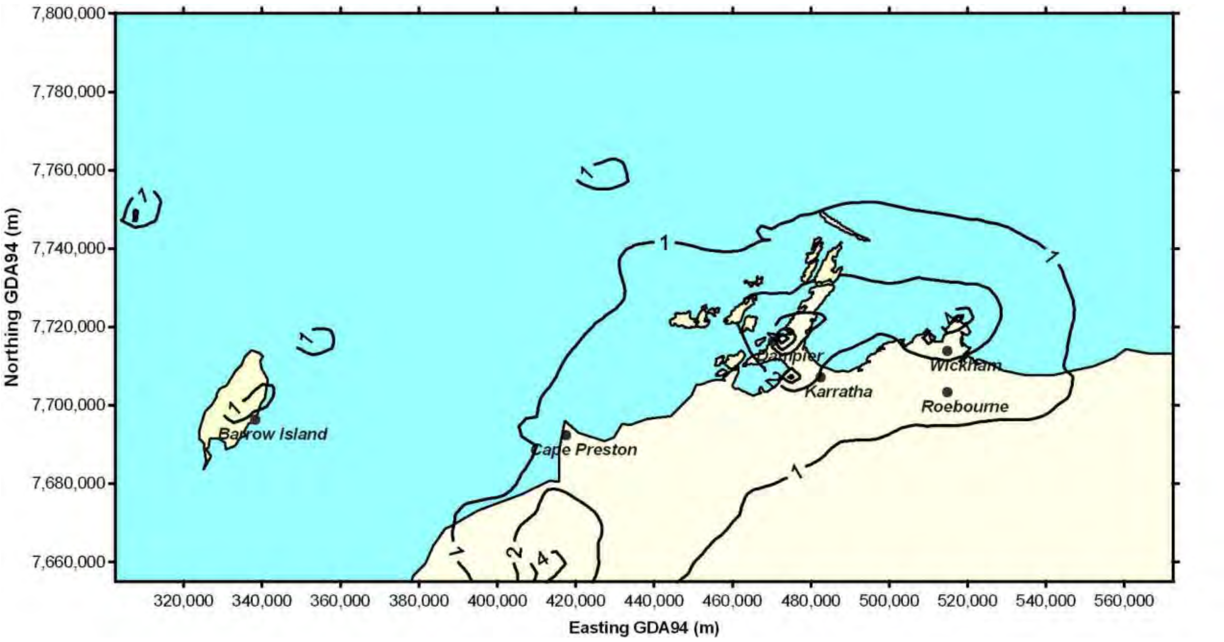

Figure 7-14 Predicted annual average NO_2 concentrations (ppb) from existing and future sources including the Foundation Project

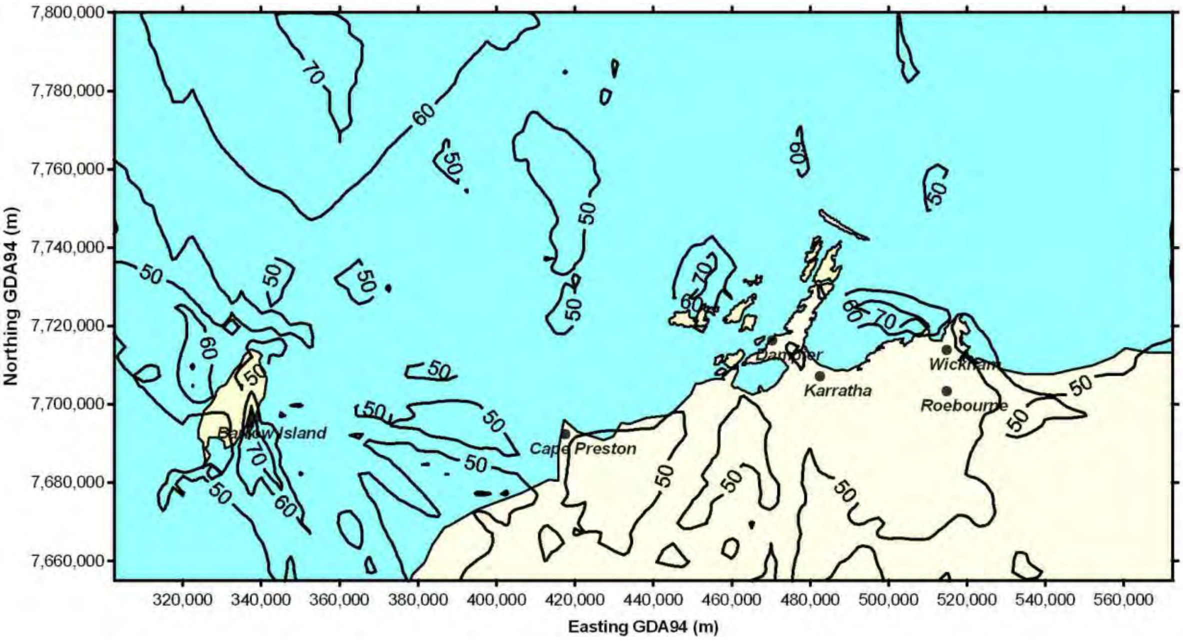

Figure 7-15 Predicted maximum 1-hour O_3 concentrations (ppb) from existing and future sources including the Foundation Project

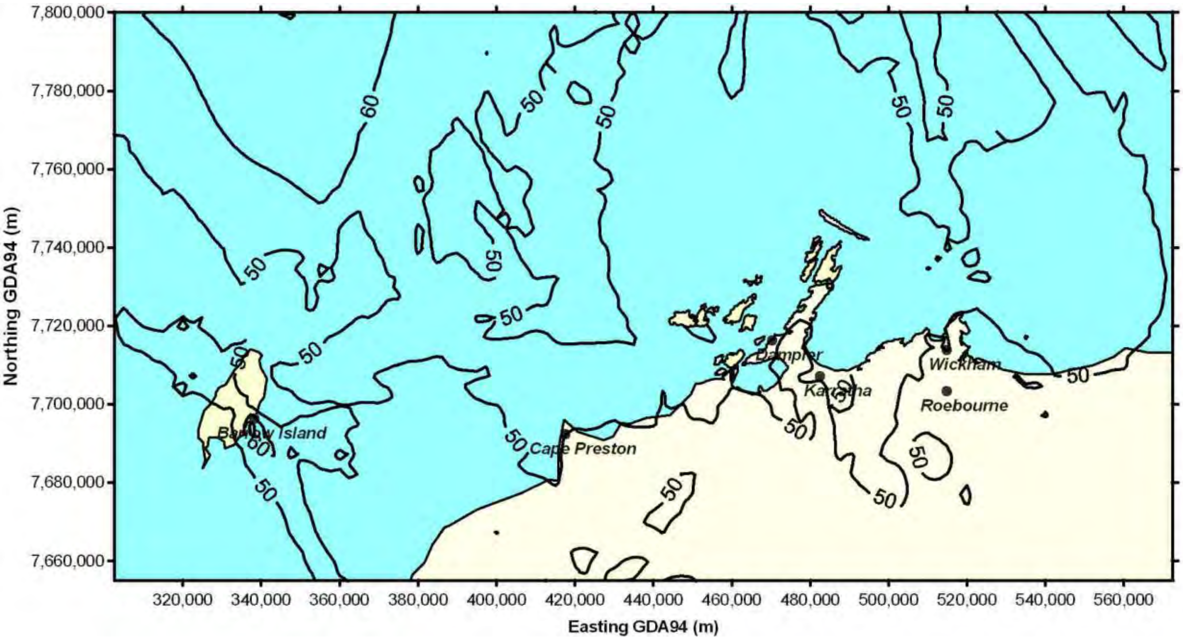

Figure 7-16 Predicted second highest 1-hour O_3 concentrations (ppb) from existing and future sources including the Foundation Project

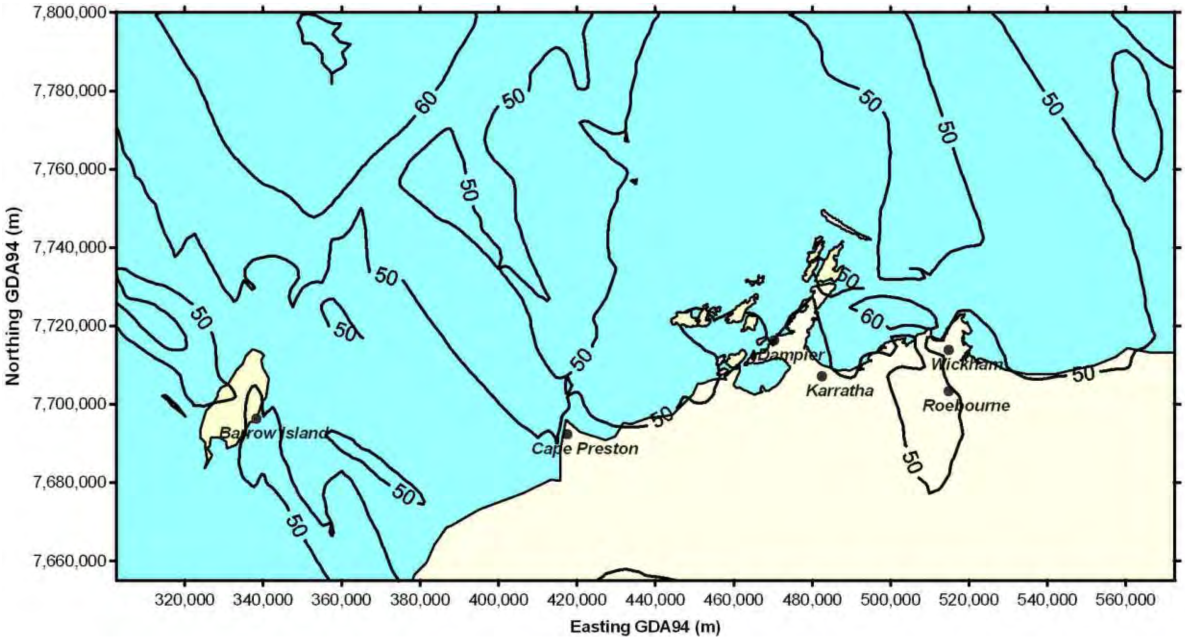

Figure 7-17 Predicted maximum 4-hour O_3 concentrations (ppb) from existing and future sources including the Foundation Project

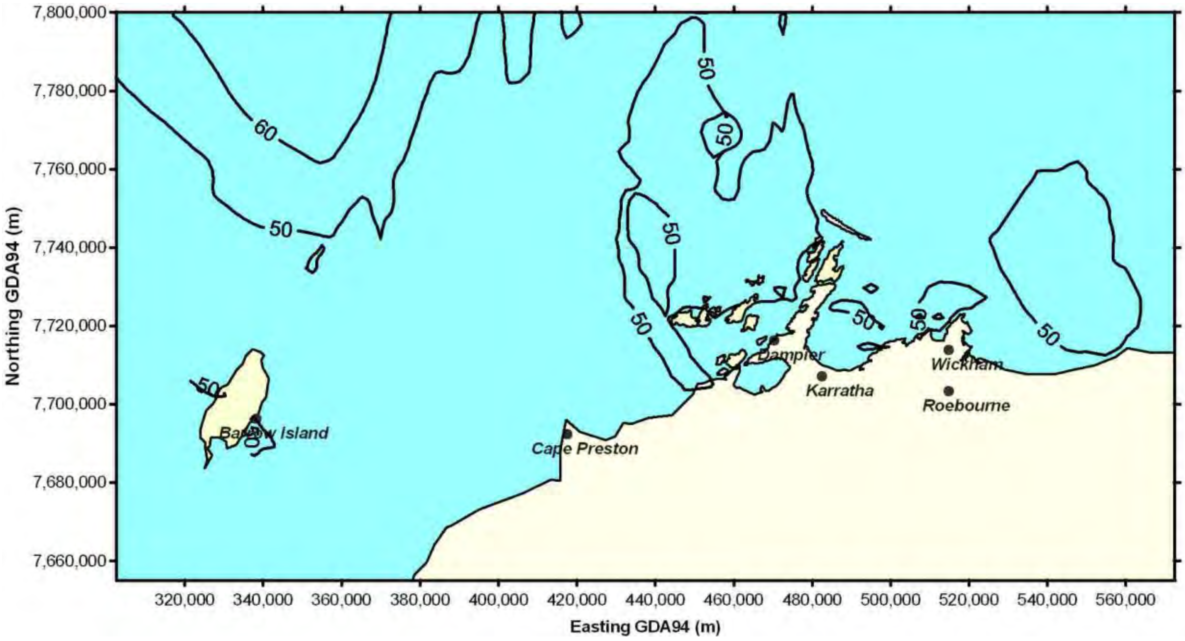

Figure 7-18 Predicted second highest 4-hour O_3 concentrations (ppb) from existing and future sources including the Foundation Project

Table 7-1 and **Table 7-2** and **Figure 7-13** to **Figure 7-18** show:

- Generally a small increase in the maximum ozone concentrations except the maximum 1-hour ozone concentration which increases from 71 to 84 ppb; and
- For NO_2, there are small increases in the maximum of 1.5 to 2 ppb though these are still at most 40% of the criteria.

7.3 Fourth Train Proposal – Routine Operations

7.3.1 Existing and Future Sources including the Fourth Train Proposal with Train 4 AGRU emissions vented to air – Scenario 2a

The predicted maximum ozone and NO_2 concentrations from natural sources, existing, approved and proposed industrial sources and the Fourth Train Proposal with the Train 4 AGRU vented to air is listed in **Table 7-1** and **Table 7-2**. Concentration plots are presented in **Figure 7-19** to **Figure 7-24**.

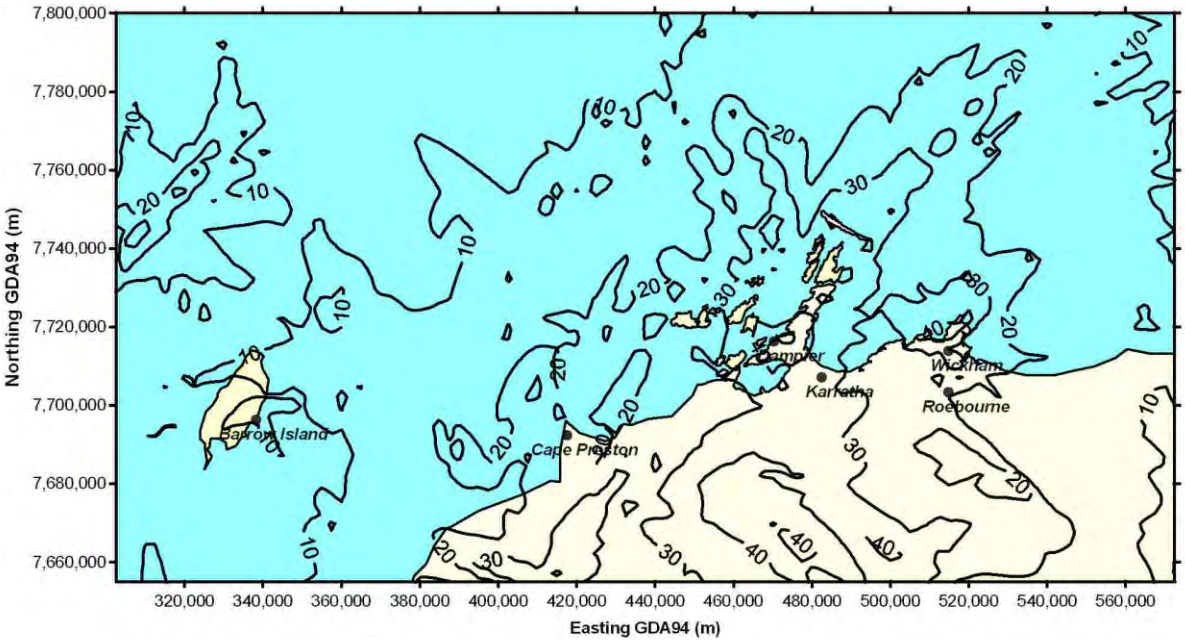

Figure 7-19 Predicted maximum 1-hour NO_2 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with the Train 4 AGRU emissions vented to air

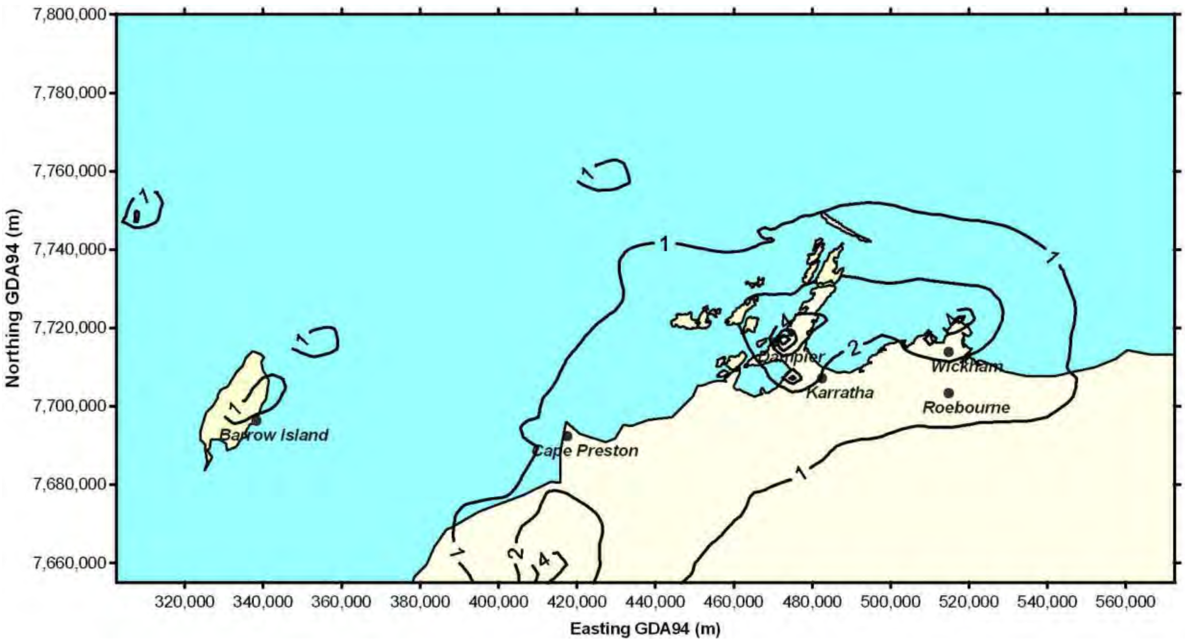

Figure 7-20 Predicted annual average NO_2 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with the Train 4 AGRU emissions vented to air

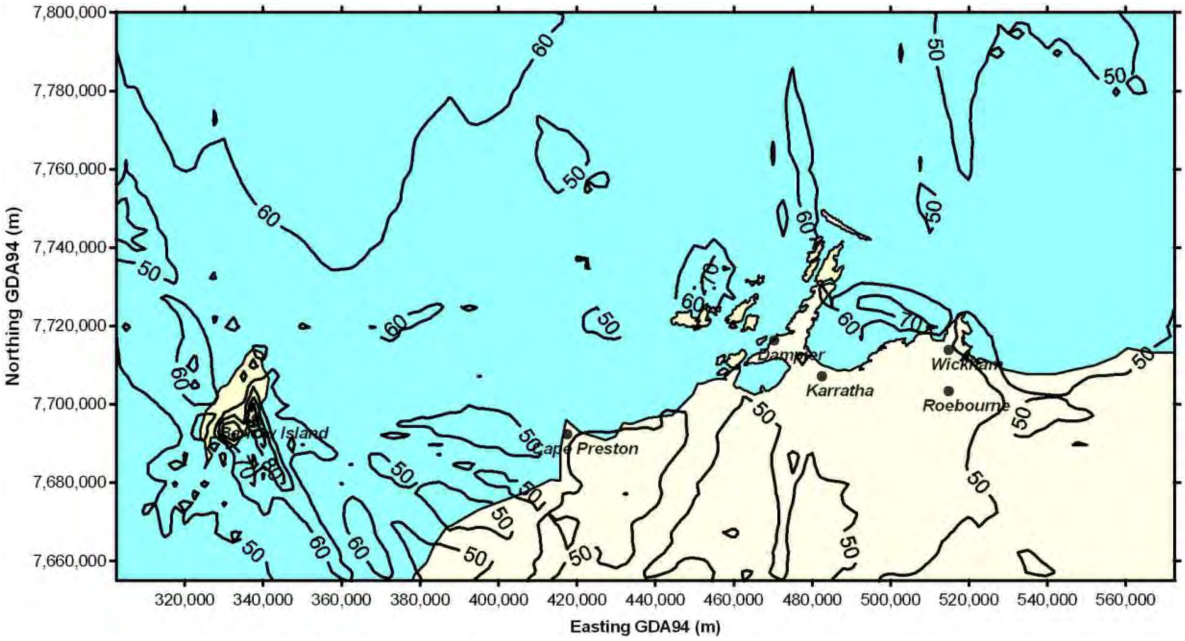

Figure 7-21 Predicted maximum 1-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with the Train 4 AGRU emissions vented to air

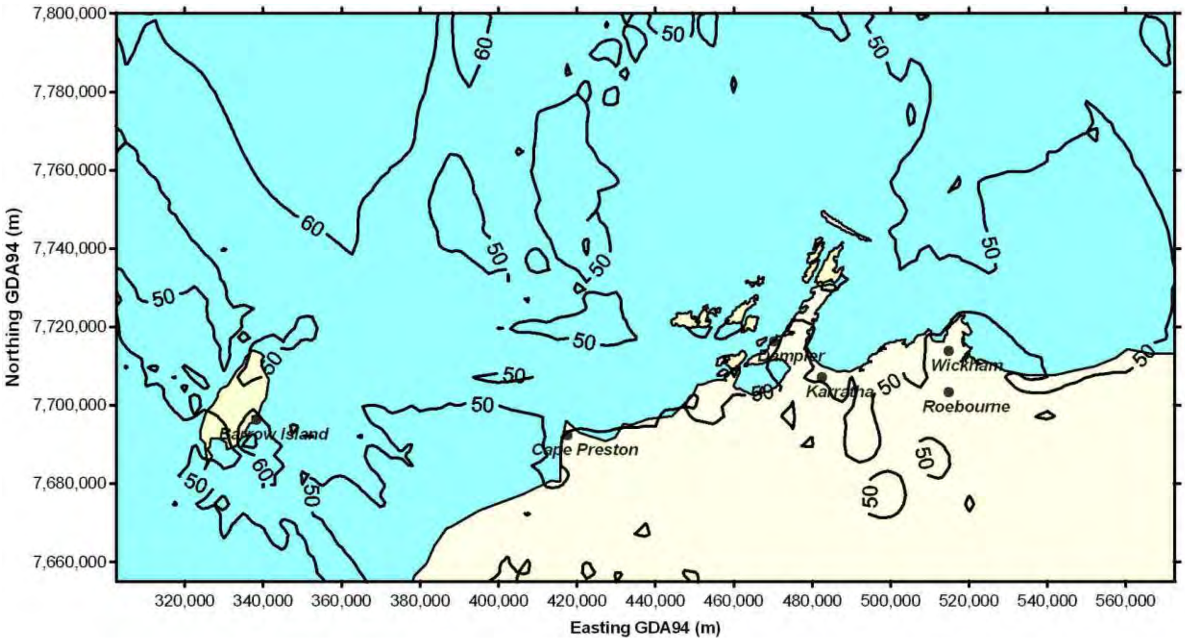

Figure 7-22 Predicted second highest 1-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with the Train 4 AGRU emissions vented to air

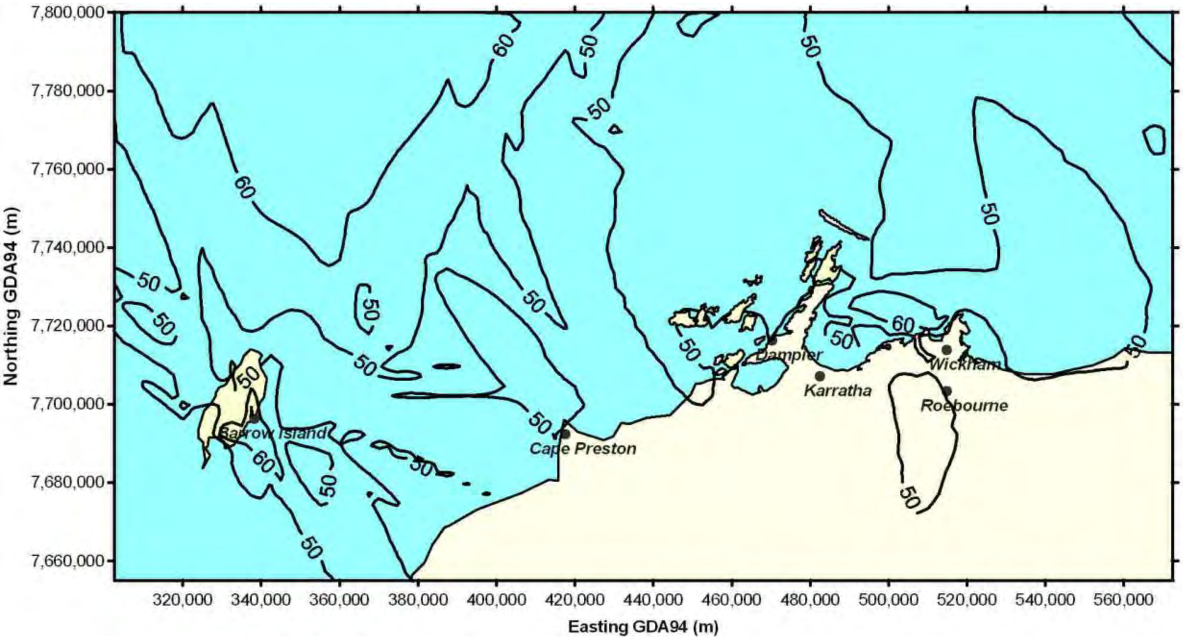

Figure 7-23 Predicted maximum 4-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with the Train 4 AGRU emissions vented to air

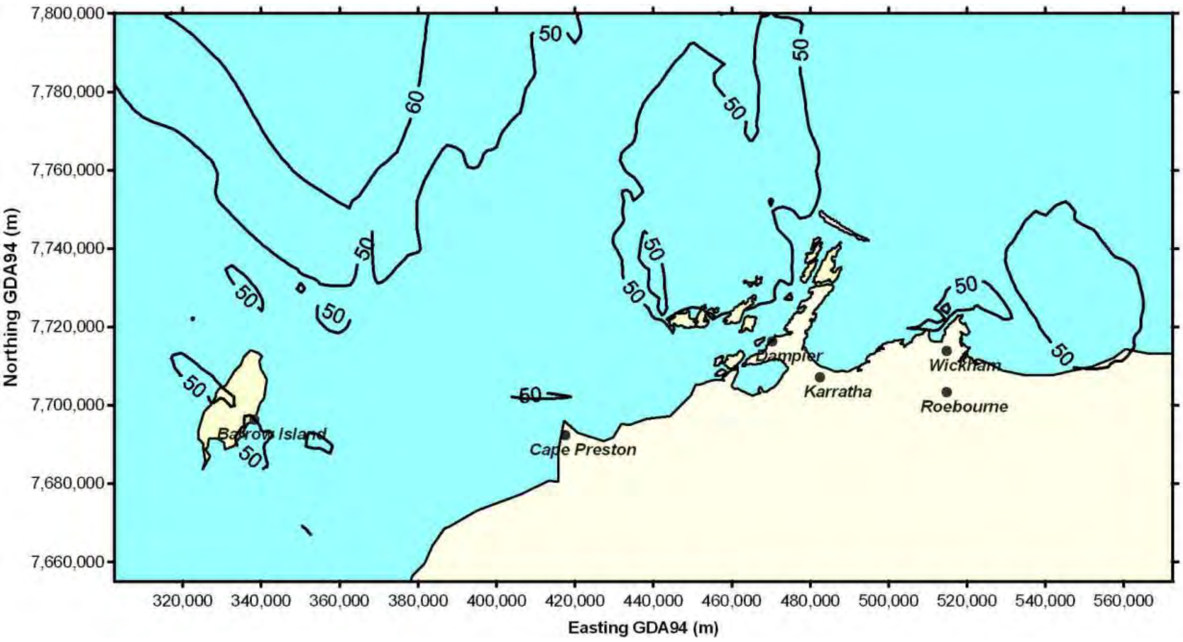

Figure 7-24 Predicted second highest 4-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with the Train 4 AGRU vented to air

Table 7-1 and **Table 7-2** and **Figure 7-19** to **Figure 7-24** indicate that:

- The maximum ozone concentrations show little change from the Foundation Project, except the maximum 1-hour concentration which increases from 84 to 101 ppb or 101% of the NEPM standard. The second highest 1-hour concentration remains at 73 ppb (73% of the NEPM standard). The maximum 4-hour concentration increases slightly from 70 to 70.5 ppb (88% of the NEPM) and the second highest 4-hour concentration reduces slightly from 69 to 67 ppb which is 84 % of the NEPM standard. Therefore, it is considered that the maximum 1-hour value is from an unlikely event and more an outlier produced by the model; and

- The maximum 1-hour NO_2 concentration increases from 48.5 to 55 ppb (55% of the NEPM standard), with the second highest staying constant at 47 ppb (47% of the standard).

7.3.2 Existing and Future Sources including the Fourth Train Proposal with Train 4 AGRU Emissions Reinjected – Scenario 2b

The predicted maximum ozone and NO_2 concentrations from natural sources, existing, approved and proposed industrial sources and the Fourth Train Proposal with the Train 4 AGRU emissions reinjected are listed in **Table 7-1** and **Table 7-2**. Concentration plots are presented in **Figure 7-25** to **Figure 7-30**.

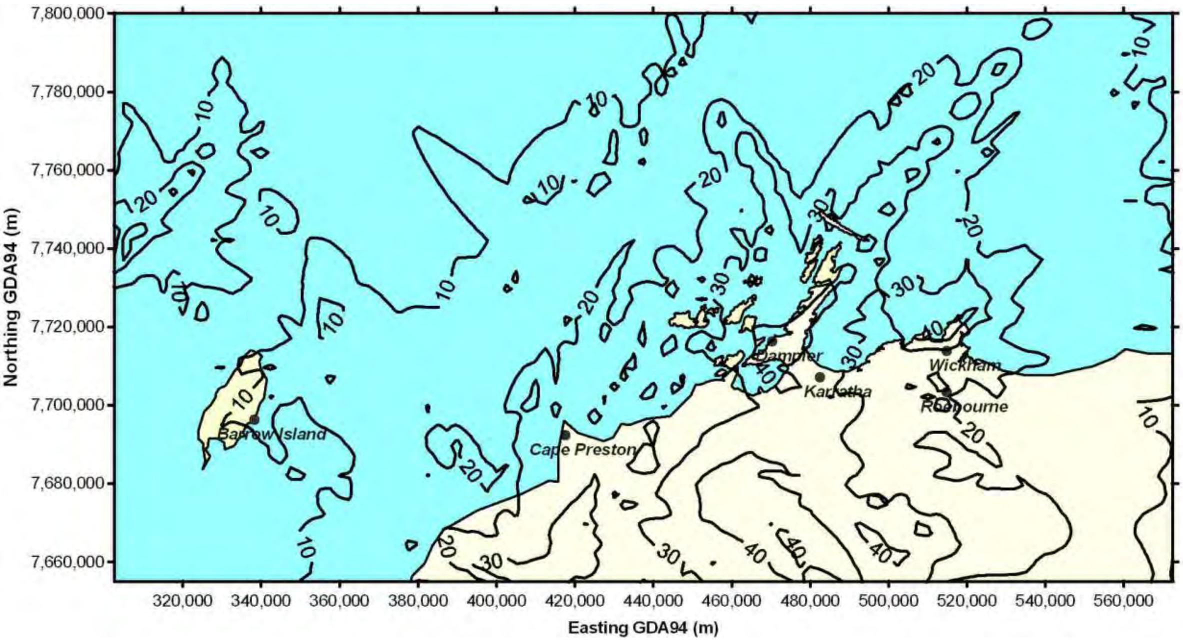

Figure 7-25 Predicted maximum 1-hour NO_2 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with the Train 4 AGRU emissions reinjected

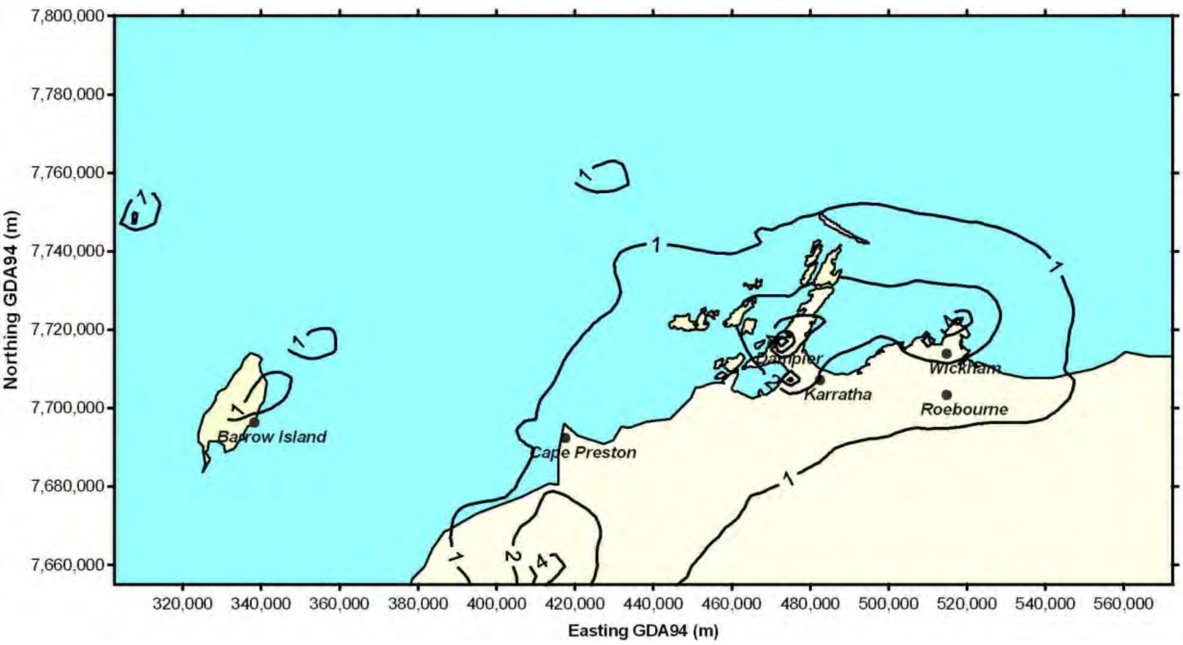

Figure 7-26 Predicted annual average NO_2 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with the Train 4 AGRU emissions reinjected

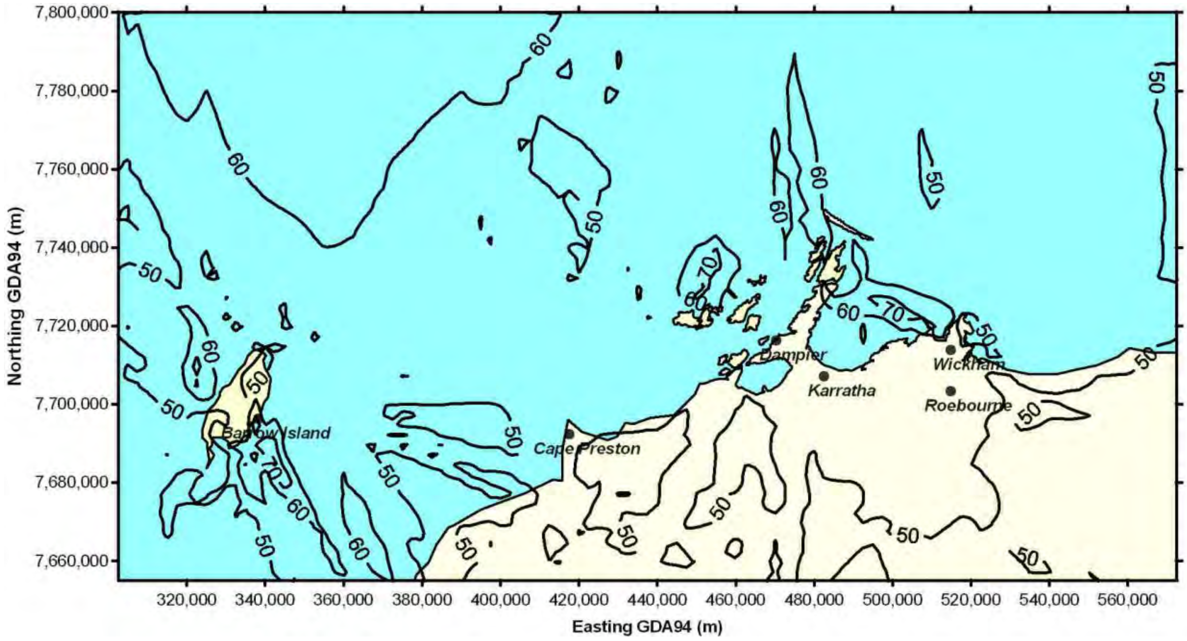

Figure 7-27 Predicted maximum 1-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with the Train 4 AGRU emissions reinjected

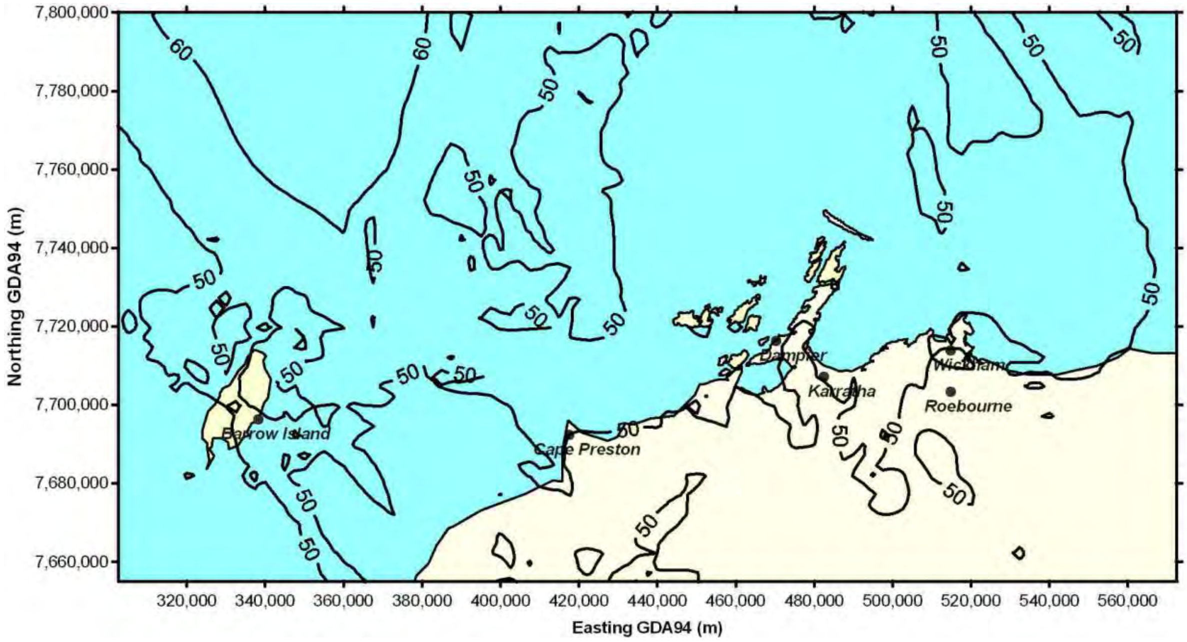

Figure 7-28 Predicted second highest 1-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with the Train 4 AGRU emissions reinjected

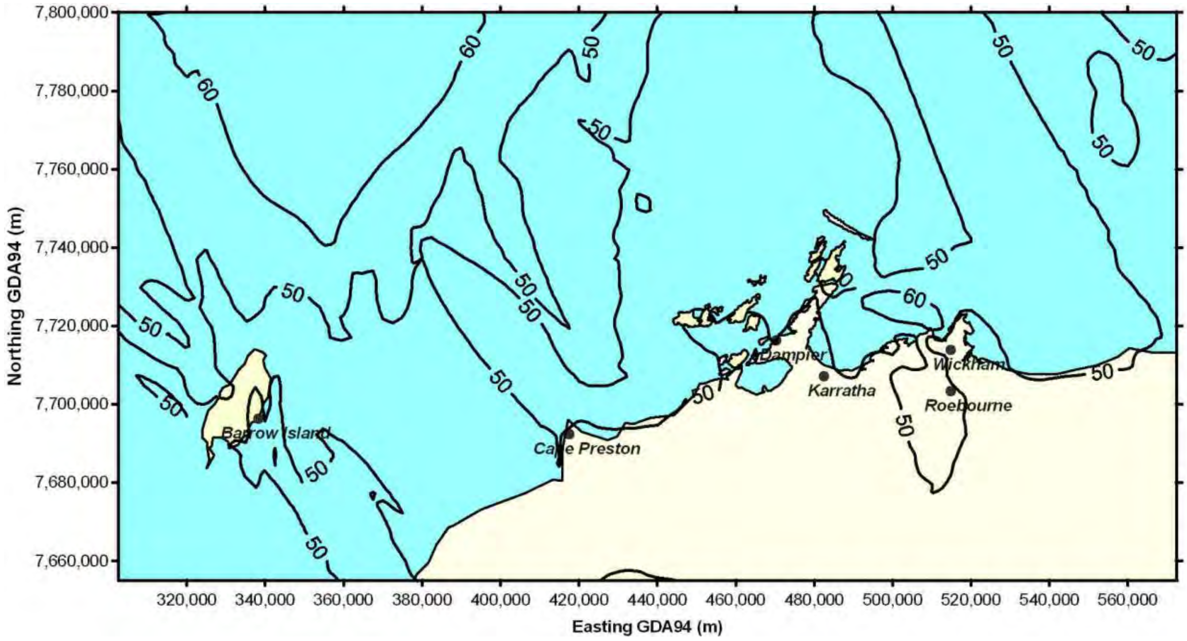

Figure 7-29 Predicted maximum 4-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with the Train 4 AGRU emissions reinjected

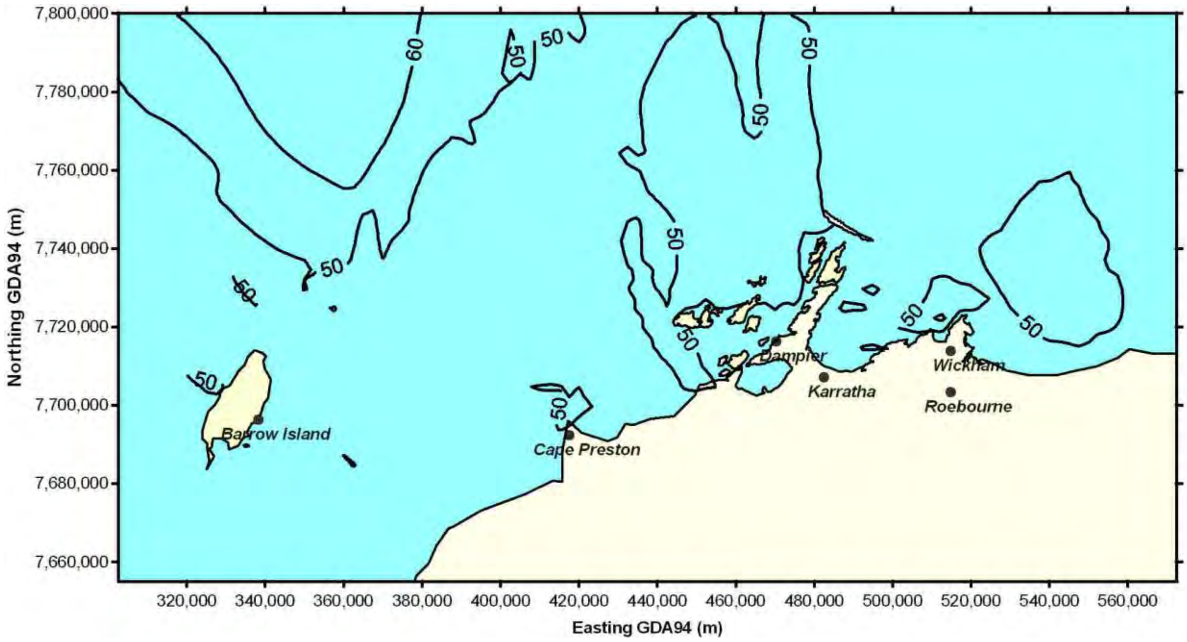

Figure 7-30 Predicted second highest 4-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with the Train 4 AGRU emissions reinjected

Table 7-1 and **Table 7-2** and **Figure 7-25** to **Figure 7-30** indicate that:

- Little change from the Foundation Project, with a slight increase in the maximum NO_2 concentrations and a slight decrease in the maximum ozone concentrations.
- The maximum 1-hour NO_2 concentrations are predicted to increase from 40 to 41% of the NEPM standard, whilst the second highest 1-hour concentration remains constant at 39%;

- The maximum and second highest 1-hour ozone concentrations decrease from 84 and 73% of the NEPM standard for the GFP to 81 and 69% with the FTP, whilst the maximum and second highest 4-hour ozone concentration decrease from 88 and 86% with the GFP to 86 and 85% with the FTP;
- This change is due the additional NO_X from the Fourth Train contributing to increase NO_2 concentrations, but decreasing the ozone concentrations as there are no additional VOCs emitted; and
- Comparison to the option without venting (Scenario 2a) indicates a significant reduction in the maximum and second highest 1-hour ozone concentrations (this will be discussed further in **Section 7.5**).

7.3.3 Existing and Approved Sources with Fourth Train Proposal with Train 4 emissions directed to a RTO – Scenario 2c

The predicted maximum ozone and NO_2 concentrations from natural sources, existing, approved and proposed sources and the Fourth Train Proposal with a RTO are listed in **Table 7-1** and **Table 7-2**. Concentration plots are presented in **Figure 7-31** to **Figure 7-36**.

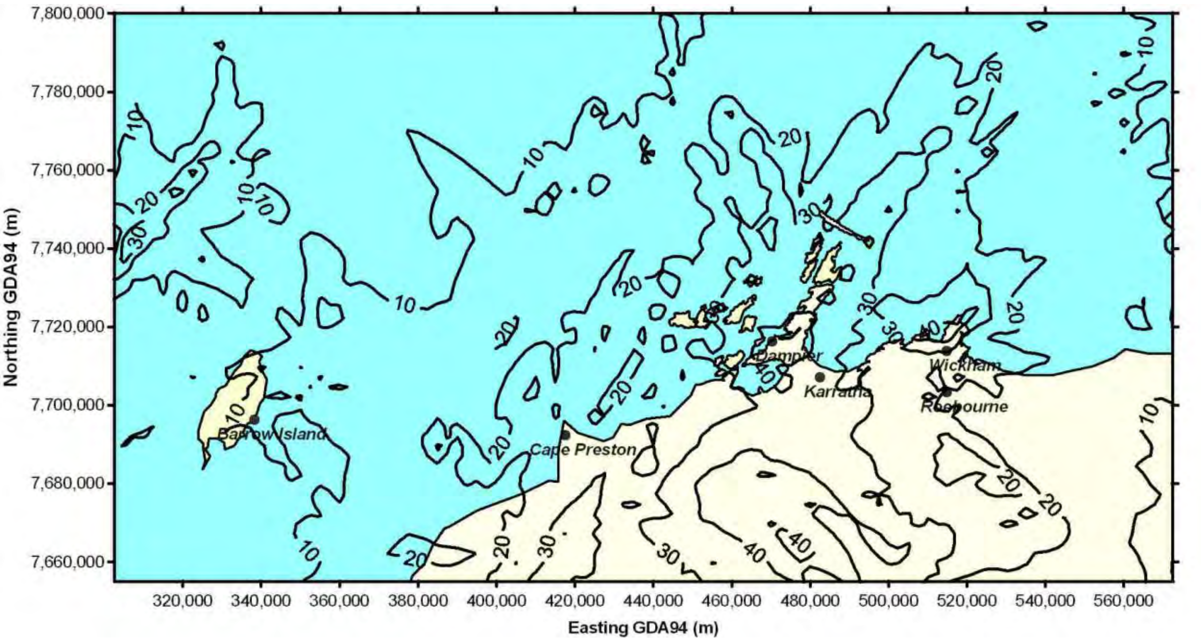

Figure 7-31 Predicted maximum 1-hour NO_2 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with Train 4 AGRU emissions directed to a RTO

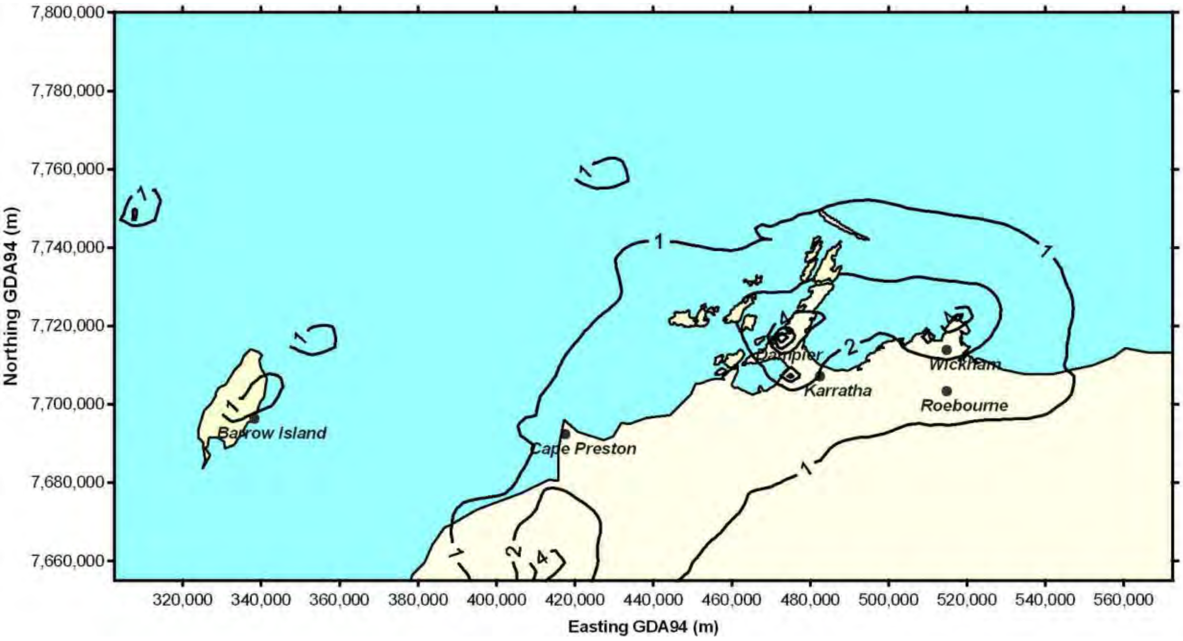

Figure 7-32 Predicted annual average NO_2 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with Train 4 AGRU emissions directed to a RTO

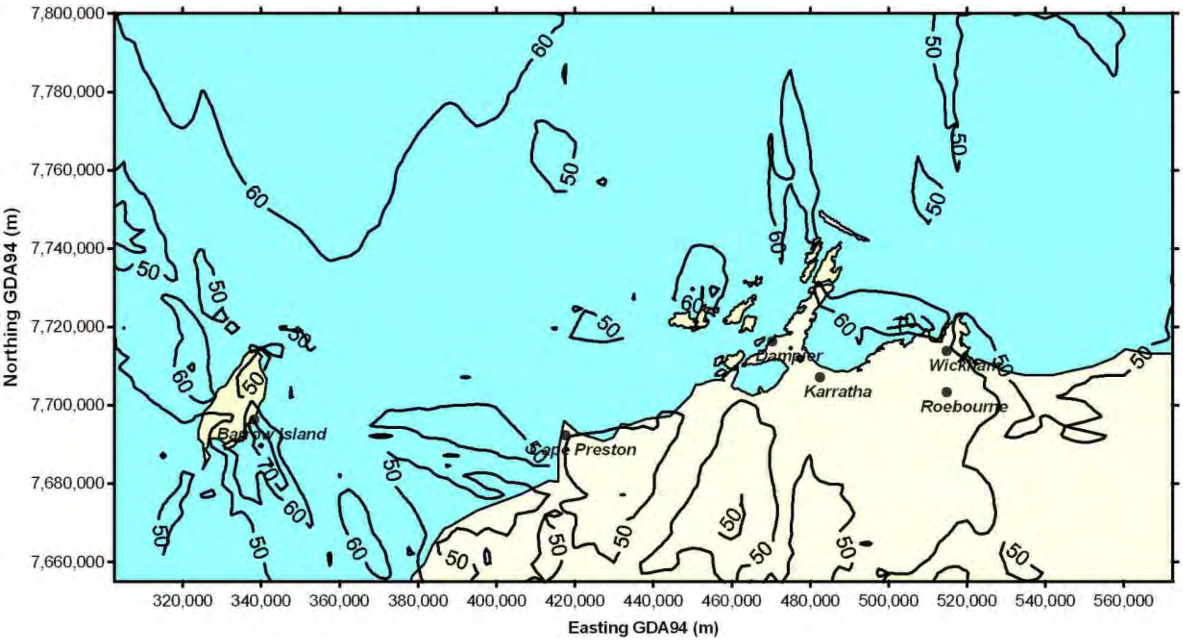

Figure 7-33 Predicted maximum 1-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with Train 4 AGRU emissions directed to a RTO

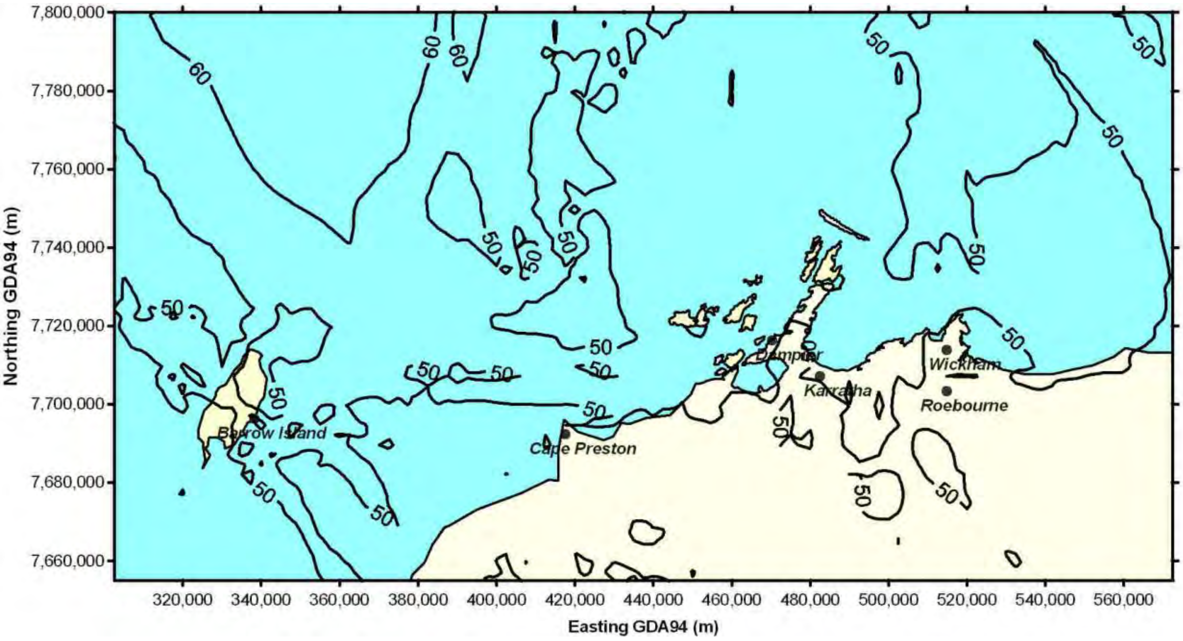

Figure 7-34 Predicted second highest 1-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with Train 4 AGRU emissions directed to a RTO

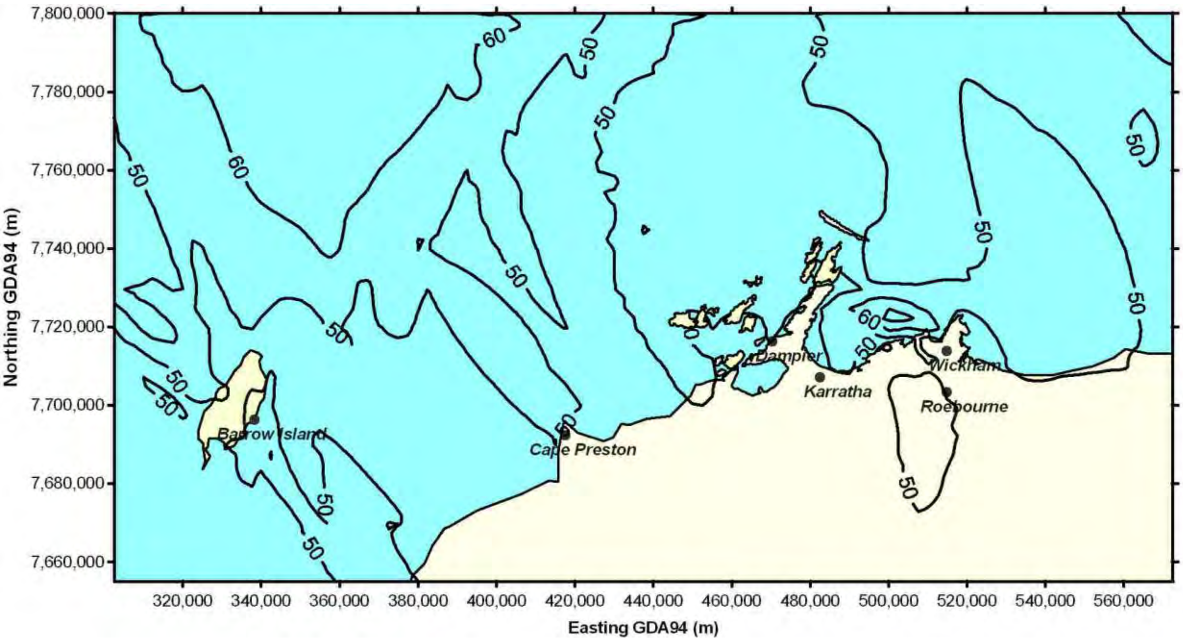

Figure 7-35 Predicted maximum 4-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with Train 4 AGRU emissions directed to a RTO

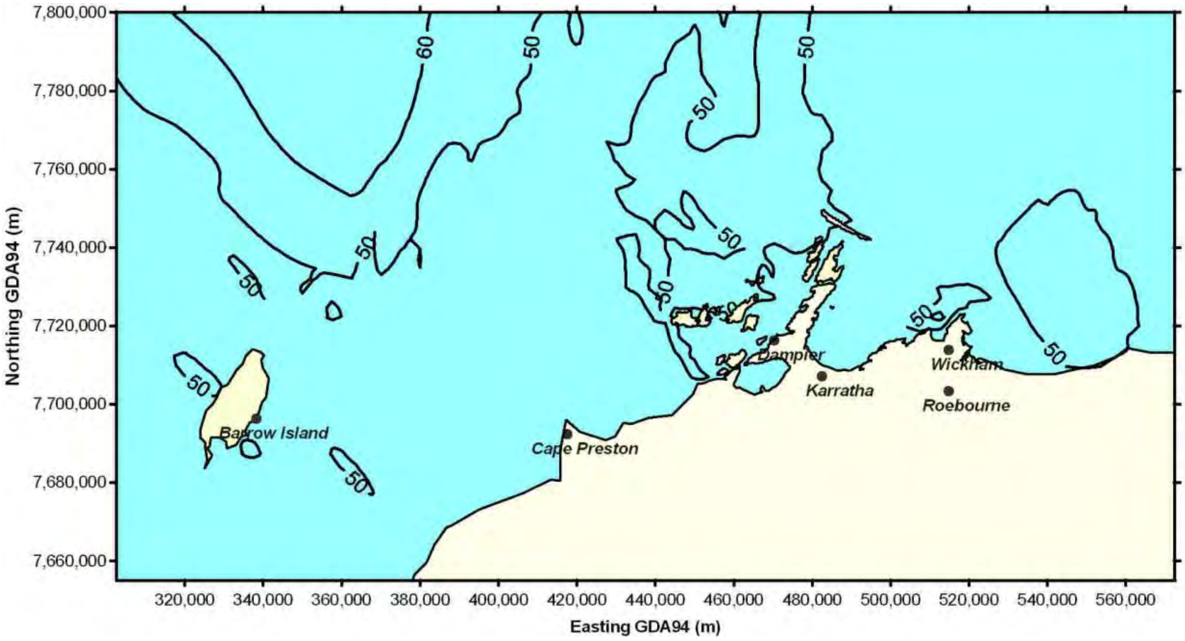

Figure 7-36 Predicted second highest 4-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with Train 4 AGRU emissions directed to a RTO

Table 7-1 and **Table 7-2** and **Figure 7-31** to **Figure 7-36** indicate that with the RTO option for the fourth LNG train AGRU :

- The NO_2 concentrations with the RTO option show a slight increase whilst the ozone concentrations generally decrease;
- The maximum 1-hour NO_2 concentrations increase from 40% for the GFP to 43% for the FTP whilst remaining constant at 39% for the 2nd highest 1-hour concentration; and
- The maximum and 2nd highest 1-hour and maximum ozone concentrations reduce, whilst the maximum 4-hour increases slightly. Overall it is considered that the ozone levels decrease based on using the 2nd highest concentration as the more robust statistic. This is also seen when comparing other statistics as presented in **Section 7.5**. Compared to the NEPM, the maximum 1-hour concentration decreases to 82% of the standard (68% using the second highest hour); and with the 4-hour maximum and second highest concentrations increasing to 91% and remaining at 84% of the standard.

Therefore, it is considered that there is a benefit including the RTO versus venting directly to air for the fourth LNG train. This will be discussed further in **Section 7.5**.

7.4 Fourth Train Proposal - Non Routine Operations

7.4.1 Existing and Future Sources with the Fourth Train Proposal with Non Routine Conditions - "Pigging" – Scenario 3

The predicted maximum ozone and NO_2 concentrations from natural sources, existing, approved and proposed sources and the Fourth Train Proposal with "pigging" occurring are listed in **Table 7-1** and **Table 7-2**. Contours plots are presented in **Figure 7-37** to **Figure 7-42**.

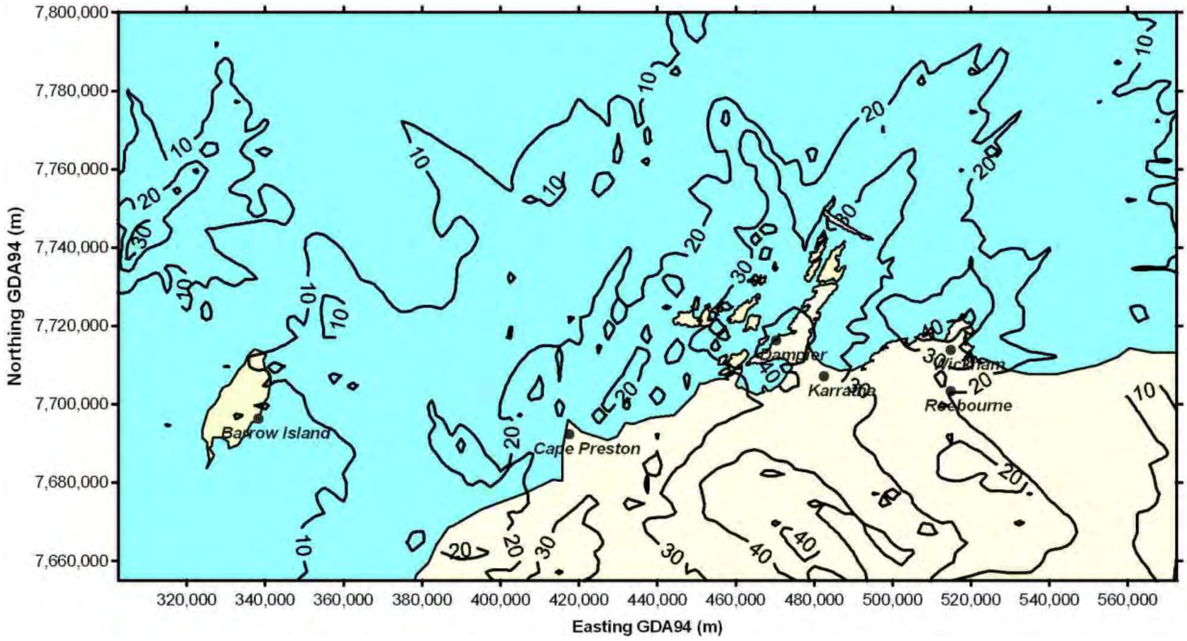

Figure 7-37 Predicted maximum 1-hour NO_2 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with "Pigging" Operations

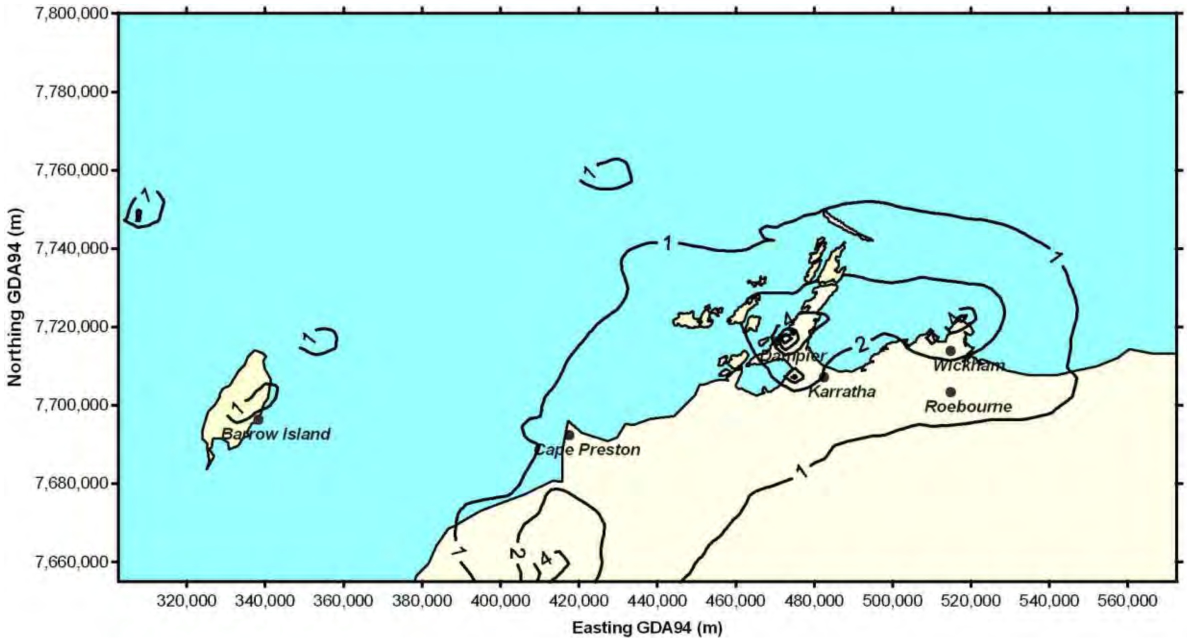

Figure 7-38 Predicted annual average NO_2 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with "Pigging" Operations

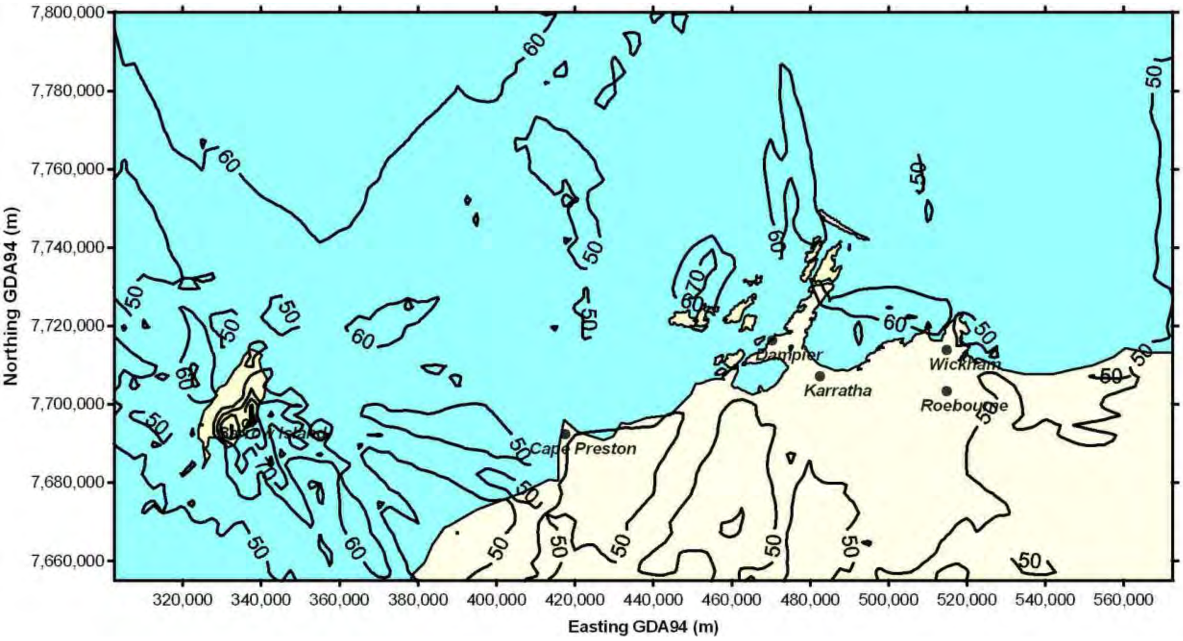

Figure 7-39 Predicted maximum 1-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with "Pigging" Operations

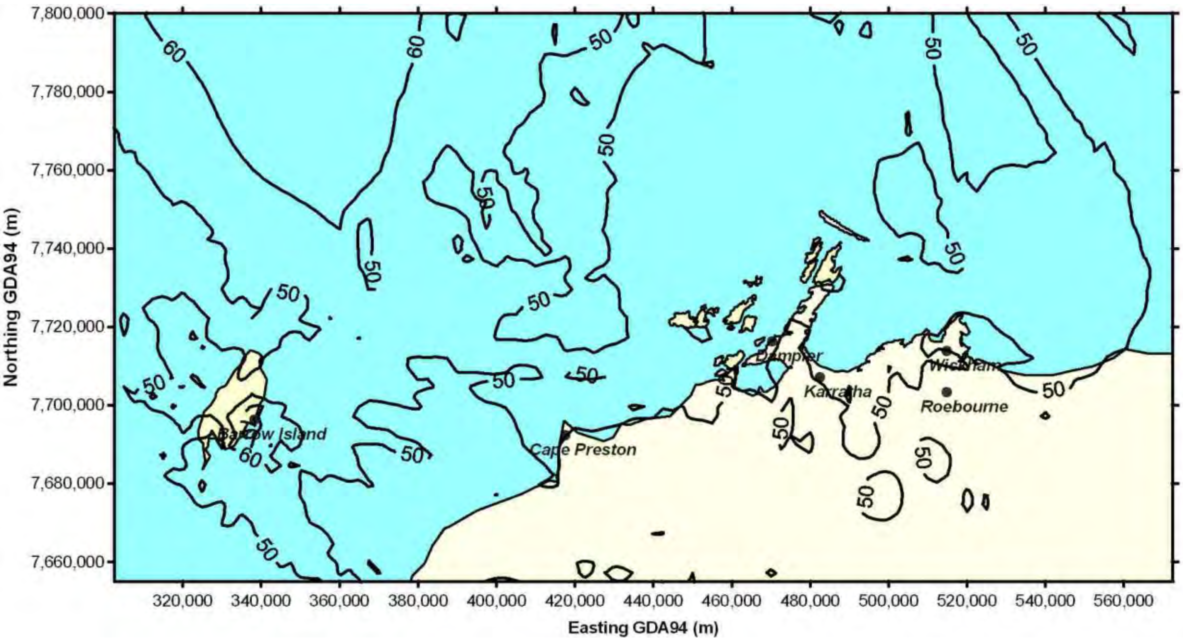

Figure 7-40 Predicted second highest 1-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with "Pigging" Operations

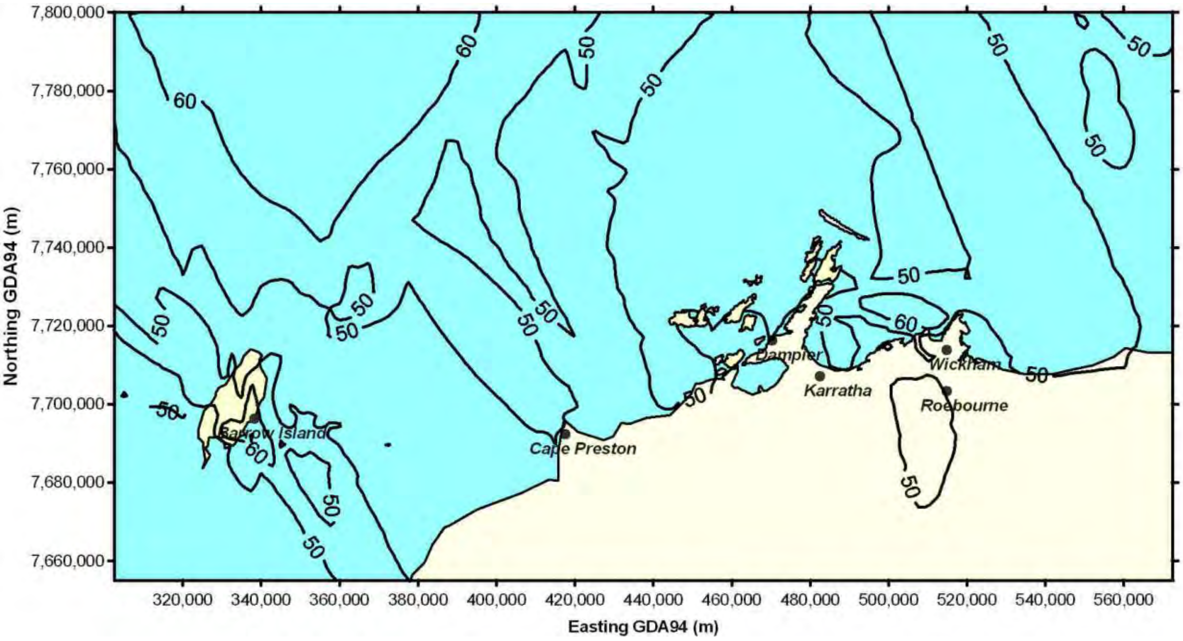

Figure 7-41 Predicted maximum 4-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with "Pigging" Operations

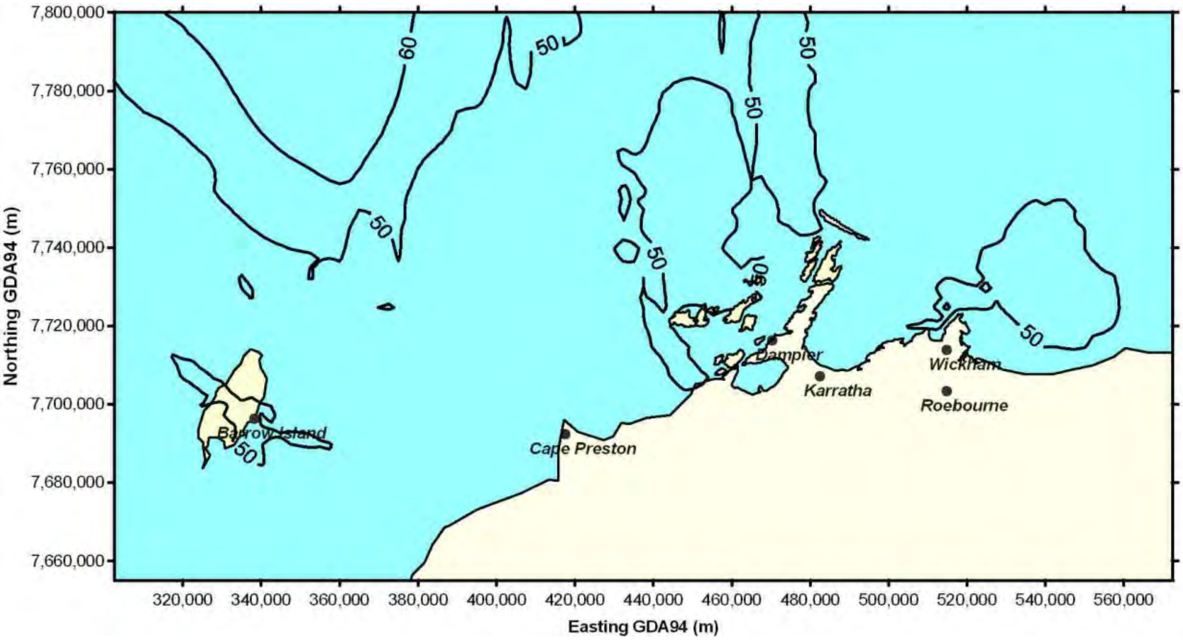

Figure 7-42 Predicted second highest 4-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with "Pigging" Operations

Table 7-1 and **Table 7-2** and **Figure 7-37** to **Figure 7-42** indicate that for the "pigging" operations in which three AGRUs emissions are released to atmosphere:

- The maximum predicted highest 1-hour and 4-hour concentrations are 93 ppb and 60 ppb or 93 and 86% of the NEPM standards. This is less than that predicted from the routine operation of the Fourth Train Proposal with venting AGRU emissions to air;
- The maximum 2nd highest 1-hour and 4-hour ozone concentrations are predicted to increase slightly above that predicted for the Fourth Train Proposal with AGRU emission venting, to 76% and 86% of the NEPM criteria; and

- The maximum NO_2 concentrations are predicted to be less than or equal to the routine case.

Therefore, the pigging operations are seen to result in concentrations that are similar to that from the routine operations of the FTP with Train 4 AGRU emissions vented to air, and higher than that from the FTP cases modelled when the Train 4 AGRU emissions are not vented. **Section 7.5** will further present how other statistics vary between the different options (such as the 9^{th} highest 1-hour or 99.9^{th} percentile).

7.4.2 Existing and Future Sources with the Fourth Train Proposal with Non Routine Conditions- Black Start – Scenario 4

The predicted maximum ozone and NO_2 concentrations from natural sources, existing, approved and proposed sources and the Fourth Train Proposal with a black start occurring for the whole year are listed in **Table 7-1** and **Table 7-2**. Contours plots are presented in **Figure 7-43** to **Figure 7-48**.

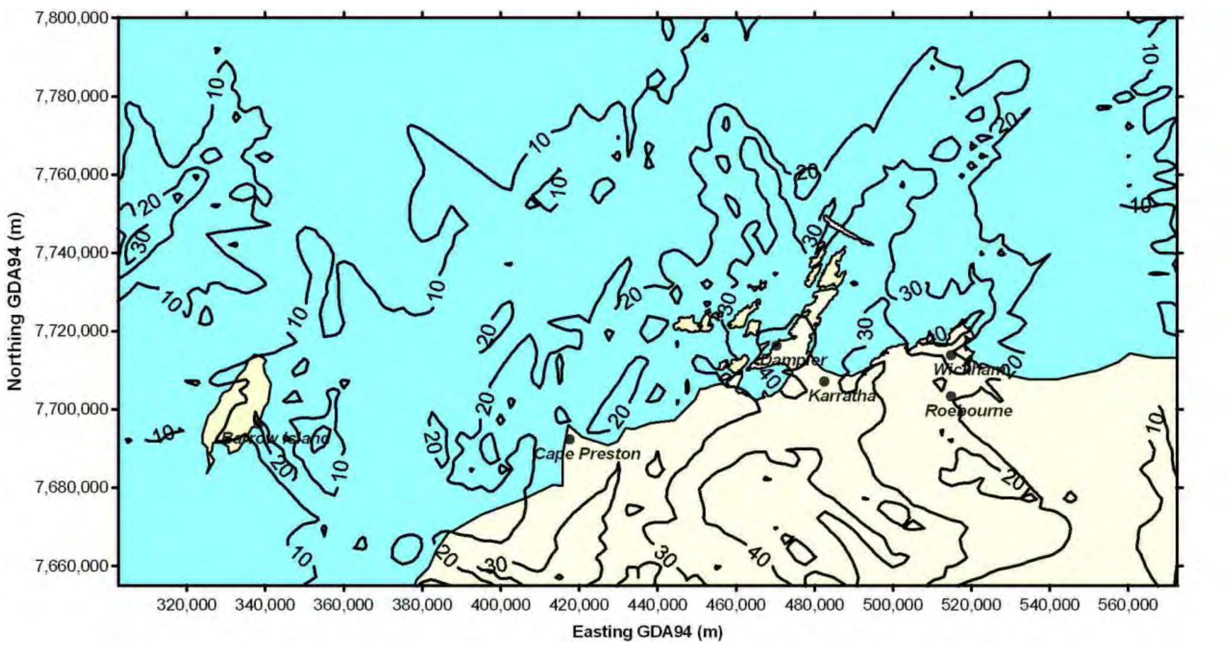

Figure 7-43 Predicted maximum 1-hour NO_2 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with a Black Start

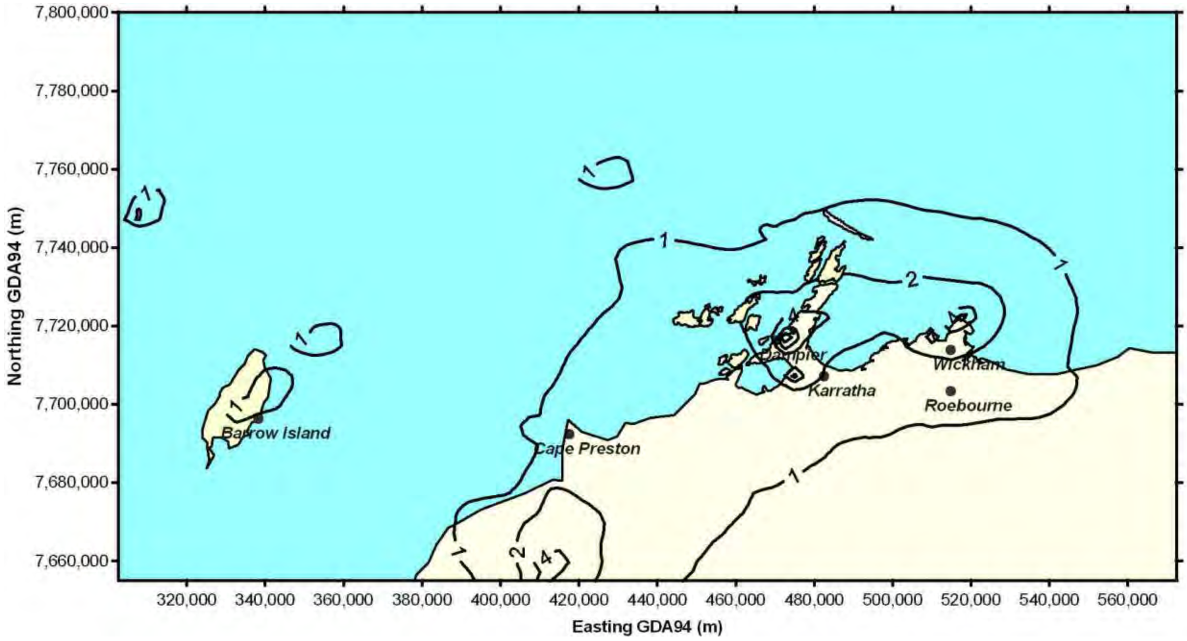

Figure 7-44 Predicted annual average NO_2 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with a Black Start

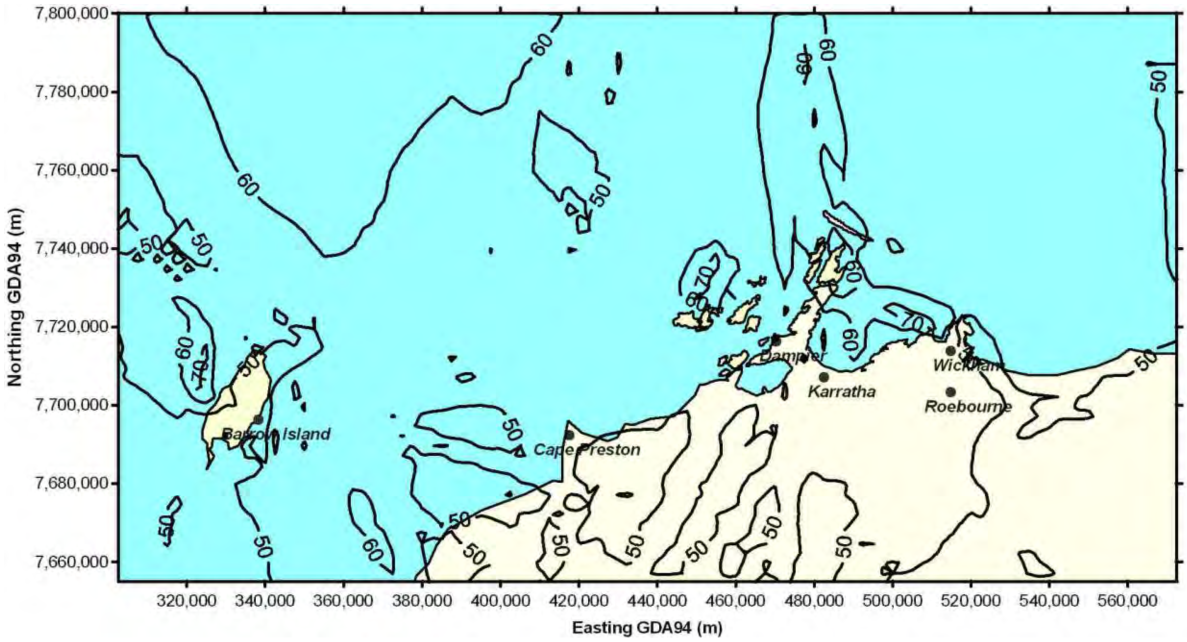

Figure 7-45 Predicted maximum 1-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with a Black Start

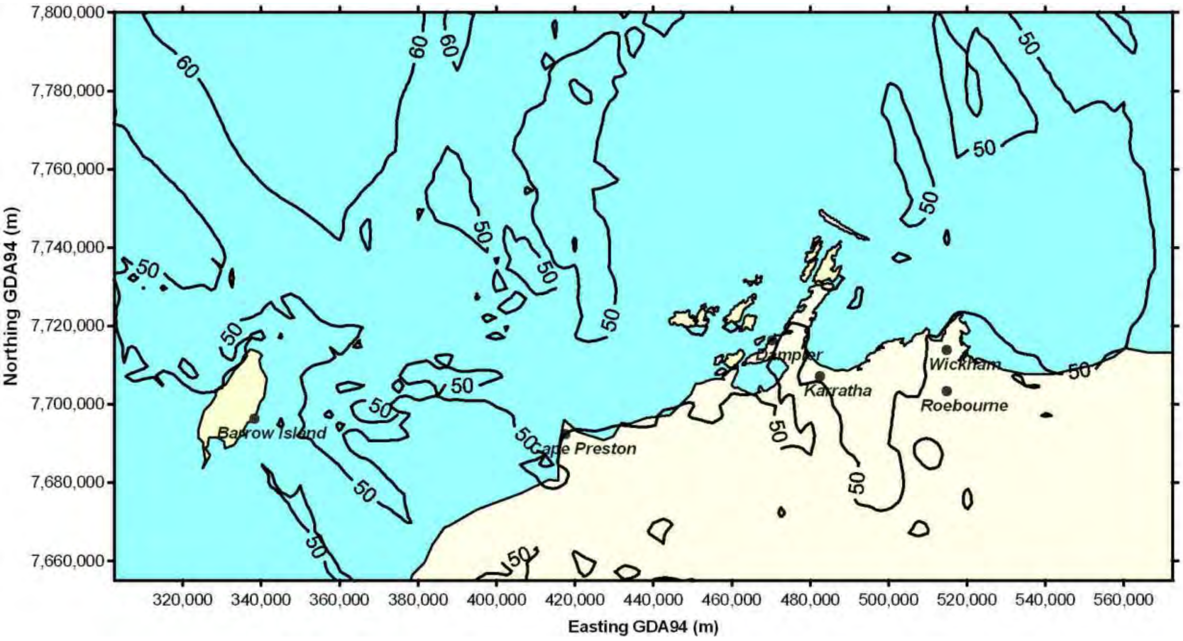

Figure 7-46 Predicted second highest 1-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with a Black Start

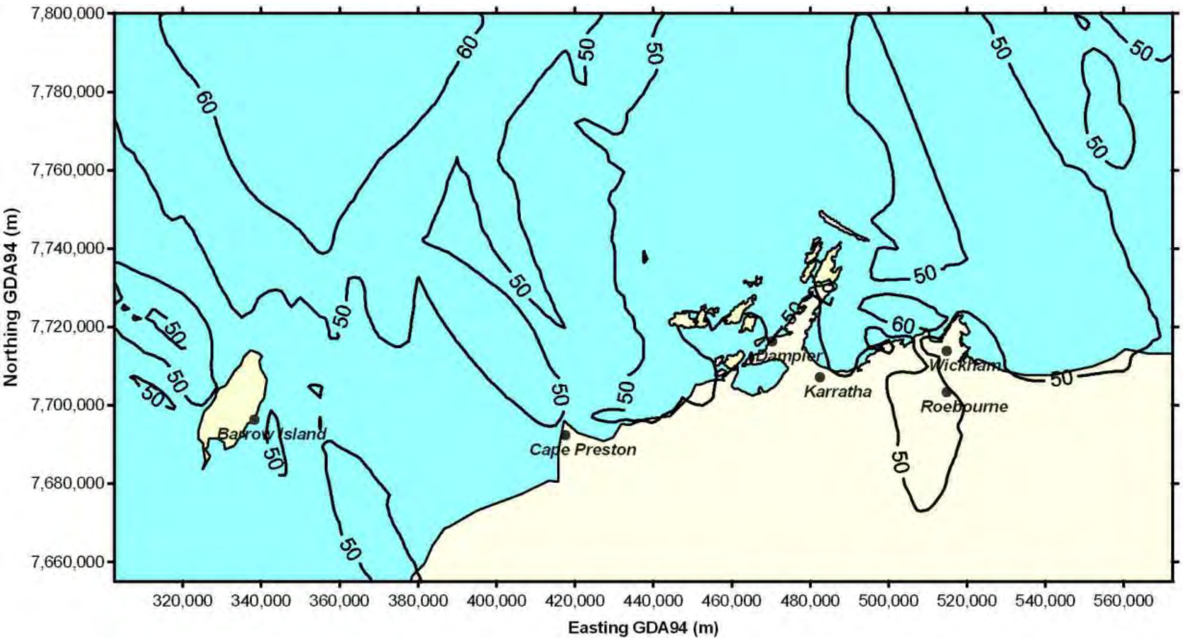

Figure 7-47 Predicted maximum 4-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with a Black Start

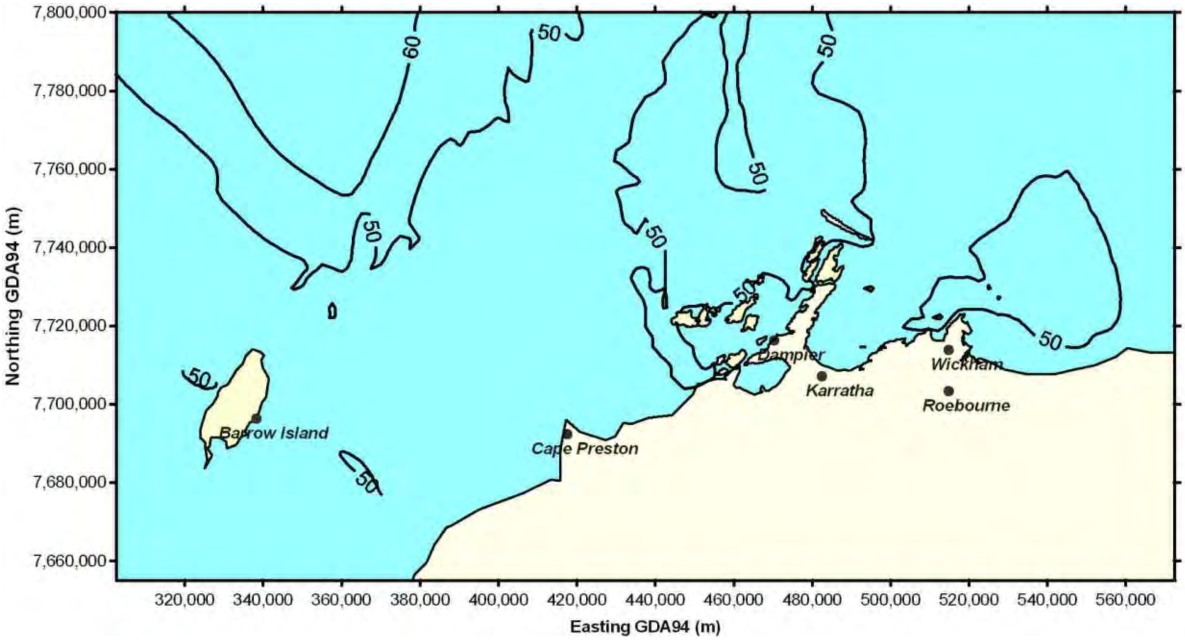

Figure 7-48 Predicted second highest 4-hour O_3 concentrations (ppb) from existing and future sources including the Fourth Train Proposal with a Black Start

Table 7-1 and **Table 7-2** and **Figure 7-43** to **Figure 7-48** indicate that the concentrations that result from a black start will be no more, and generally less, than from the routine operation. Therefore, given the low frequency of these events, they are not predicted to be an issue for regional pollutant levels.

7.5 Concentrations at Select Receptors

To further illustrate the change in ozone concentrations for the various modelled scenarios, the concentrations statistics at various sites are presented in **Figure 7-49** to **Figure 7-55**.

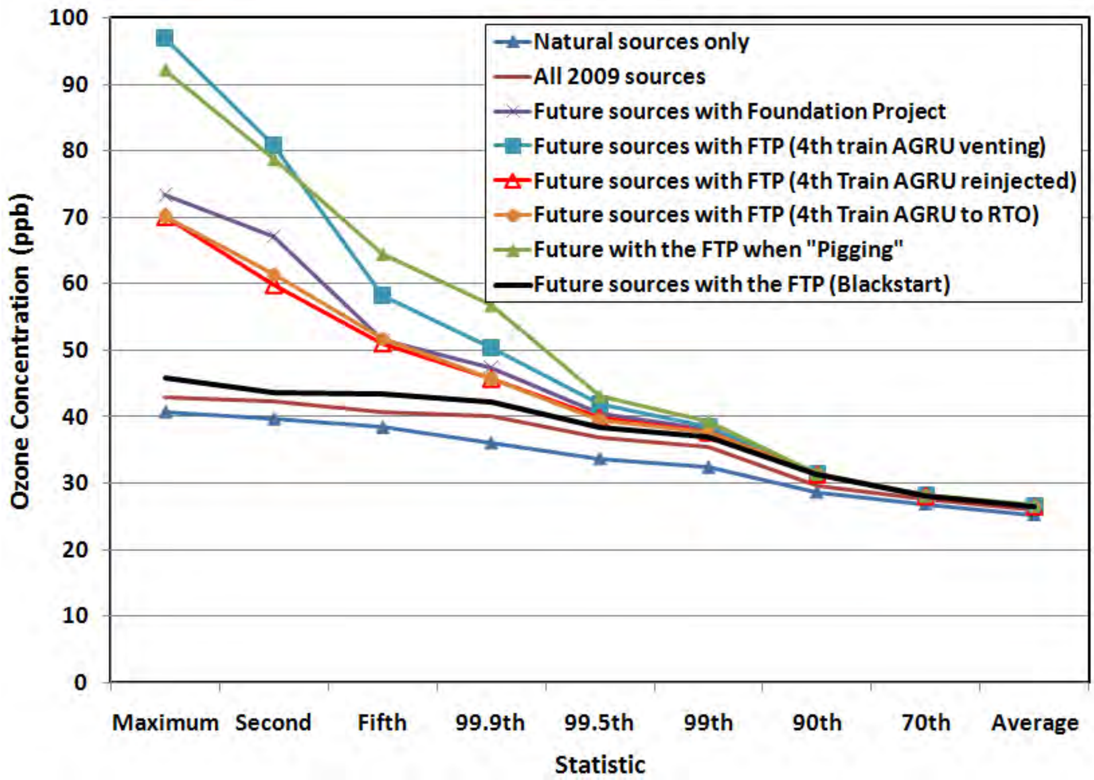

Figure 7-49 Predicted 1-hour O_3 concentrations (ppb) for various scenarios at the Barrow Island Chevron Camp

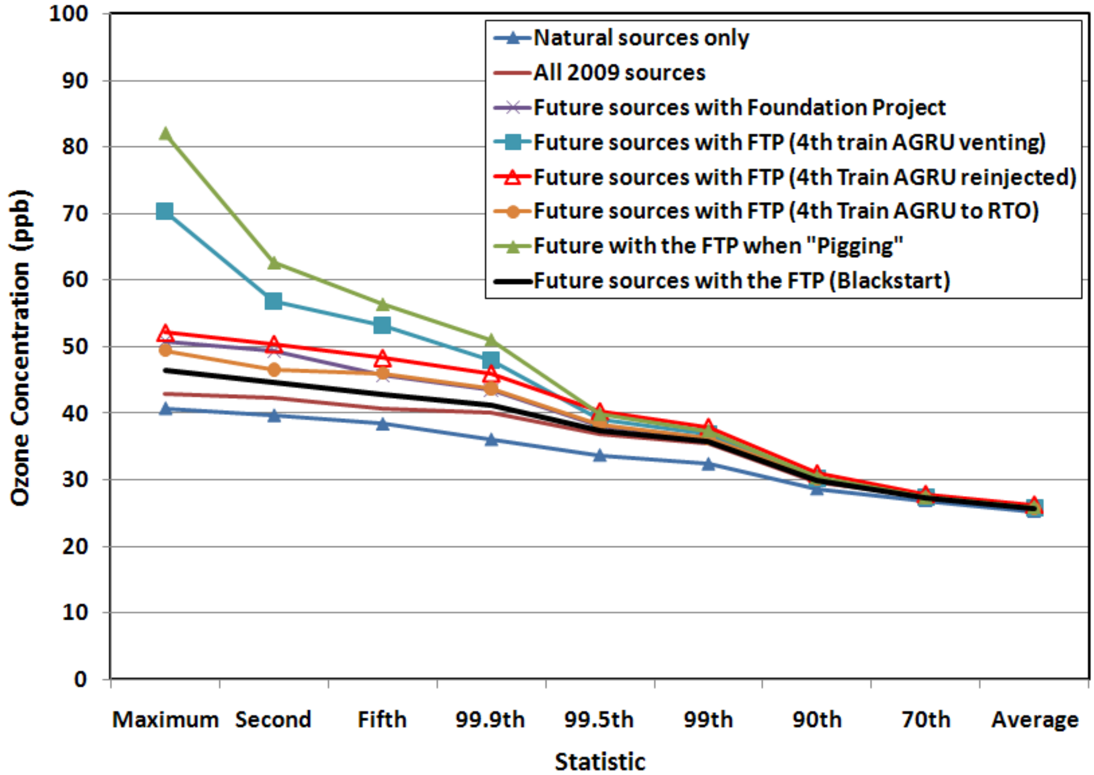

Figure 7-50 Predicted 1-hour O_3 concentrations (ppb) for various scenarios at the WA Oil Base on Barrow Island

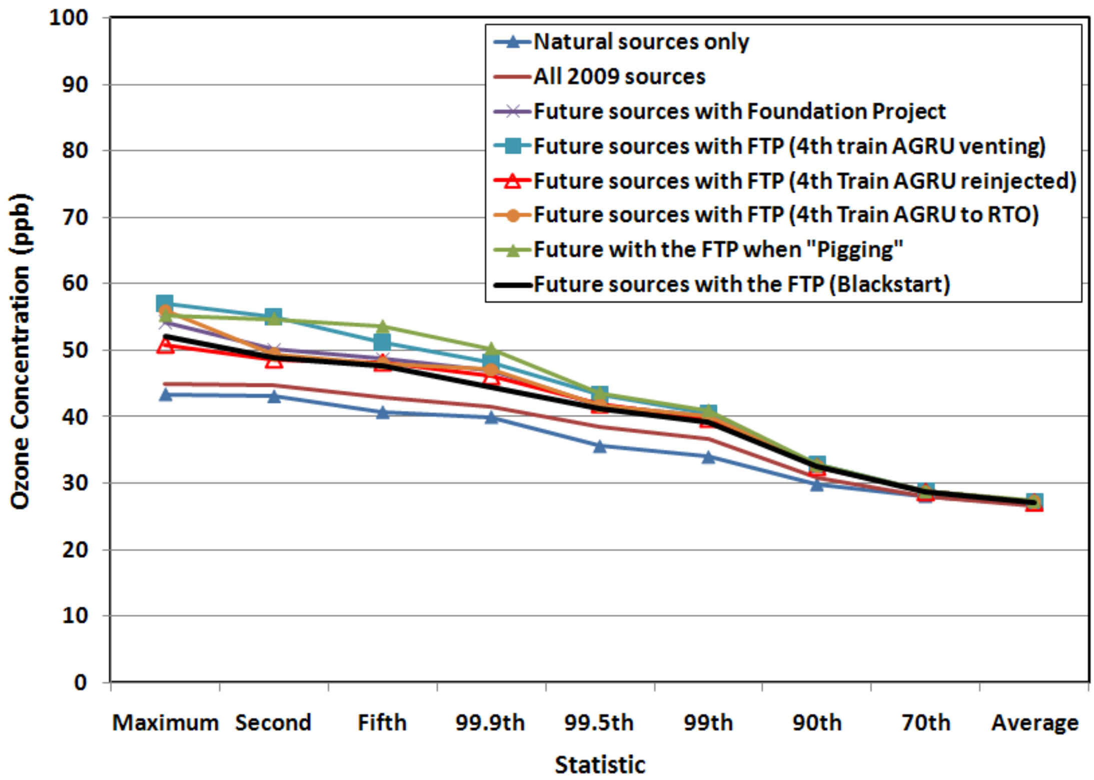

Figure 7-51 Predicted 1-hour O_3 concentrations (ppb) for various scenarios at Varanus Island

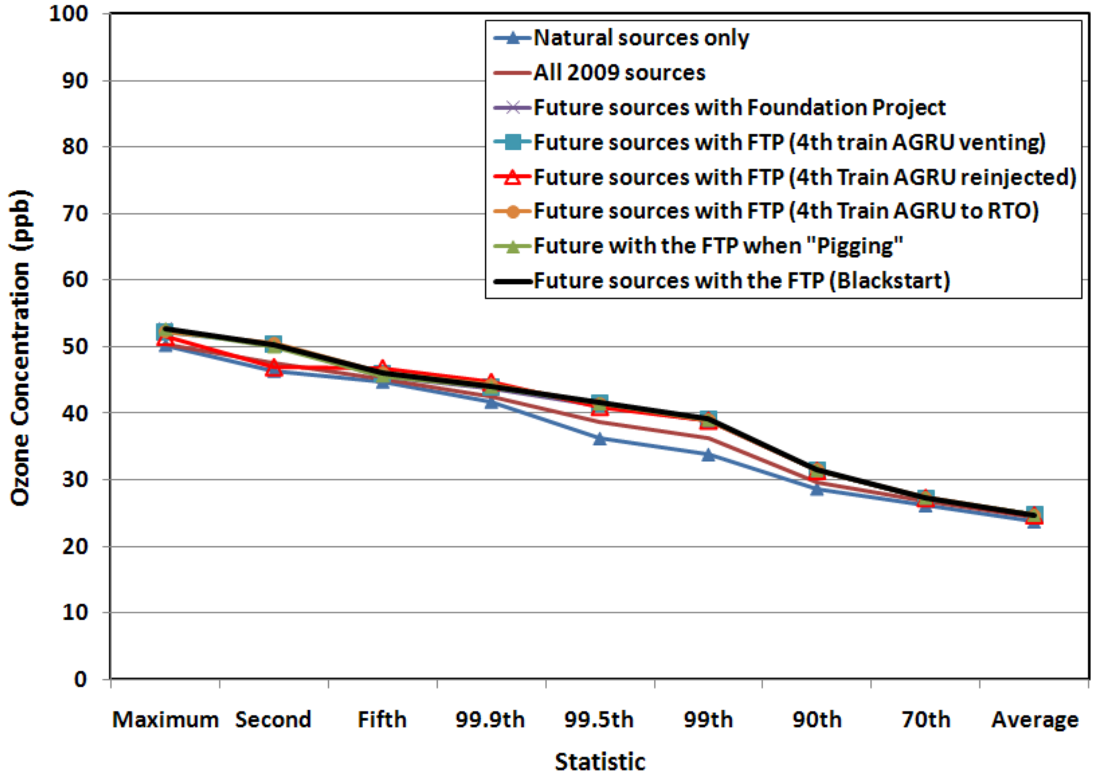

Figure 7-52 Predicted 1-hour O_3 concentrations (ppb) for various scenarios at Mardie Station

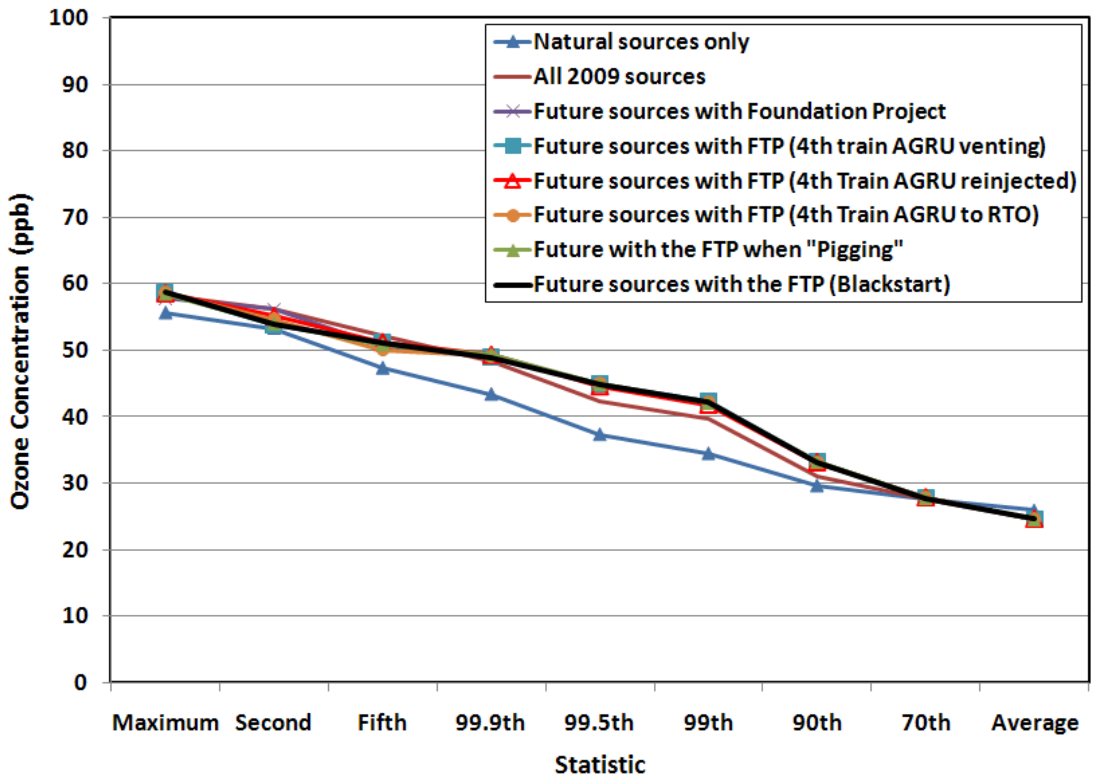

Figure 7-53 Predicted O_3 concentrations (ppb) for various scenarios at Dampier

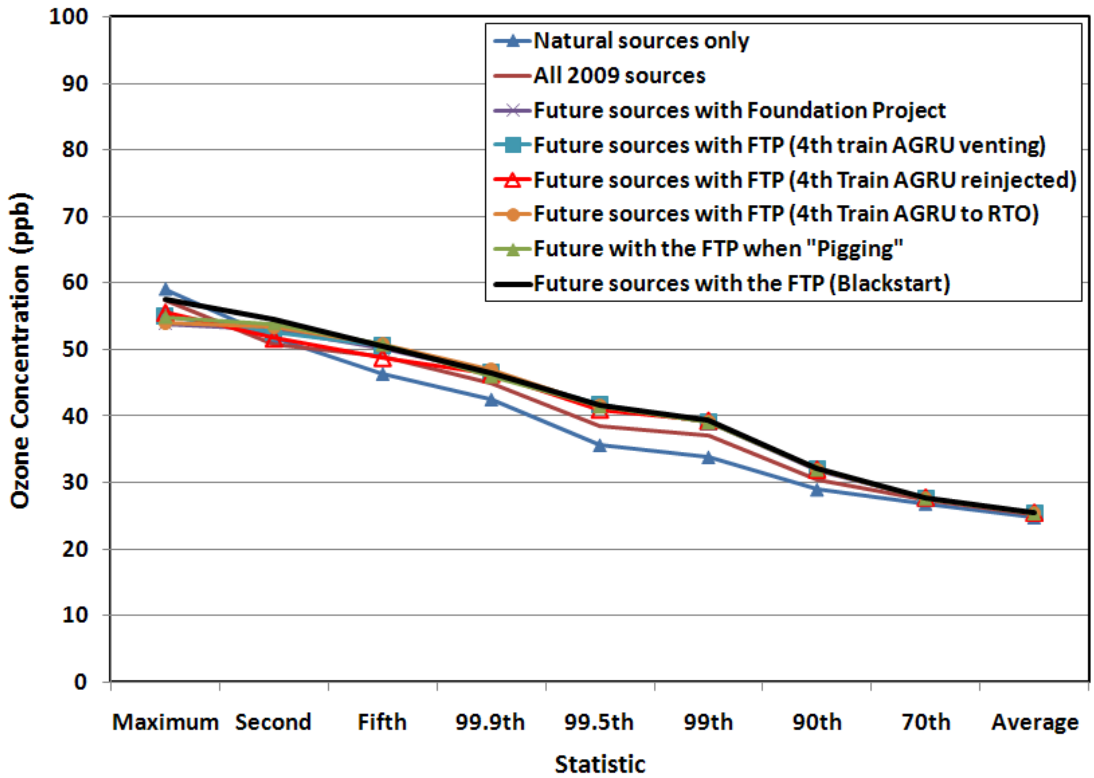

Figure 7-54 Predicted 1-hour O_3 concentrations (ppb) for various scenarios at Karratha

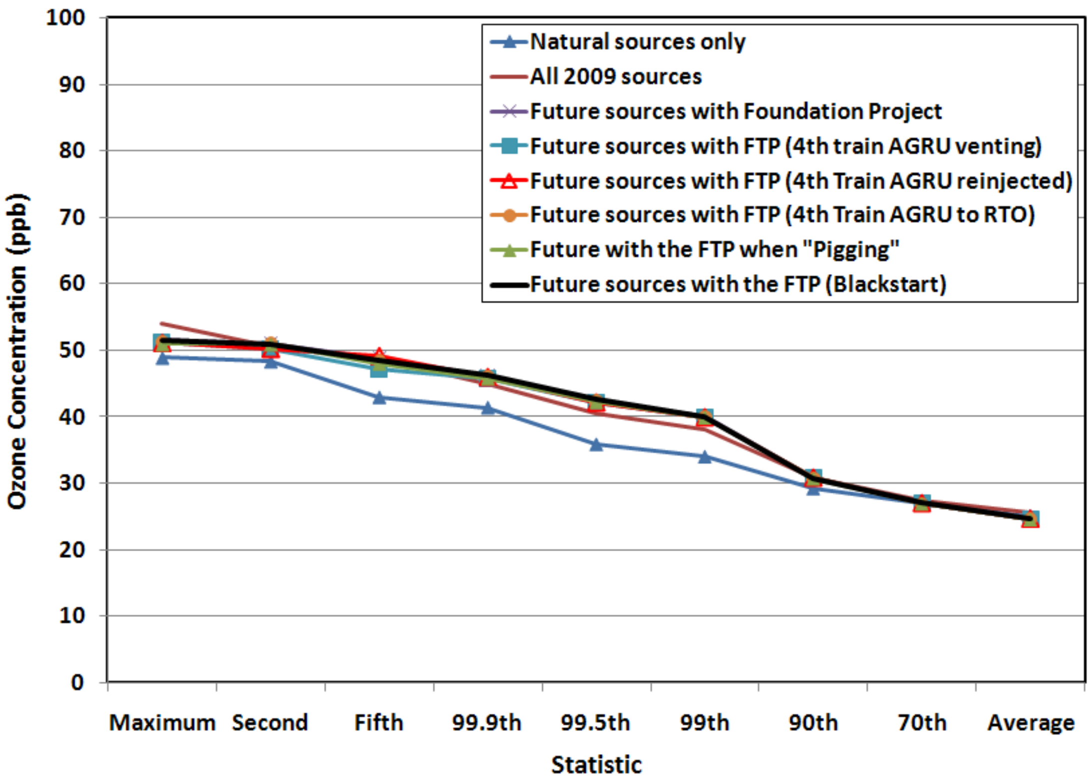

Figure 7-55 Predicted 1-hour O_3 concentrations (ppb) for various scenarios at Wickham

Figure 7-49 to **Figure 7-55** indicates:

- Maximum changes in the 1-hour ozone concentrations occur close in to the plant at Barrow Island near the Chevron Camp and are fairly localised. Concentrations on most of Barrow Island are much lower as for example at the WA Oil base, with much lower impacts predicted at nearby Varanus Island and with little change discernable at the mainland receptors;
- At Barrow Island, of the Fourth Train routine scenarios modelled, the option of venting the fourth train emissions to air results in a significant increase above that from the Foundation Project for the maximum to 99.9th percentile (about the 9th highest hour in the year) 1–hour concentrations. This indicates the sensitivity of the predicted ozone levels to additional AGRU emissions. The predicted impacts from the Fourth Train Proposal with an RTO or re-injection are much lower than for the venting case and generally similar to, and in cases slightly lower than, the approved Foundation Project;
- The predicted concentrations from "pigging" with three AGRUs venting continually are generally the highest concentrations of any of the cases modelled (excluding the maximum and second highest concentrations at the Chevron Camp). These maximums however, are unlikely to occur as they would require three AGRUs to be venting at the same time during the worst case meteorological conditions;
- The predicted impact from a black start is predicted to be very low, and not much higher than the existing levels and less than routine operations of the Foundation Project;
- At Varanus Island, the predicted concentrations are much lower, but show a similar pattern with the maximum ozone concentrations predicted to occur for the Fourth Train Proposal if Train 4 AGRU emissions are vented to air and for the pigging operations; and
- For the mainland sites there is generally negligible difference for the various Gorgon scenarios modelled, indicating little contribution from the Gorgon Project there.

8 Predicted Deposition Rates – Fourth Train Proposal with Existing and Future Sources

8.1 Introduction

The following section presents predicted deposition rates of nitrogen and sulphur compounds from the Project and all other existing and future proposed sources in the region. Predictions are made for the two routine cases for the Fourth Train Proposal:

- Scenario 2a/2b - without an RTO (the direct venting or re-injection cases); and
- Scenario 2c - with an RTO.

Non routine operations are not modelled as they are very short term releases and will not have an appreciable effect on the annual average deposition rates used to compare to criteria.

The modelling results from the two cases are presented for two regions:

1. To assess the local impacts on and around Barrow Island for which a fine grid run of TAPM-CTM has been used (inner meteorological grid of 1 km and pollution grid of 0.5 km); and
2. On a very regional scale (meteorological grid of 25 km and pollution grid of 10 km) to address the impacts at areas as far away as Coral Bay.

8.2 Local Deposition

Predicted annual dry deposition rates of sulphur are presented in **Figure 8-1** and **Figure 8-2**.

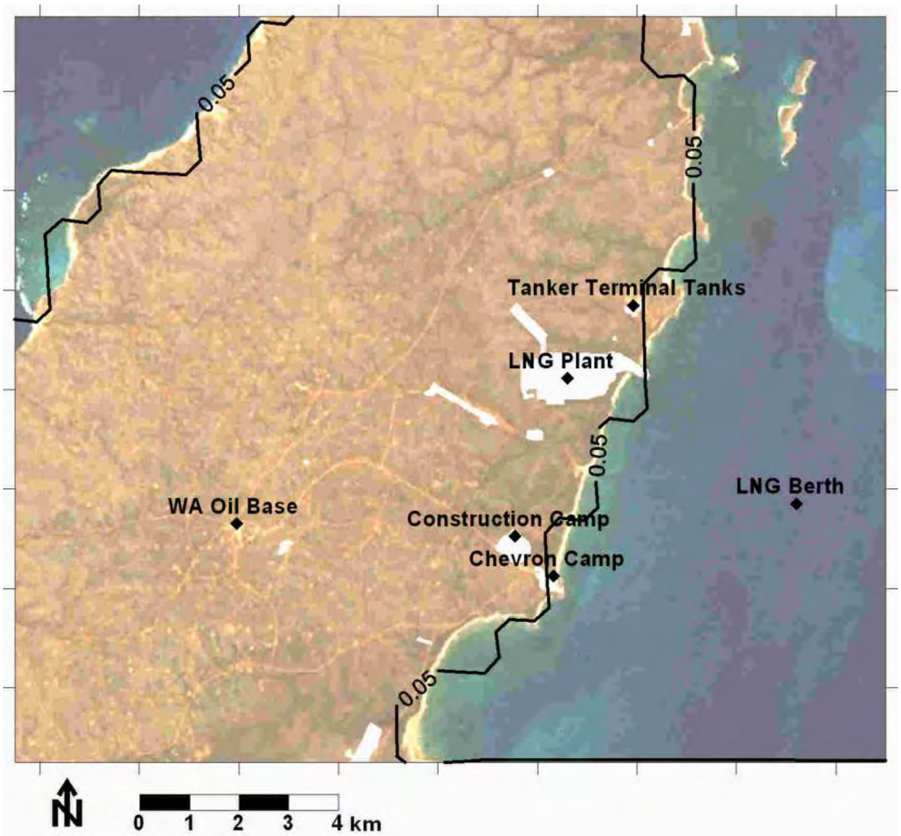

Figure 8-1 Predicted annual dry sulphur deposition (kg/ha/yr) at Barrow Island. All future Pilbara sources and the FTP without a RTO.

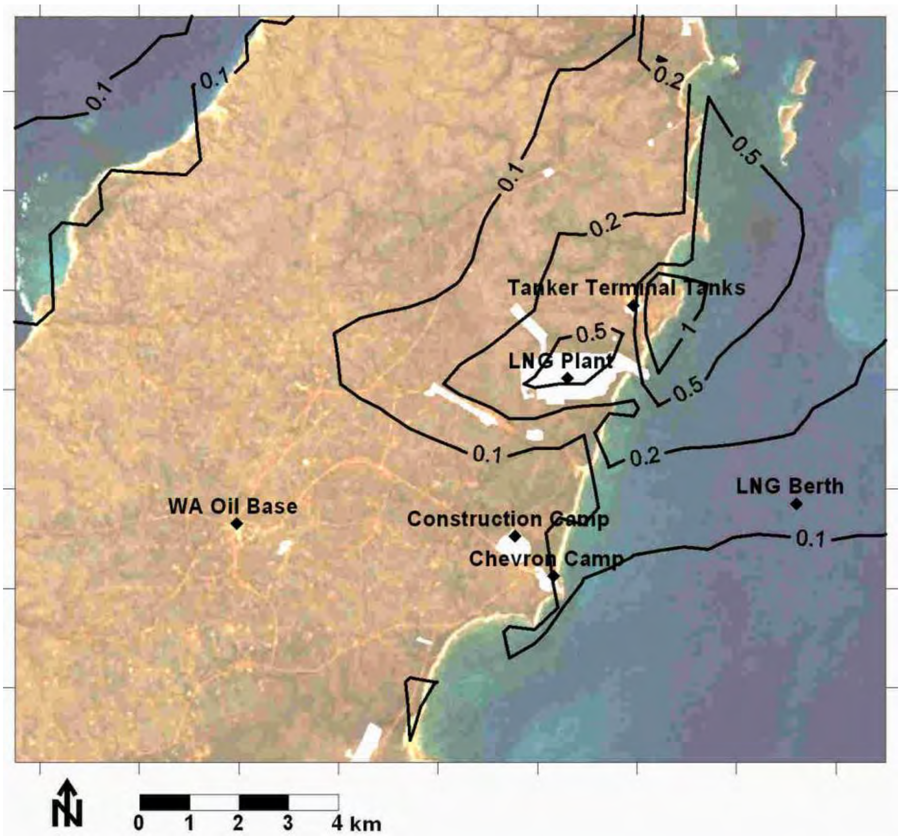

Figure 8-2 Predicted annual dry sulphur deposition (kg/ha/yr) at Barrow Island. All future Pilbara sources and the FTP with a RTO.

Figure 8-1 indicates that the without the RTO option, the FTP will lead to a negligible change in sulphur deposition on Barrow Island with very low values of up to 0.022 kg/ha/yr across the island with higher values over the ocean of around 0.1 kg/ha/yr.

With an RTO, the FTP will be the largest local source, with the highest sulphur deposition levels of 1.7 kg/ha/yr occurring around 2 km to the NE of the plant (see **Figure 8-2**). Sulphur deposition offshore near the berth areas are probably understated somewhat (e.g. a factor of two) as the ship emissions were modelled without any downwash which cannot be included in TAPM-CTM. This would not be expected to have any significant impact on land, as the only ships modelled with high sulphur in the fuel are the condensate ships which are fairly infrequent.

Predicted annual deposition rates of nitrogen from the FTP are presented in **Figure 8-3** without a RTO and in **Figure 8-4** with an RTO.

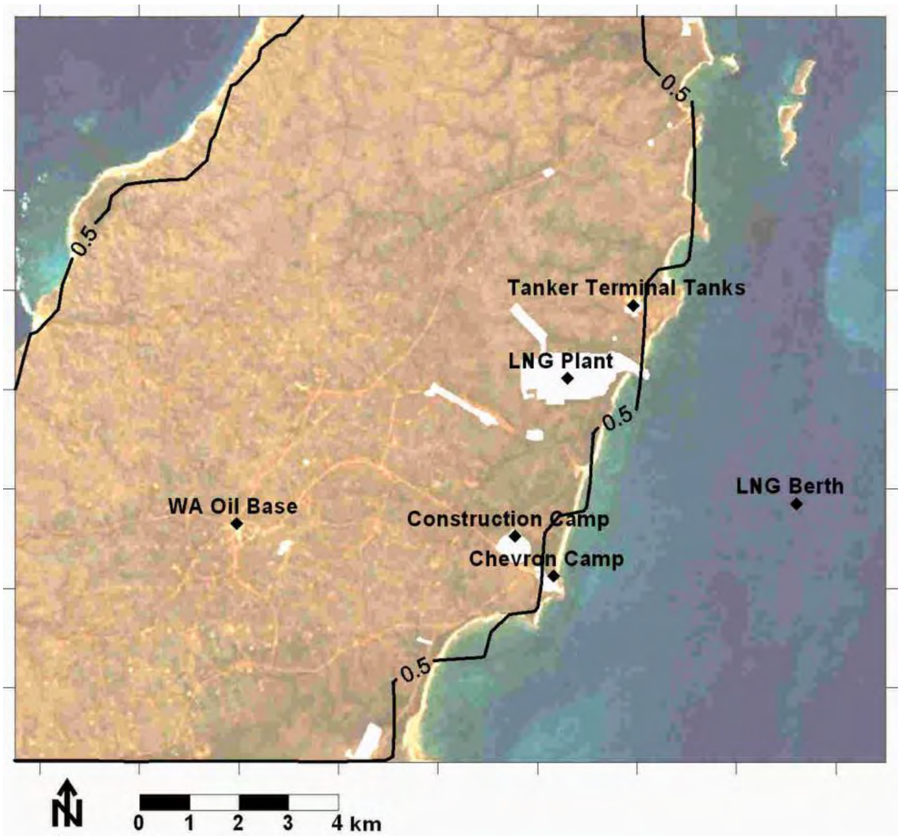

Figure 8-3 Predicted annual dry nitrogen deposition (kg/ha/yr) at Barrow Island. All future Pilbara sources and the FTP without a RTO.

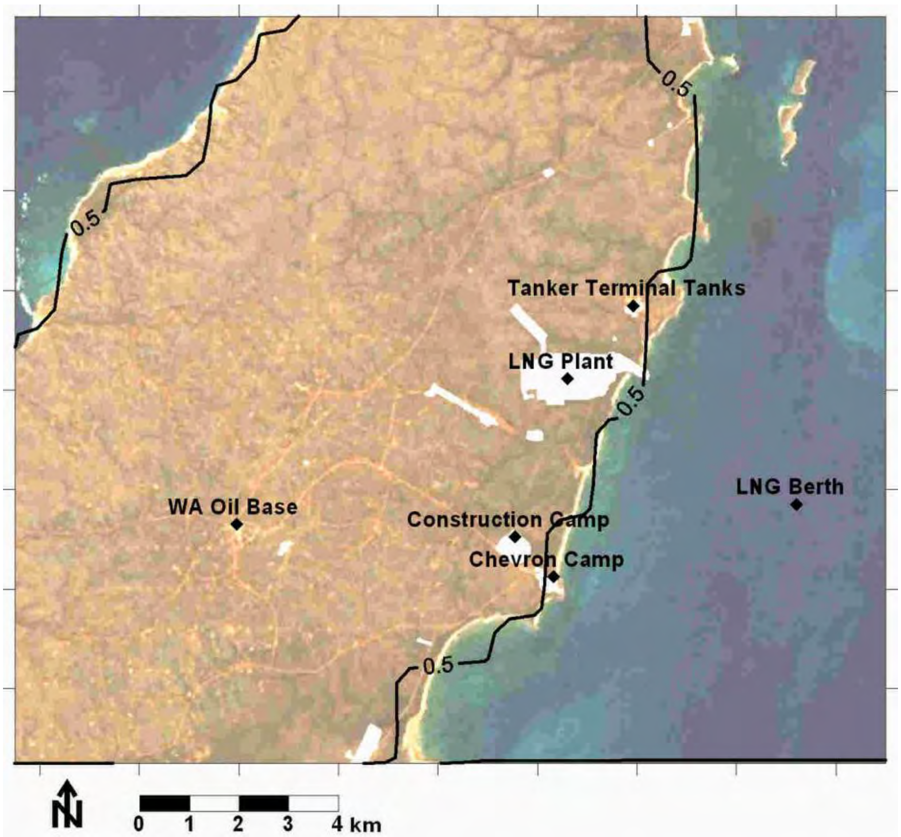

Figure 8-4 Predicted annual dry nitrogen deposition (kg/ha/yr) at Barrow Island. All future Pilbara sources and the FTP with a RTO.

Figure 8-3 and **Figure 8-4** indicates negligible difference between the two options, this being due to the RTO being a small source of NO_X within the FTP and the FTP being a small source of the N deposition. Both figures indicate that the nitrogen deposition levels are fairly uniform over the land with a maximum of 0.68 kg/ha/yr decreasing to about 0.23 kg/ha/yr over water. The difference between deposition rates over land and water are caused by the differences in the deposition velocities with over water rates being lower due to lower solubility of nitrogen species. The major source of deposition is predicted to be nitric acid which forms from NO_2. The major component of this is from NO_2 from natural sources as globally natural sources make up to 90% of NO_X emissions (Goddish, 1991), with some contribution from distant anthropogenic NO_X sources. Nitrogen deposition from local combustion sources are predicted to contribute a much smaller amount.

For comparison to the adopted criteria for this project, an estimate of the wet deposition component is required. This is estimated based on the Burrup Rock Art Monitoring Management Committee (BRAMMC) study (Gillett, 2008), where wet deposition was measured to account for only 15% to 31% of the total deposition at each site. Assuming conservatively that wet deposition accounts for 30%, the total deposition rates were increased by a factor of 1.43. The resultant estimates are maximum sulphur and nitrogen deposition rates of 0.32 and 0.97 kg/ha/yr respectively for the no RTO option and 2.4 and 0.97 kg/ha/yr respectively with an RTO. Comparison to the WHO guideline value of 4 to 8 kg/ha/year for sulphur deposition and 15 to 20 kg/ha/year for nitrogen deposition indicates that the predicted levels are acceptable.

For comparison to this study estimates, the 2008 Foundation Project estimates (SKM 2008), predicted a maximum dry sulphur deposition value of 0.08 kg/ha/year (from 0.16 kg/ha/year of SO_2) using the model TAPM. This is in reasonable agreement with the values predicted here for the FTP of 0.015 to 0.1 kg/ha/yr for the non RTO option. The nitrogen dry depositions predicted here (max 0.68 kg/ha/yr) are, however, much larger than the 0.19 kg/ha/year predicted (from 0.61 kg/ha/year of NO_2) in 2008, as the modelling here includes other nitrogen species which are important in the total deposition and not just NO_2.

8.3 Regional Deposition

Areas out to Coral Bay were assessed using the outer domain of TAPM-CTM with a 10 km pollution grid with sulphur and nitrogen deposition presented in **Figure 8-5** to **Figure 8-8**.

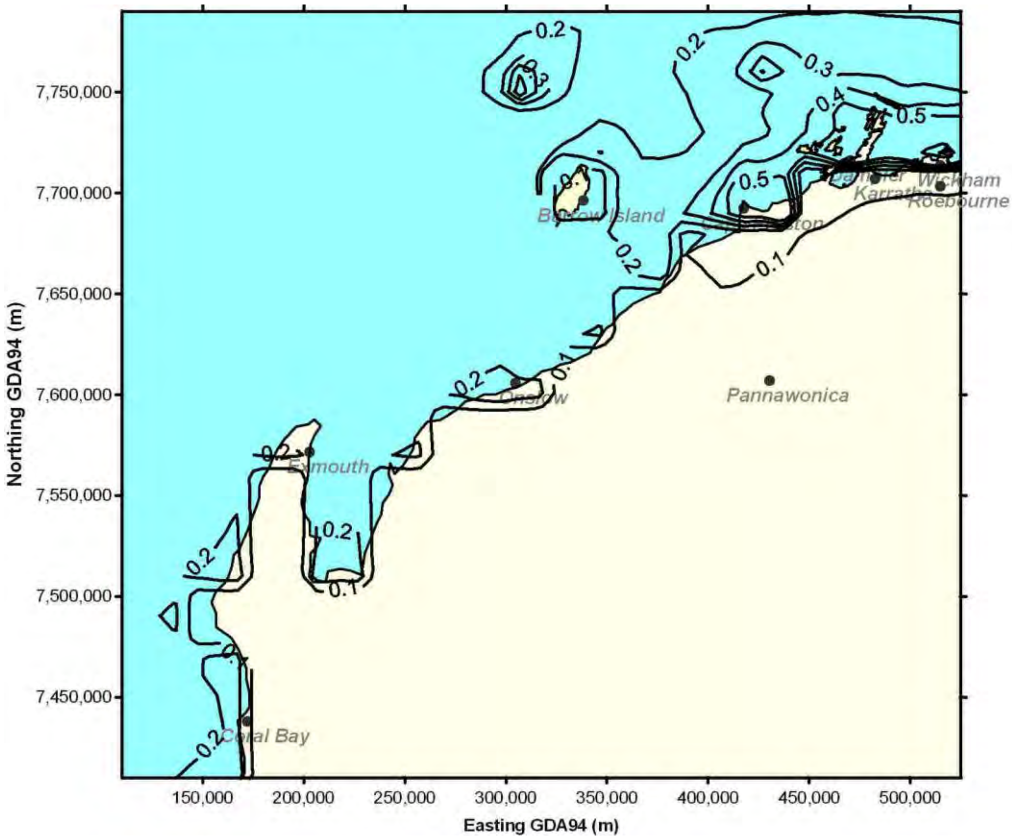

Figure 8-5 Predicted annual dry sulphur deposition (kg/ha/yr) for the Pilbara. All future Pilbara sources and the FTP without a RTO.

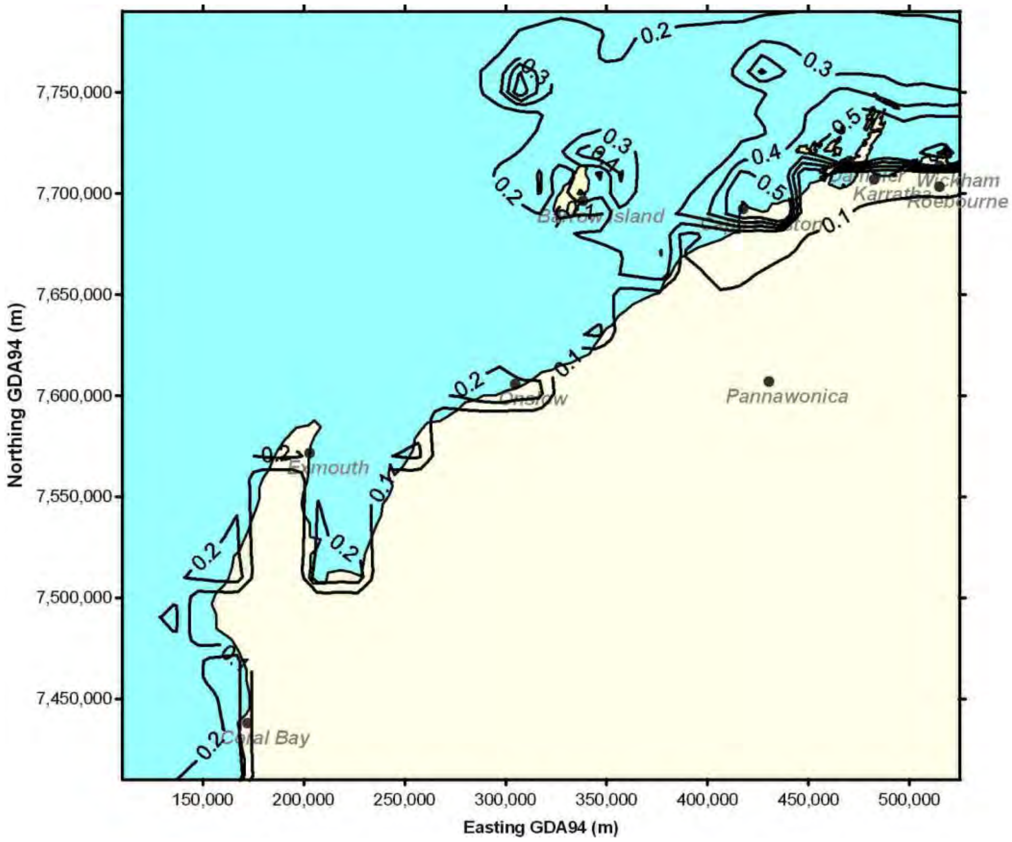

Figure 8-6 Predicted annual dry sulphur deposition (kg/ha/yr) for the Pilbara. All future Pilbara sources and the FTP with a RTO.

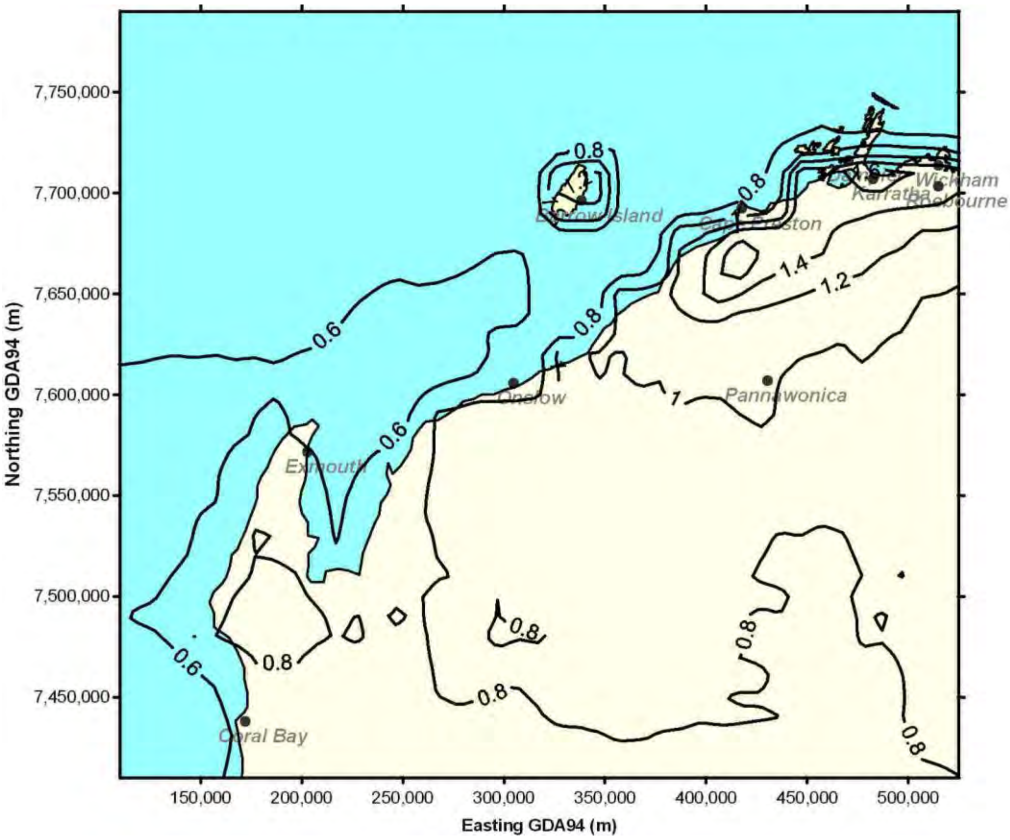

Figure 8-7 Predicted annual dry nitrogen deposition (kg/ha/yr) for the Pilbara. All future Pilbara sources and the FTP without a RTO.

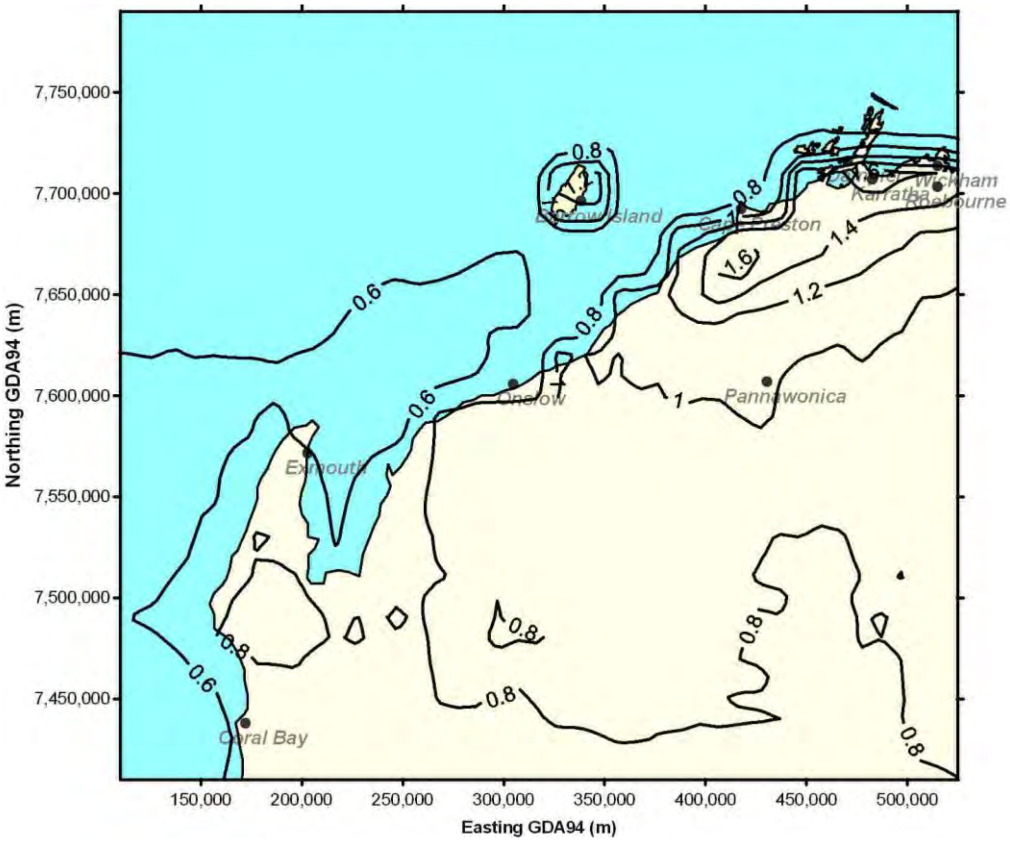

Figure 8-8 Predicted annual dry nitrogen deposition (kg/ha/yr) for the Pilbara. All future Pilbara sources and the FTP with a RTO.

Figure 8-5 and **Figure 8-6** indicate that:

- The predicted dry sulphur depositions over the Pilbara generally are very low at below 0.2 kg/ha/yr;
- The highest levels for the future are predicted to be in the Wickham area with a deposition rate of 1.25 kg/ha/yr. This rate is not influenced by the addition of a RTO for the FTP; and
- With the Gorgon Project including a RTO, the area with a significant increase is only in the Barrow Island region, particularly to the NE due to the prevailing SW winds. The increase on a regional scale of the Gorgon Project without a RTO is however, negligible.

Figure 8-7 and **Figure 8-8** indicate that the predicted dry nitrogen depositions:

- Generally over the Pilbara are low at below 1.0 kg/ha/yr; and
- Are highest in the Cape Preston, Dampier/Karratha and Wickham areas due to the existing and proposed sources there. Highest predicted values on the 10 km grid are 1.76 kg/ha/yr.

For the region to the south west of the Project, such as areas like Coral Bay, predicted dry deposition rates with all sources are about 0.2 kg/ha/yr for sulphur and 0.65 kg/ha/yr for nitrogen. Using a wet to dry deposition ratio of 1.43, the total deposition at this location is estimated at 0.29 kg/ha/year for sulphur and 0.93 kg/ha/year for nitrogen , which are well below their respective criteria.

9 Conclusions

Chevron is constructing the three Train 15 Mtpa Gorgon Gas Development (The Foundation Project) on Barrow Island, off the North West coast of Western Australia. Since receiving approval for the Foundation Project, the opportunity for progressing a fourth LNG train was identified after additional hydrocarbon resources in the Greater Gorgon Area were discovered. As part of environmental assessment of this proposal, this report assesses the air quality impact of NO_2, CO, SO_2, PM_{10}, $PM_{2.5}$, ozone and atmospheric acidic deposition. This report does not cover impacts of BTEX or H_2S which are to be covered under other studies.

To assess the impacts, two models have been utilised - TAPM for predicting local impacts on a scale out to 10 km from the plant and TAPM-CTM for predicting regional scale ozone and NO_2 to assess the cumulative impacts on sensitive mainland sites with the addition of the Gorgon Gas Development .

The results from the local TAPM modelling for the LNG plant by itself indicated that:

- The Fourth Train Proposal will result in concentrations of the pollutants assessed to be well below their respective NEPM criteria and only marginally above that from the Foundation Project.
- For the Fourth Train Proposal assuming no RTO for train 4, the maximum concentration predicted from the project at any location is at most 29% of its criterion, this being for the maximum 1-hour NO_2 concentrations;
- For the Fourth Train Proposal assuming an RTO for train 4 (to combust the VOCs including benzene to water vapour and carbon dioxide), the predicted concentrations of all pollutants assessed in this study apart from SO_2 remain the same as for the case without an RTO. The SO_2 concentrations are predicted to increase significantly, but still remain well below the standard at all locations. Maximum 1-hour, 24-hour and annual average SO_2 concentrations are predicted to be at most 37, 20 and 9% of their respective NEPM standards. This occurs because the RTO is the largest source of SO_2 as it oxidizes the H_2S in the AGRU gas stream to SO_2.
- Modelling for the expected worst case emission scenario, a full plant black start, results in only a small increase in the maximum CO, NO_2 and particulate concentrations. The maximum 1-hour NO_2 concentration increases from 29 to 31% of the NEPM standard, whilst the maximum 8-hour CO concentration increases from 0.3 to 0.4% of its NEPM standard. The change is only minor because although the black start flaring is estimated to cause a large emission of NO_X, CO etc, the very large amount of heat released is predicted to result in very large plume rise, such that the plume is not mixed to the ground. Maximum 24-hour particulate concentrations increase from 6 to 9% of the NEPM $PM_{2.5}$ reporting standard, which is again low and in any case occurs on the Plant site itself.

Considering existing sources on Barrow Island along with the Fourth Train Proposal it is predicted that:

- Existing sources are predicted to result in higher concentrations of NO_2, CO and PM than from the Fourth Train Proposal. The existing NO_2 concentrations are relatively high at 54% of the 1-hour and 86% of the annual average NEPM standard, with these occurring immediately adjacent to the Tanker Terminal sources and the Central Power Station. These concentrations remain unchanged with the addition of the Gorgon sources.

- Likewise existing maximum CO concentrations are predicted to be 5.2% of the NEPM standard and are predicted to remain unchanged with the addition of the Gorgon sources; and
- The existing PM concentrations are also predicted to be 65% of the NEPM PM_{10} standard (using the maximum to compare to the goal) and 85% of the NEPM $PM_{2.5}$ annual reporting standard. This is predicted to occur next to the Tanker Terminal diesel generator though the majority of the cumulative concentrations are due to background levels. With the addition of the Gorgon Fourth Train Proposal, the levels are predicted to remain unchanged at 65% of the NEPM PM_{10} standard and increase marginally to 86% of the NEPM $PM_{2.5}$ annual reporting respectively.
- As existing sources of SO_2 are low, cumulative predictions are the same as that predicted from the Gorgon Fourth Train Proposal.

The results from the regional TAPM-CTM modelling indicated that:

- The maximum highest ozone levels from natural sources in the region are predicted to be up to 70 and 88% of the 1-hour and 4-hour NEPM standards. These relatively high levels are due to emissions from bush fires. The second highest 1-hour and 4-hour concentrations which, for natural sources, are more strictly comparable to the NEPM, are predicted at 70% and 86% of the standard. This indicates the significant contribution that fires make to ozone levels in the region.
- With the addition of all existing and proposed anthropogenic sources, including the approved Gorgon Foundation Project, the maximum and second highest 1-hour ozone concentrations anywhere are predicted to increase from 70 to 84% and from 70 to 73% of the NEPM 1-hour standard. The maximum and second highest 4-hour concentrations however are predicted to remain the same as from "natural" sources only at 88 and 86% of the 4-hour standard.
- For assessing the Fourth Train Proposal routine operation impacts, three options were modelled. These are with the Train 4 AGRU emissions being either vented to air, reinjected or combusted by a RTO.

  For the option of venting to air, the peak 1-hour ozone concentrations are predicted to increase on and near Barrow Island with the maximum 1-hour ozone concentration increasing from 84 to 101 ppb (101% of the NEPM standard). The second highest concentration however, shows no change at 73% of the NEPM 1-hour standard. Without venting (the reinjection or RTO options), the maximum and second highest 1-hour concentrations are predicted to be lower than from the Gorgon Foundation Project at 82 and 69% of the NEPM 1-hour standard. This reduction is considered to occur as the ozone concentrations are primarily dependent on VOC emissions, which are not increased with these two options, with the small increase in NO_X actually acting to reduce the peak ozone levels.

  For the predicted 4-hour ozone concentrations, there is little difference in the maximums predicted between the three options as the highest 4-hour averages are due to other sources such as fires. With venting, the maximum and second highest 4-hour ozone concentrations are 88% and 84% of their respective standards; with re-injection, they are predicted to be 86 and 85% of the standards; and with an RTO, 91 and 84% of the standards.

- To assess the impacts of the Fourth Train proposal non-routine operations, two cases, the "pigging" case in which three AGRUs vent continually and the black start case were assessed. The predicted maximum ozone concentrations anywhere on the model grid from the pigging operations were generally slightly lower than that predicted from the Fourth Train Proposal routine operation with its AGRU venting. On Barrow Island however, the predicted concentrations were typically higher than any of the other cases modelled (excluding the maximum and second highest concentrations at the Chevron Camp). These maximums however, are very unlikely to occur as they would require three AGRUs to be venting at the same time during the worst case dispersive conditions. Predicted concentrations from non routine black starts were very low and as such are not an issue.
- At the mainland sites, there is generally negligible difference for the various Gorgon scenarios modelled indicating little contribution from the Gorgon Project there and that the impacts are generally localised to the Barrow Island region.

The deposition modelling was conducted using TAPM-CTM including all other existing and proposed sources. The results indicate:

- With the Fourth Train AGRU emissions reinjected, the maximum sulphur and nitrogen deposition rates (wet and dry) on Barrow Island would be 0.32 and 0.97 kg/ha/yr. With the Fourth Train AGRU emissions directed to an RTO, the maximum sulphur and nitrogen depositions are 2.4 and 0.97 kg/ha/yr respectively. These predictions are below the adopted WHO guidelines of 4 to 8 kg/ha/year for sulphur and 15 to 20 kg/ha/year for nitrogen deposition.
- At distant areas such as Coral Bay, the deposition rates are much less, well below their respective criteria with total deposition rates for both cases at around 0.29 kg/ha/year of sulphur and 0.93 kg/ha/year of nitrogen.

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Appendix D2: Gorgon Expansion Project Phase 2 Acid Gas Vent Dispersion Modelling

CHEVRON ENERGY TECHNOLOGY COMPANY

Gorgon Expansion Project Phase 2
Acid Gas Vent Dispersion Modeling

Report Prepared for:

Gorgon Gas Development Project

(Gorgon DMS Doc. No. G4-NT-REP00000007)

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NOTICE

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Table of Contents

1 Introduction and Background

Chevron Australia Pty Ltd (Chevron Australia) seeks approval to enable production from the Gorgon Gas Development Foundation Project, (i.e.: Trains 1-3), to be expanded from the approved 15 million tonnes per annum (MTPA) to 20 MTPA through the development of the Gorgon Gas Fourth Train Expansion Proposal. The Foundation Project, which incorporates three Liquefied Natural Gas (LNG) processing trains on Barrow Island (BWI) is currently under construction. Since receiving approval for the Foundation Project, the opportunity for progressing a fourth LNG train was identified after additional hydrocarbon resources in the Greater Gorgon Area were discovered.

The Fourth Train Expansion Proposal involves the installation of facilities for gathering gas from these new offshore fields in the Greater Gorgon Area, transporting the gathered gas to, and processing it through a fourth LNG train on Barrow Island. Existing LNG and condensate export facilities (constructed as part of the Foundation Project) will be used where practicable to export products generated by this Train 4 Expansion Proposal from Barrow Island.

The approved Gorgon Foundation Project is a three 5 MPTA LNG Train Gas Treatment Plant development to be built on BWI off the northwestern coast of Western Australia (Figure 1). Feed gas from the nearby Gorgon and Jansz gas fields will be piped to separation facilities on Barrow Island. Once separated from water and condensate, the gas stream will be combined and run through one of three Acid Gas Removal Units (AGRUs). The removed acid gas, containing high concentrations of CO_2 and residual amounts of volatile organic compounds and hydrogen sulfide, will be compressed and injected into the subsurface Dupuy Formation during normal operations. However, episodic venting of acid gas to the atmosphere will occur, primarily associated with maintenance and unplanned upset conditions, following start-up of the Gas Treatment Plant operations.

Chevron Energy Technology Company (ETC) was requested to perform a dispersion modeling analysis for acid gas venting from an expanded 4x5 MTPA Gorgon Gas Treatment Plant on Barrow Island. The analysis included running a simulation model to estimate potential Ground Level Concentrations (GLC) of various substances in the acid gas, at eight (8) different receptor locations. The study included two (2) release scenarios for venting from LNG Train 4 and LNG Trains 1-3. The substances included in the modeling work were: hydrogen sulfide, (H_2S), benzene, toluene, ethylbenzene, & xylene – (BTEX). Each substance was modeled separately. The GLC for these substances can be used to compare against various air quality and health risk criteria, as applicable to the different receptor locations.

ETC is the internal Chevron Corporate resource for Subject Matter Experts (SME) in a number of technical areas, such as dispersion modeling, consequence analysis, and health risk assessments. The ETC Staff Group is involved with many of the major capital projects within Chevron which are located world-wide and cover both upstream and downstream facilities.

BWI is a Class A Nature Reserve, and as such, human access to the island is restricted. Human receptors on the island will consist entirely of workers supporting either the Gorgon Gas Treatment Plant operations, or the pre-existing WA Oil crude oil gas production operations that are still ongoing on the island. Areas on the island supporting routine human habitation include:

- Workplace locations that are part of the Gorgon Project, (i.e. processing facilities inside the Gas Treatment Plant fenceline, the administration buildings, permanent operations facilities, the Materials Offloading Facility (MOF) and LNG Jetty in the waters immediately adjacent to the Gas Treatment Plant),
- Workplace locations associated with other activities on the island (i.e. the terminal tanks north of the Gas Treatment Plant, the WA Oil base, the WAPET landing and the BWI airport), and
- Residential facilities where off-duty workers will be housed (The Gorgon Construction village and the existing Chevron camp). The relative positions of these sensitive receptor locations are shown on the map of Barrow Island, (Figure 2).

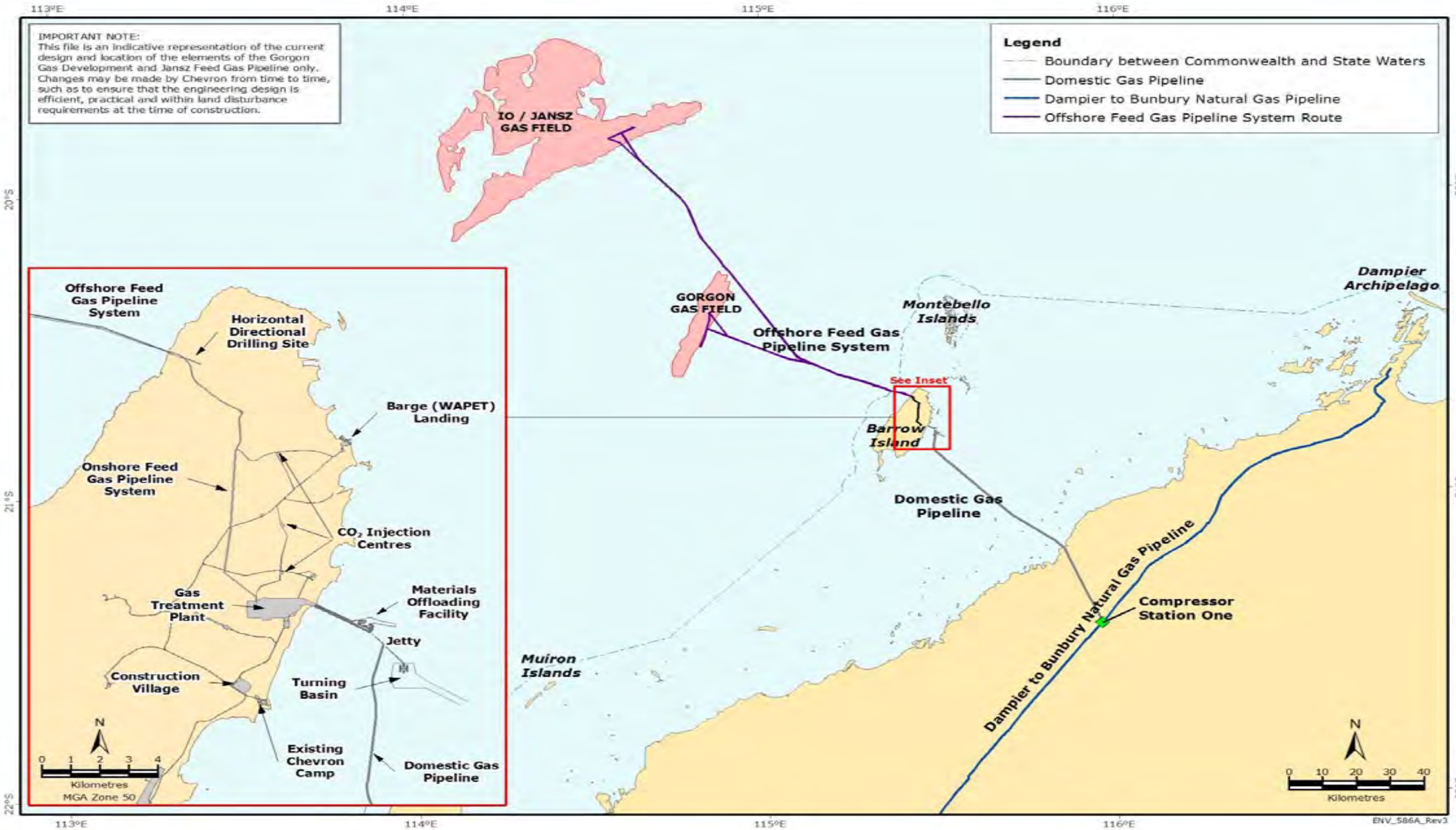
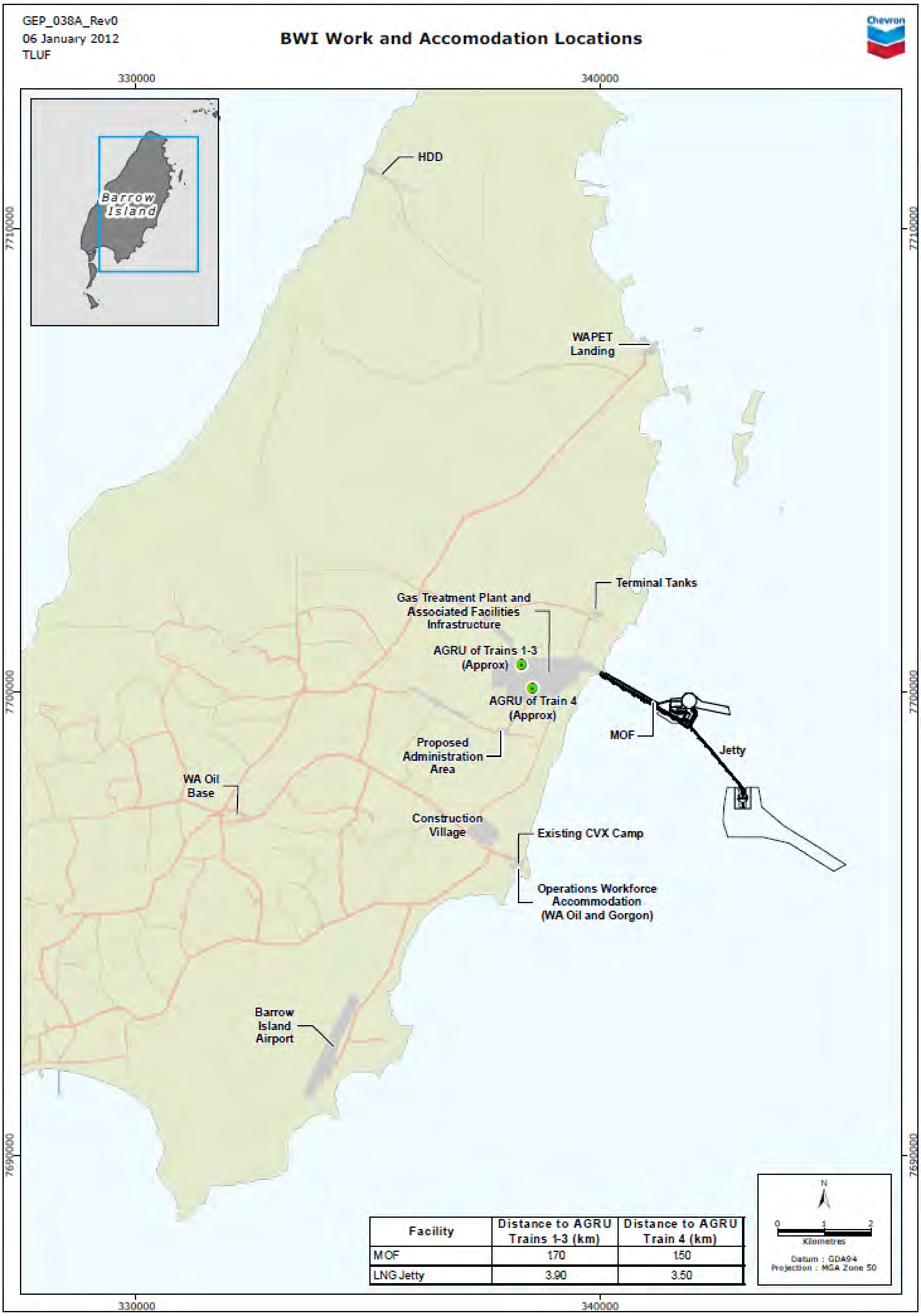


Figure 1 - Location of Gorgon Gas Development on Barrow Island.



Facility	Distance to AGRU Trains 1-3 (km)	Distance to AGRU Train 4 (km)
MOF	170	150
LNG Jetty	3.90	3.50

Figure 2 – Receptor Locations on Barrow Island.

2 Study Objectives

The objective of this study is to support development of the Gorgon Expansion Environmental Impact Assessment Study through dispersion modeling of Train 4 acid gas venting from the identified acid gas vent within the Gas Treatment Plant. The purpose of the dispersion modeling is to provide estimates of the maximum ground level concentrations of H_2S and BTEX at various receptor locations, due to venting from LNG Train 4 and LNG Trains 1-3. The results can be used to determine the potential impacts to the health of BWI personnel.

3 Methodology and Assumptions

The methodology used for this study is based on Corporate Guidelines and Practices, and is aligned with generally accepted industry practices and models. Process conditions and flow rates of the modeled acid gas releases are based on current process design data and assumptions about the design of the Train 4 AGRUs. This data is used as inputs into the dispersion model, [Ref 1]. The computer simulation used a state-of-the-art dispersion model called Canary, to predict the downwind concentrations for various releases and weather conditions.

To estimate the ground level concentrations from multiple simultaneous venting, the individual centerline plumes were superimposed. This is a conservative assumption, since in most cases, the centerlines of the plumes will not align with each receptor point. However, this allows a simplified method to estimate the downwind concentrations from multiple release points, at multiple receptor locations.

3.1 Canary Model

The dispersion model used in this study is the Canary Model, version 4.3. Canary is a proprietary model Chevron licenses from Quest Consultants and is composed of sophisticated, state-of-the-art thermodynamics, fluid dynamics, and dispersion sub-models which are all based on peer-reviewed, public-domain technical work available in the literature. Canary is a comprehensive computer package which has algorithms to account for the following material behaviors in simulating a release: the release rate, the liquid-vapor flash, any liquid pool formation and vaporization, aerosol formation and evaporation, momentum-jet dispersion, dense-cloud dispersion, and passive or neutral density dispersion (Gaussian). Since the release scenarios from the acid gas vents are high-exit velocity releases, the Canary model was chosen as the appropriate model to use, since it has a momentum-jet routine. The model can handle multi-component releases, such as CO_2 with hydrogen sulfide and BTEX.

3.2 Release Scenarios

The Gorgon Project team provided the following (2) scenarios to analyze:

Scenario A: Venting from (1) AGRU, as noted as Scenario 4a in Table 1.

Scenario B: Simultaneous venting from all (4) AGRU Trains. The release from the Train 4 Vent is noted as Scenario 4a and the release from Vents from Trains 1-3 is noted as Scenario 4d and in Table 1.

Note: Nomenclature of Scenario "4a" and "4d" is from the previous ETC Gorgon Acid Gas Modeling Study, [Ref 2], with the same modeling assumptions.

The location of the vents is shown in Figure 3.

Table 1: Individual Vent Release Scenarios

Acid Gas Vent[1]	Scenario[1]	Description	Composition[1]	H_2S Concentration, (ppm)	Benzene Concentration, (ppm)	Toluene Concentration, (ppm)	Ethylbenzene Concentration, (ppm)	Xylene Concentration, (ppm)	Rate, (kg/hr)	Operating Temperature, (C)	Operating Pressure, (bara)	Vent Height, (m)	Vent Diameter, (m)
1	4a[2]	High back press. from wells. Vent Stack at northern end of Acid Gas Removal Units	A	156	213	427	2	117	286,988	49	2.2	56	0.381
1	4d[2]	High back press. from wells. Vent Stack at northern end of Acid Gas Removal Units	A	156	213	427	2	117	652,246 (Total for (3) Vents)	49	2.2	56	0.381 (x 3)

[1] Vent number, scenario definition and composition are as defined in Technical Memorandum on Acid Gas Venting Scenarios Summary, [Ref. 1].

[2] Scenario 4a and 4d are the same as described in Chevron ETC Report "*Gorgon Acid Gas Dispersion Modeling Report*," Doc No: G1-TE-H2-1100-NOTX001, [Ref 2].

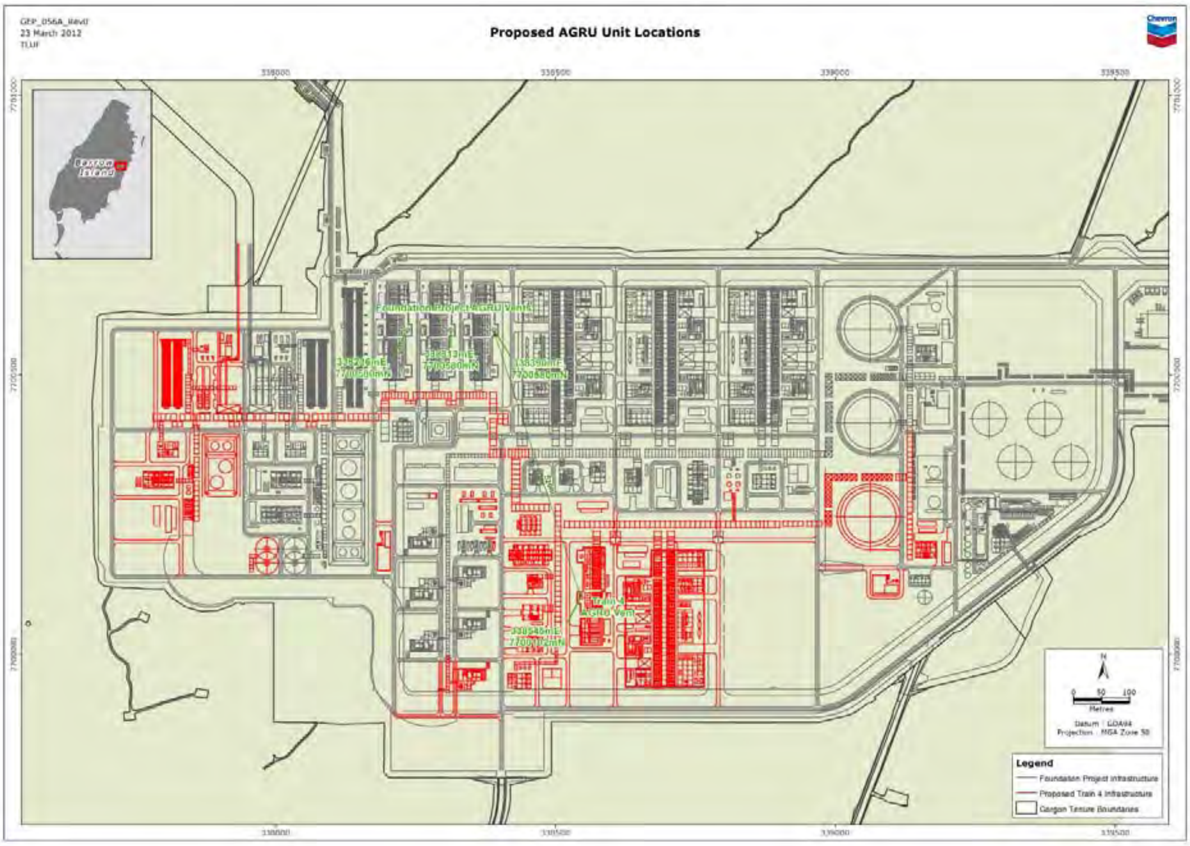


Figure 3 - Location of Acid Gas Vents on Gas Treatment Plant Plot Plan

3.3 Receptors

Fir indicative purposes, the receptors used in this study are listed in Table 2, with the distance from the Train 1-3 vent shown. All receptors have been assumed to be at the same elevation as the base of the vents. The type of the applicable exposure risk criteria for each of the receptors is listed, and is based on the use of the facilities at those locations.

Table 2: Receptors & Criteria

Receptor	Distance from Train 1-3 Vent, (km)	Acceptable Exposure Risk Criteria Type
Inside Fenceline of the Gas Treatment Plant	< 0.6	Occupational
Proposed Administration Area	1.4	Occupational
MOF	1.7	Occupational
Terminal Tanks	1.9	Occupational
Construction Village	3.4	Residential
LNG Jetty	3.9	Occupational
CVX Camp	4.25	Residential
WA Oil base	6.8	Occupational & Residential

3.4 Meteorological Conditions

The meteorological conditions that were used in the dispersion modeling are the worst case conditions that resulted in the maximum ground level concentrations, which is based on the previous ETC Acid Gas Modeling Report, [Ref 2]. Worst case weather conditions for receptor locations outside the fenceline is E Stability and 1.0 m/s wind speed, and D stability and 1.5 m/s for locations inside the fenceline for the scenarios in this study.

The minimum wind speed used in this study is 1 m/sec, as measured at a reference height of 10m, which is the typical height used for dispersion modeling.

3.5 Health Risk Criteria

For receptor locations that have personnel performing work functions, an occupational health risk criteria was used to compare to the predicted GLC from the dispersion modeling. Internal Chevron occupational health exposure standards were used for hydrogen sulfide and benzene [Ref. 3] as these were deemed to be more stringent than the relevant Australian NOHSC standards. For toluene, ethylbenzene, and xylene, the Australian NOHSC 1003 [Ref. 4] Time Weighted Average (TWA)[1] standard was used.

For the other receptors locations that had the public or housed off-shift workers, a residential health risk criteria was used. These were based on the Department of Environmental and Conservation (NSW): "Approved Method for the Modelling and Assessment of Air Pollutants in New South Wales", 26 August 2005 [Ref. 6]. The health

[1] Exposure standard – Time Weighted Average (TWA) means the average airborne concentration of a particular substance when calculated over a normal eight hour working day, for a five day working week." [Ref. 5]

risk concentration criteria for each of the substances analyzed in this study are shown in Table 3.

Table 3: Health Risk Concentration Criteria

Substance	Health Risk Criteria, [ppb]	
	Occupational-Exposure	Residential-Exposure
Hydrogen Sulfide	5,000[1]	1.5[3]
Benzene	1,000[1]	9[3]
Toluene	100,000[2]	90[3]
Ethylbenzene	100,000[2]	1,800[3]
Xylene	80,000[2]	40[3]

1 – Chevron Occupational Health Exposure Standard [Ref. 3]

2 - NOHSC Exposure Standard (National Occupational Health & Safety Commission - Australia), [Ref. 4]

3 – Impact Assessment Criteria – Department of Environmental and Conservation (NSW): "Approved Method for the Modelling and Assessment of Air Pollutants in New South Wales"26 August 2005, [Ref. 7]

4 Results

All of the release scenarios were modeled using the worst case meteorological condition, (i.e.: wind speed & stability class), to estimate potential GLCs at each receptor location. The predicted maximum concentration at each receptor is based on the downwind distance from the vent and assuming it is on the centerline of each of the plumes. The centerline of the plume will be the maximum concentration at any given downwind distance.

A summary of the predicted maximum concentrations for Scenario A at each of the receptors and their corresponding health risk criteria is listed in Tables 4 & 5. Table 4 is for receptors using occupational-based criteria, and Table 5 is for receptors where residential-based criteria apply. Tables 6 & 7 summarize the modeling results for Scenario B, (health and occupational risk criteria, respectively). The downwind distance versus the maximum ground level concentrations for Scenarios A & B are shown in Tables 8 & 9, (respectively).

Table 4: Scenario A – One AGRU Venting
Dispersion Modeling Results – Occupational-Based Criteria

Substance	Predicted Maximum Ground-Level Concentration, (ppb)						Occupational-based Criteria Concentration, (ppb)
	Inside Fenceline, (<600m)	Admin, Proposed, (1,400m)	MOF, (1,500m)	Terminal Tanks. (1,900m)	Jetty, (3,500m)	WA Oil Base, (6,800m)	
Hydrogen Sulfide	36	3	3	2	< 1	< 1	5,000
Benzene	50	4	4	2	< 1	< 1	1,000
Toluene	100	9	8	4	< 1	< 1	100,000
Ethylbenzene	< 1	< 1	< 1	< 1	1	< 1	100,000
Xylene	28	2	2	1	< 1	< 1	80,000

Table 5: Scenario A - One AGRU Venting
Dispersion Modeling Results – Residential-Based Criteria

Substance	Predicted Maximum Ground-Level Concentration, (ppb)			Residential-based Criteria Concentration, (ppb)
	Construction Village, (3,400m)	Existing CVX Camp, (4,250m)	WA Oil Base, (6,800m)	
Hydrogen Sulfide	0.4	0.22	< 0.1	1.5
Benzene	< 1	< 1	< 1	9
Toluene	1	< 1	< 1	90
Ethylbenzene	< 1	< 1	< 1	1,800
Xylene	< 1	< 1	< 1	40

Table 6: Scenario B – Simultaneous Venting from Four AGRU's Dispersion Modeling Results – Occupational-Based Criteria

Substance	Predicted Maximum Ground-Level Concentration, (ppb)						Occupational-based Criteria Concentration, (ppb)
	Inside Fenceline of the Gas Treatment Plant, (<600m)	Proposed Administration Area, (1,400m)	MOF, (1,700-Train 1-3; 1,500-Train 4)	Terminal Tanks. (1,900m)	Jetty, (3.900-Train 1-3; 3,500-Train 4)	WA Oil Base, (6,800m)	
Hydrogen Sulfide	47	9	7	5	< 1	< 1	5,000
Benzene	65	13	10	7	< 1	< 1	1,000
Toluene	130	26	20	13	2	< 1	100,000
Ethylbenzene	< 1	< 1	< 1	< 1	< 1	< 1	100,000
Xylene	50	7	5	4	< 1	< 1	80,000

Table 7: Scenario B – Simultaneous Venting from Four AGRU's Dispersion Modeling Results – Residential-Based Criteria

Substance	Predicted Maximum Ground-Level Concentration, (ppb)			Residential-based Criteria Concentration, (ppb)
	Construction Village, (3,400m)	CVX Camp, (4,250)	WA Oil Base, (6,800m)	
Hydrogen Sulfide	1.3	0.7	0.2	1.5
Benzene	1	< 1	< 1	9
Toluene	3	1	< 1	90
Ethylbenzene	< 1	< 1	< 1	1,800
Xylene	< 1	< 1	< 1	40

Table 8: Scenario A - One AGRU Venting
Dispersion Modeling Results – Distance versus Concentration
E Stability and 1 m/sec wind speed

Downwind Distance from Vent, (m)	Predicted Maximum Ground Level Concentration, (ppb)				
	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
500	10	14	28	< 1	8
1,000	6	8	16	< 1	4
1,500	3	4	8	< 1	2
2,000	1	2	4	< 1	1
2,500	< 1	1	2	< 1	< 1
3,000	< 1	< 1	1	< 1	< 1
3,500	< 1	< 1	1	< 1	< 1
4,000	< 1	< 1	< 1	< 1	< 1
4,500	< 1	< 1	< 1	< 1	< 1
5,000	< 1	< 1	< 1	< 1	< 1

Table 9: Scenario B - Simultaneous Venting from Four AGRU's
Dispersion Modeling Results – Distance versus Concentration
E Stability and 1 m/sec wind speed

Downwind Distance from Vent, (m)	Predicted Maximum Ground Level Concentration, (ppb)				
	H_2S	Benzene	Toluene	Ethylbenzene	Xylene
500	23	32	64	< 1	18
1,000	17	23	46	< 1	12
1,500	9	12	23	< 1	6
2,000	4	6	12	< 1	3
2,500	2	3	7	< 1	1
3,000	1	1	4	< 1	< 1
3,500	< 1	1	3	< 1	< 1
4,000	< 1	< 1	2	< 1	< 1

4,500	< 1	< 1	1	< 1	< 1
5,000	< 1	< 1	< 1	< 1	< 1

5 Summary and Conclusions

The dispersion modeling results indicate that the predicted maximum concentrations of hydrogen sulfide and BTEX at all of the receptors are below the relevant health risk concentration criteria. For those receptors using an occupational-based criteria, the predicted concentrations are significantly less than one order-of-magnitude than the criteria. For the residential-based criteria receptors, all of the predicted concentrations are below the criteria.

6 References

1. Memorandum from Ian Downey, 18 November 2009, Re: Acid Gas Venting Scenarios Summary.
2. Chevron ETC Report, "*Gorgon Acid Gas Dispersion Modelling Report,*" Doc No: G1-TE-H2-1100-NOTX001
3. COESC (2008). *Chevron Occupational Exposure Standards,* June 2008. Chevron Occupational Exposure Standards Committee, Richmond, CA.
4. National Occupational Health and Safety Commission (Worksafe Australia), Exposure Standards for Atmospheric Contaminants in the Occupational Environment, Guidance Note [NOHSC:3008(1995)] and National Exposure Standards [NOHSC:1003(1995), May 1995 (as amended).
5. 2010 TLV's and BEI's, American Conference of Governmental Industrial Hygienists.
6. Department of Environmental and Conservation (NSW): "Approved Method for the Modelling and Assessment of Air Pollutants in New South Wales", 26 August 2005.
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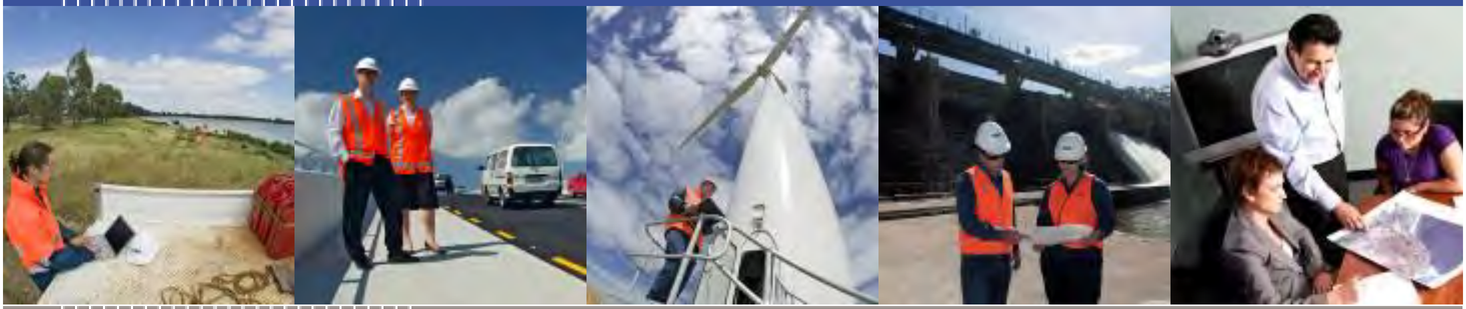
Appendix D3: Gorgon Light Emissions Study – Fourth Train Proposal



Report

Gorgon Light Emissions Study - Fourth Train Proposal

DMS No: G4-NT-REP00000160

30 MAY 2013

Prepared for

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Abbreviations

Abbreviation	Description
AHD	Australian Height Datum (Equivalent to 2.34 m above LAT)
BOG flare	Boil-off gas flare
cd	Candela
m CD	Metres above chart datum
EM radiation	Electromagnetic radiation
FTP	Fourth Train Proposal
GJVs	Gorgon Joint Ventures
GTP	Gas Treatment Plant
LAT	Lowest astronomical tide (chart datum)
LDC	Luminance distribution curve
LED	Light emitting diode
lm	Lumen
LNG	Liquefied natural gas
LNG LF	LNG loading facility
MOF	Materials off-loading facility
nm	Nano metre, 10^{-9} metres
PARS	Pre-assembled racks
SERLs	Sensitive environmental receptor locations
SI	Système International [d'Unités] (International System [of Units])
SPD	Spectral power distribution
sr	Steradian
µm	Micro metre, 10^{-6} metres
WWTP	Wastewater treatment plant
YCBN	Yacht Club Beach (North)
YCBS	Yacht Club Beach (South)

Glossary

Term	Description
Airglow	Very weak emission of light by a planetary atmosphere, which causes the night sky to never be completely dark
Australian Height Datum	Height measured against mean sea level
Beam angle	The angle formed by light emitted from a light source at 50 per cent (I_{50}) of the peak light intensity (I_{100}).
Brightness	Perceived (not measured) luminance
Candela	The SI base unit of luminous intensity emitted by a light source in a specified direction, defined as lumens per steradian (lm/sr)
Condensate	Mixture of hydrocarbons, typically C6+

Glossary

Term	**Description**
Foundation Project	Gorgon Gas Development Foundation Project
Glare	The effect of brightness or differences in brightness within the visual field sufficiently high to cause annoyance, discomfort or loss of visual performance.
Gorgon Project	Foundation and Expansion Projects
Illuminance (lux)	Luminous flux received onto a surface, expressed as lumens per metre squared (lm/m^2).
Lambertian reflectance	Ideal, diffuse reflection (equal in all directions)
Lambertian reflectance	lumination is evenly scattered (reflected) in all directions by a surface
Line of Sight	Unobstructed view of light source, above the horizon.
Lumen	The SI derived unit of luminous flux, only for visible EM radiation (cd.sr).
Luminaire	A complete lighting unit consisting of a lamp or lamps, along with the parts designed to distribute the light, hold the lamps, and connect the lamps to a power source. Also called a fixture.
Luminance (nit)	Non-SI unit of light reflected from a surface. It is defined as candela per metre squared (cd/m^2)
Lux	The SI derived unit of illuminance. It is defined as lumens per metre squared ($cd.sr/m^2$ or lm/m^2).
Reflectance (ρ)	The ratio of light reflected from a surface to the light incident on the surface. Reflectance is used to determine luminance from a surface, where: Luminance (L) = Illuminance (E) x Reflectance (ρ) /pi (π)
Road U04	Carriageway between Foundation Project LNG storage tanks and LNG train 3.
Skyglow	Anthropogenic sourced increase in night sky brightness producing an increased luminous background level
Spectral power distribution	The radiant power at each wavelength in the visible region
Steradian	The SI derived unit of solid angle (dimensionless)
Wavelength	The spatial period of the wave, i.e. the distance over which the wave's shape repeats. When white light shines through a prism, the white light is broken apart into the colours of the visible light spectrum. Each colour has a different wavelength. Red has the longest wavelength and violet has the shortest wavelength.

Executive Summary

The Gorgon Gas Development Foundation Project (Foundation Project), which incorporates three liquefied natural gas (LNG) trains to process gas from the Gorgon and Jansz-Io gas fields, is currently under construction on Barrow Island. Subsequent to receiving approval for the Foundation Project, the opportunity for progressing a fourth LNG train was identified following discovery of additional hydrocarbon reserves in the Greater Gorgon Area. Chevron Australia Pty Ltd (Chevron Australia) is currently seeking approval for the development of the fourth LNG train and associated infrastructure, known as the Gorgon Gas Development Fourth Train Proposal (FTP).

Model – Typical Outcomes

The purpose of the study was to predict the light spill outside of the boundary of the Gorgon Gas Development. Light spill was modelled during the operation of the Gas Treatment Plant (GTP), under various scenarios.

Modelled Scenarios

Five (5) scenarios were identified for modelling of light spill outcomes, as presented in Table ES-1.

Table ES-1 Modelled Scenarios

Scenario	Description of Option
A	Normal operations
B (a)	Single LNG train maintenance (all task areas)
B (b)	Single LNG train maintenance (two task areas)
C	LNG Storage Tank #3, rooftop maintenance
D	Maintenance works in General Utilities area

Light Sources

Luminaires used as light sources include fluorescent lights (vertical and horizontal) and LED (vertical) task lighting. The details of specific locations and characteristics of each individual light source, relating to normal or task-related activities in the GTP, were not provided at the time modelling was undertaken. Modelling was based on maps of generic lighting levels provided by Chevron and on the values given in the Chevron Basis of Design for Lighting for the Foundation Project:

- Normal lighting – 20 lux average and normally switched 'ON'; and
- Task lighting – 50 lux minimum and normally switched 'OFF', with a 1:3 averaging factor. Hence the minimum illuminance level for task lighting is 50 lux (average), with a maximum of 150 lux (average).

As a result of the 1:3 averaging factor, modelling under scenarios B(a) to D have used task illuminance (average) intensities of 50 lux, 100 lux and 150 lux, for each scenario.

Potentially Sensitive Environmental Receptor Locations

The locations shown in Table ES-2 are the mid-points of the beaches in the vicinity of the Gorgon Project that were identified by Chevron Australia, for the Foundation Project, as potentially sensitive environmental receptor locations (SERLs).

Executive Summary

Table ES-2 Potentially Sensitive Environmental Receptor Locations (SERLs)

Location	Beach Length (m)	Easting	Northing	Distance to FTP (m)
Yacht Club Beach (Sth)	1,231	338 494	7 697 012	3,060
Yacht Club Beach (Nth)	912	338 831	7 698 020	1,730
Inga Beach	1,034	339 325	7 699 072	730
Double Island	N/A	343 050	7 705 600	4,770
Bivalve Beach	779	339 617	7 700 071	556
Terminal Beach	582	340 261	7 701 056	883

Modelled Outputs

Under the modelled scenarios, the primary light spill intercepts the GTP ground surfaces, and other infrastructure, prior to being intercepted by the LNG storage tank walls and associated infrastructure. Reflectance from the ground and infrastructure is assumed to be Lambertian (ideal diffusely reflecting surface).

Due to the topography of the sand dunes above the SERLs, and the terracing installed during Foundation Project construction, the model predicts that no primary or secondary reflections will directly illuminate the beaches, below the coastal sand dunes, from infrastructure with an elevation less than a light tower on top of LNG Storage tanks (62.8 m AHD + 3 m = 65.8 m AHD).

Luminous flux resulting from secondary reflection from the LNG Storage Tank #2 wall, supporting the pump platform, has been estimated (refer Appendix E) at 60×10^{-4} lumens (1 metre from the wall) at the wall location, while for LNG Storage Tank #3, luminous flux has been estimated at 20×10^{-4} lumens at the wall location. The estimated light sources resulting from reflection of light off metal surfaces is diminished over distance as discussed in Appendix D.

It is considered unlikely that secondary reflection from the rooftop of LNG Storage Tanks #2 and #3 would result in direct illumination at the SERLs. However, modelling of light spill for scenarios A to D, where light spill can result from atmospheric dispersion of secondary reflections, has been included in the outputs from modelling.

Illuminance Level

The light modelling for scenarios A to D indicates that primary lateral (illumination to the ground, as opposed to exittance from the ground) light spill is restricted to on-site locations within the GTP. Secondary lateral light spill is generally the result of horizontal, low angle, primary, Lambertian reflections from concrete, crushed stone and dry, bare soil (worst case scenario). These surfaces typically reduce the reflected (exittance) light intensity by up to 90 per cent. Light spill, during maintenance works on the LNG storage tanks, does not materially change the intensity of light incident on the GTP ground surfaces.

Modelled outputs predict that indirect, atmospheric dispersion results in illuminance to the SERLs, as a result of assessing task lighting scenarios at the GTP, within the range of values presented in Table ES-3.

The modelled scenarios generate predicted light spill intensities, at all of the defined potential SERLs, of less than 20×10^{-4} lux, the equivalent light intensity of a moonless, clear night sky with airglow, with typical light spill intensities less than 1.0 x 10^{-4} lux, the equivalent light intensity of a moonless, overcast night sky, for task lighting scenarios between 50 lux and 150 lux (average).

Table ES-3 Predicted Illuminance at Potential Sensitive Receptors (from GTP)

Scenario	A	B(a)	B(b)	C	D
SERL			**Illumination (x 10^{-4} Lux)**		
Bivalve Beach	< 4.0	< 6.0	< 6.0	< 20	< 4.0
Terminal Beach	< 0.4	< 1.0	< 1.0	< 2.0	< 2.0
Inga Beach	< 1.0	< 5.0	< 4.0	< 3.0	< 3.0
Yacht Club Beach (Nth)	< 0.2	< 1.0	< 1.0	< 0.6	< 0.6
Yacht Club Beach (Sth)	< 0.1	< 0.6	< 0.5	< 0.3	< 0.3
Double Island	< 0.1	< 0.2	< 0.2	< 0.2	< 0.2

NOTES[1]:

500 x 10^{-4} lux is the equivalent illuminance of a Quarter moon, clear night sky with airglow.

10 x 10^{-4} lux is the equivalent illuminance of a Moonless, clear night sky with airglow.

1 x 10^{-4} lux is the equivalent illuminance of a Moonless, overcast night sky.

Spectral Power Distribution

Modelled light source spectral power distribution (SPD) outputs indicate that filtered light sources have a bias towards the long wavelength end of the visual spectrum (> 560 nm). Unfiltered light sources retain a neutral SPD, with a marginal red bias.

The illuminance for wavelengths below 560 nm (the green-yellow interface), are predicted to be individually less than 4 x 10^{-4} lux, and cumulatively less than 27 x 10^{-4} lux, at the potential SERLs. Wavelengths greater than 560 nm are predicted to be cumulatively less than 27 x 10^{-4} lux at the potential SERLs. The ratio of illuminance for the red end of the visible spectrum to the blue end of the visible spectrum is estimated as typically seven to one.

[1] Refer to Appendix D for explanation of perceived changes in intensity

Introduction

1.1 Gorgon Project

The Foundation Project comprises subsea gathering systems and pipelines that will deliver feed gas from the Gorgon and Jansz–Io gas fields to Barrow Island (refer Figure 1-1) for treatment in a Gas Treatment Plant (GTP). Under the Foundation Project, the Gorgon Project will comprise three liquefied natural gas (LNG) production trains capable of producing a nominal capacity of five (5) million tonnes LNG per annum (MTPA) per train, in addition to condensate and domestic gas.

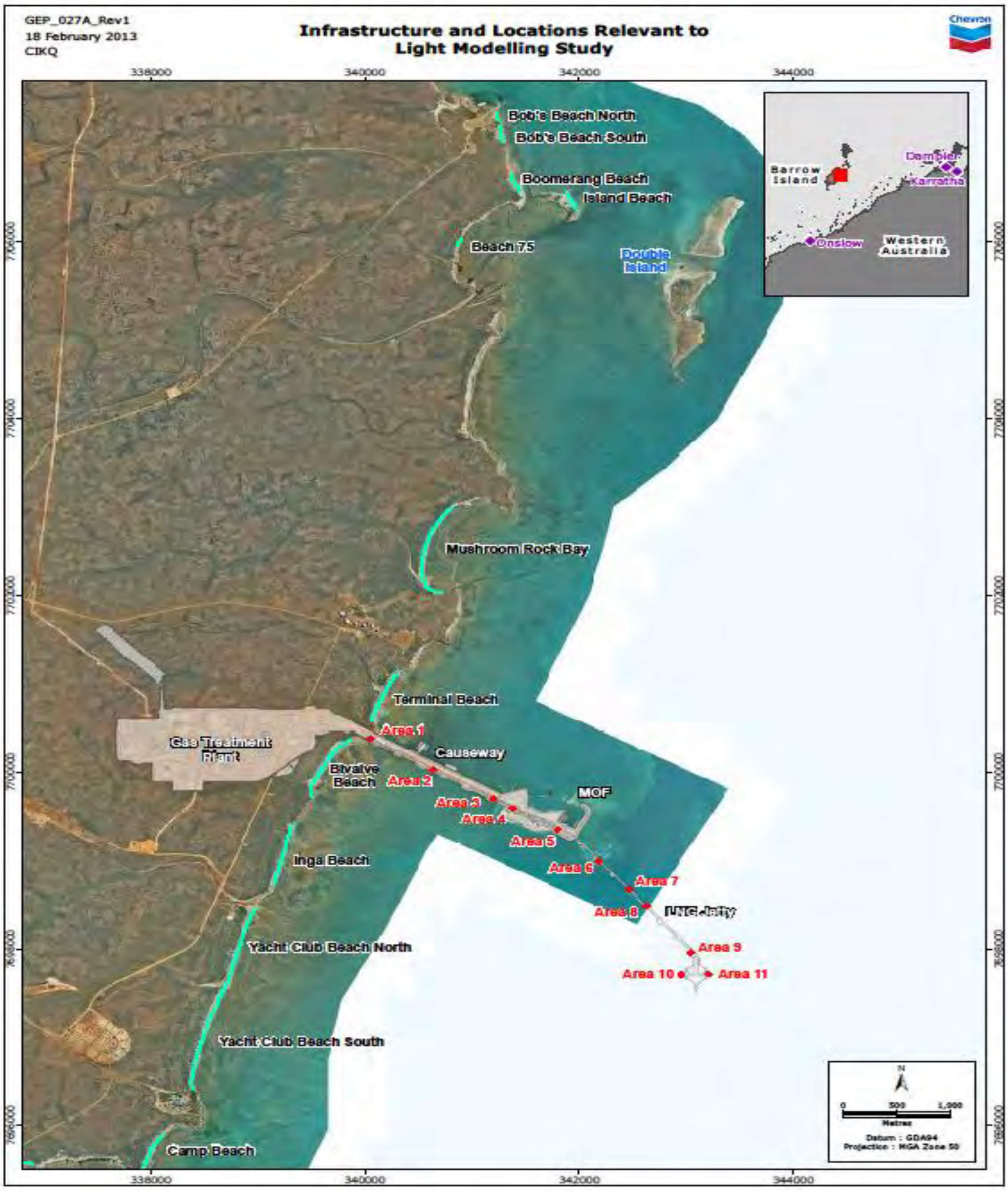

Figure 1-1 Location of Gas Treatment Plant and Coastline

URS

Introduction

Chevron Australia Pty Ltd (Chevron Australia) now proposes to develop additional gas fields in the Greater Gorgon Area. To support this development, additional subsea infrastructure, to gather the gas from the gas fields and deliver it to Barrow Island, is proposed. On Barrow Island, the Gorgon Project is planned to be expanded with the addition of a fourth LNG train, installation of a third LNG Storage Tank, north of the Condensate Storage Tanks, and supporting utilities and services. This additional development is called the Gorgon Gas Development Fourth Train Proposal (FTP).

1.2 Light Emission Study

Between 2011 and 2012 a Light Emission study was undertaken to predict light spill (illuminance and spectral power distribution) outside of the boundary of the Gorgon Gas Development. Light spill was modelled for the operation of the Gas Treatment Plant (GTP), under various scenarios, and with a third LNG storage tank, located north of the Condensate Storage tanks, under maintenance lighting scenario.

1.3 Onshore Model Development

1.3.1 Site Topography

The topography of the site is a significant factor in the modelling of light spill. The Gorgon Project site has been terraced and this has reduced the overall elevation of installed infrastructure.

The plan view of terracing shown in Figure 1-2 indicates that the lowest terracing has been installed closest to the coastline, with an embankment (at 13.6 m AHD) placed between the main infrastructure and the coastline. The south elevation shown in Figure 1-2 shows that the Gorgon Project extends for a distance of approximately 2,300 metres (east-west) and varies in ground level elevation between 12.0 and 20.5 m AHD.

1.3.2 Road U04

A carriageway runs north-south between the LNG storage tanks and LNG Train #3. This carriageway is referenced as Road U04 (refer Figure 1-2). This road is the eastern boundary for the use of unfiltered fluorescent light during task lighting.

1.3.3 Site Infrastructure

The onshore infrastructure used for the purposes of modeling is shown in Figure 1-3. Modeling included all four LNG trains, three LNG storage tanks and additional supporting infrastructure. LNG Storage Tank #3 is located to the north of the Condensate Storage Tanks.

1.3.4 Sensitive Environmental Receptor Locations (SERLs) from On-shore light sources

Six (6) sensitive environmental receptor locations (SERLs) were identified along the eastern coastline of Barrow Island. The SERLs comprise:

- Double Island southern beaches;
- Terminal Beach;
- Bivalve Beach;
- Inga Beach;
- Yacht Club Beach (North); and
- Yacht Club Beach (South)

1 Introduction

The MGA Zone 50[2] coordinates for the more distant identified potentially sensitive environmental receptor locations on the east coast of Barrow Island, and their distance from the eastern limit of the 12 m AHD Gorgon Project terrace, are shown in Table 1-1.

Table 1-1 SERL Distance from LNG Storage Tank #3

Location	Beach Length (m)	Easting	Northing	Distance to LNG Storage Tank #3 (m)
Double Island	N/A	343 050	7 705 600	4,770 (northeast)
Terminal Beach	582	340 261	7 701 056	883 (east, northeast)
Bivalve Beach	779	339 617	7 700 071	556 (east, southeast)
Inga Beach	1,034	339 325	7 699 072	1,070 (south)
Yacht Club Beach (Nth)	912	338 831	7 698 020	2,070 (south, southwest)
Yacht Club Beach (Sth)	1231	338 494	7 697 012	3,400 (south, southwest))

Due to the proximity of the LNG Storage Tank #3 to both Terminal and Bivalve Beaches, these two SERLs have been further investigated considering both their orientation and elevation and the height of the fringing sand dune system. The results of this investigation are presented in Appendix G.

[2] MGA is a metric rectangular grid system (i.e. east and north). It is a Cartesian coordinate system based on the Universal Transverse Mercator projection and the Geocentric Datum of Australia 1994. The unit of measure is the metre.

Introduction

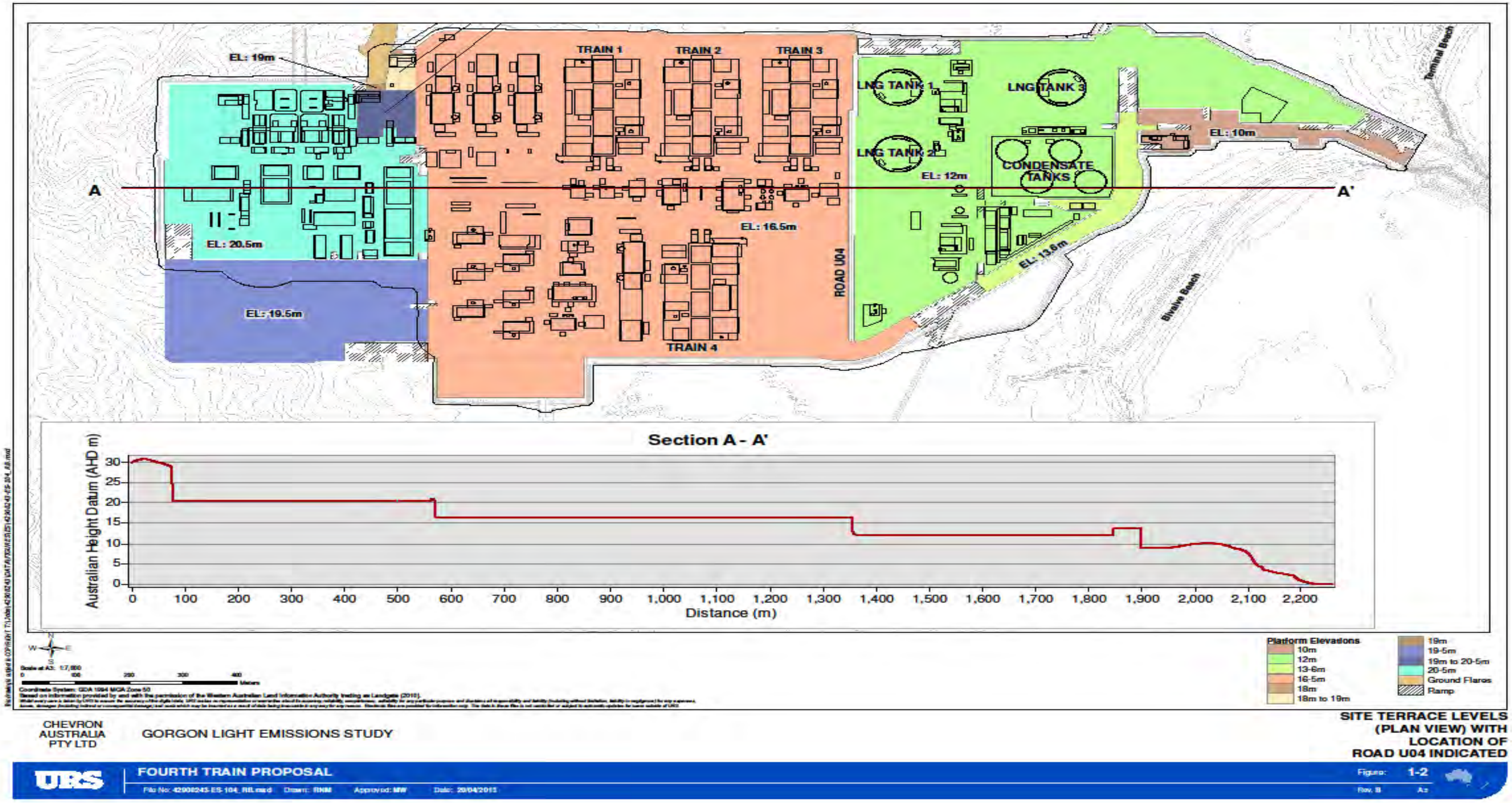

Figure 1-2 Site Terrace Levels

1 Introduction

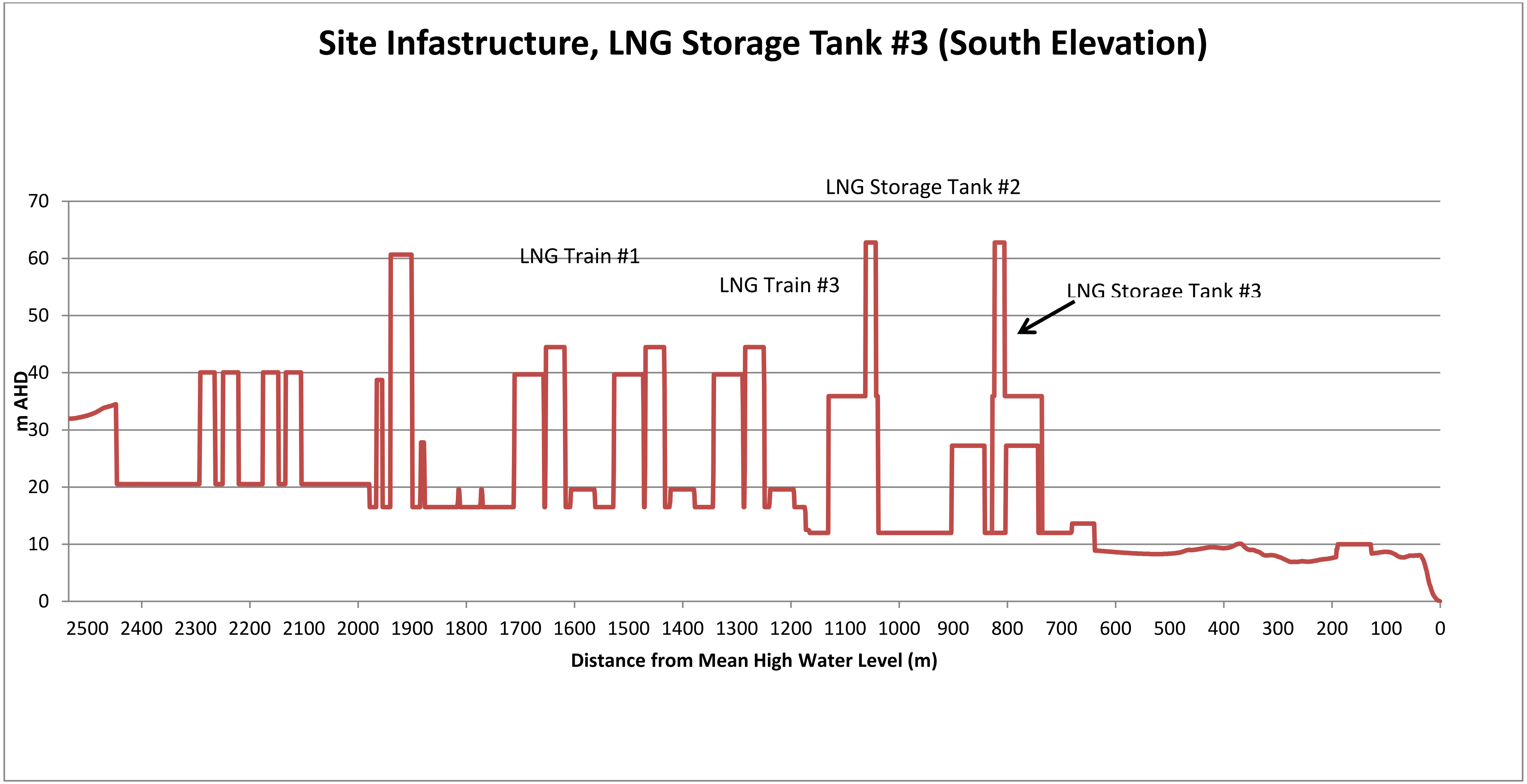

Figure 1-3 Site Infrastructure Elevation Profile

Light Sources

2.1 Light Sources

The light emission model investigates light spill from potential light sources in the GTP, such as LNG trains, tanks, and General Utilities Area.

Luminaires used as light sources include fluorescent lights (vertical and horizontal) and LED (vertical) task lighting. The details of specific locations and characteristics of each individual light source, relating to normal or task-related activities in the GTP, were not provided at the time modelling was undertaken. Modelling was based on maps of generic lighting levels provided by Chevron and on the values[3] given in the Chevron Basis of Design for Lighting[4] and spatial data as provided by Chevron as normal and task lighting plans (refer section 3.1):

- Normal lighting – 20 lux average and normally switched 'ON'; and
- Task lighting – 50 lux minimum and normally switched 'OFF', with a 1:3 averaging factor. Hence the minimum illuminance level for task lighting is 50 lux (average), with a maximum of 150 lux (average).

As a result of the 1:3 averaging factor, modelling under scenarios B(a) to D have used task illuminance (average) intensities of 50 lux, 100 lux and 150 lux, for each scenario.

2.1.1 Fluorescent Luminaires

Fluorescent lighting includes luminaires that are:

- Mounted vertically, at an angle of approximately 42 degrees (to horizontal), and at an elevation of approximately 2.5 metres above platform level;
- Mounted horizontally, at an angle of approximately 42 degrees (to horizontal), and at an elevation of approximately 2.3 metres above platform level;
- Mounted horizontally, at an elevation of approximately 2.5 metres above platform level; and
- Mounted horizontally, at an elevation of approximately 0.8 metres above platform level.

All fluorescent lights used in locations east of Road U04 are filtered (Filter 768) to reduce emissions of wavelengths less than 560 nm. Beam angles used for fluorescent lights are shown in Table 2-1, while the luminance distribution curve (LDC) and intensity is shown in Figure 2-1, with an utilisation factor (η) of 55 per cent.

Table 2-1 Fluorescent Luminaire Beam Spread Angles (degrees)

Beam Spread	I_{50} – Half-Peak Angle	I_{10} – One-tenth Peak Angle
Axial (C90-C270)	102.2	143.8
Transverse (shielded)	124.6	146.4
Transverse (un-shielded)	192.9	237.8

2.1.2 LED Luminaires

Monochromatic (yellow) light emitting diode (LED) luminaires are used for task lighting on some infrastructure. LED luminaires have a typical beam angle of 29.7 degrees and a field angle of

[3] URS has not independently verified the data provided by Chevron.
[4] G1-TE-E-0000-PDB0002, Rev. 2, August 2009.

56.6 degrees. Task lighting is typically mounted at an elevation of 3.0 metres above platform level at an angle of approximately 42 degrees (to horizontal). The typical LED LDC and intensity is shown in Figure 2-2, with an utilisation factor (η) of 100 per cent.

2.1.3 Light Spill

Light emitted from the various luminaires will be incident on the platform and infrastructure where illumination is required. Light will also spread across the platform and, where grid-mesh or platform geometry allows, will illuminate the environment below the illuminated work area. Such light spill will be shadowed by the platform. Light will also reflect off infrastructure. Reflected light will be attenuated by the albedo of the illuminated surface on which it is incident and will be reduced in area by infrastructure in the direct line of sight.

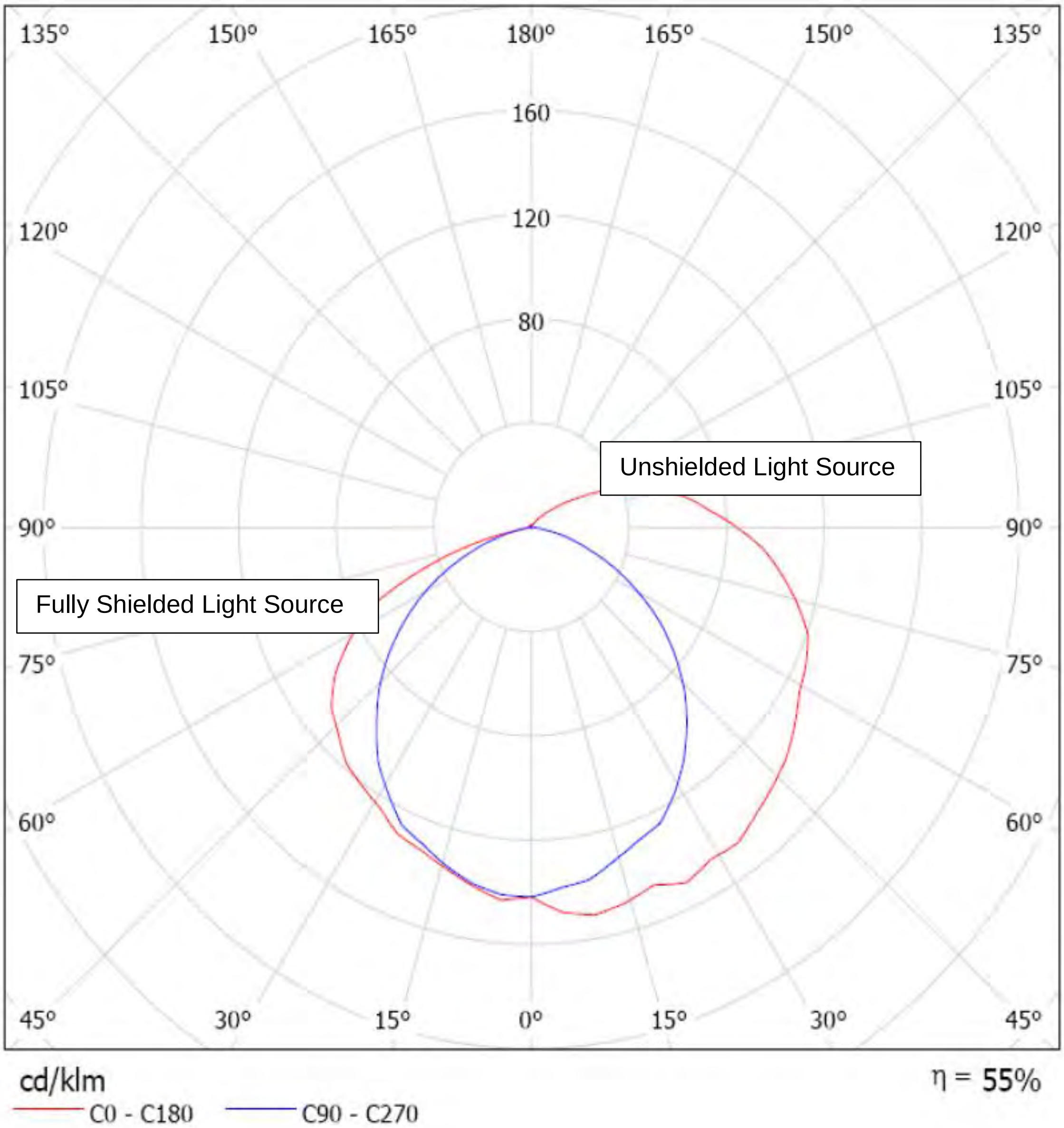

Figure 2-1 Cooper Crouse-Hinds eLLK 920 Fluorescent LDC (Polar) at 55% utilisation efficiency

2 Light Sources

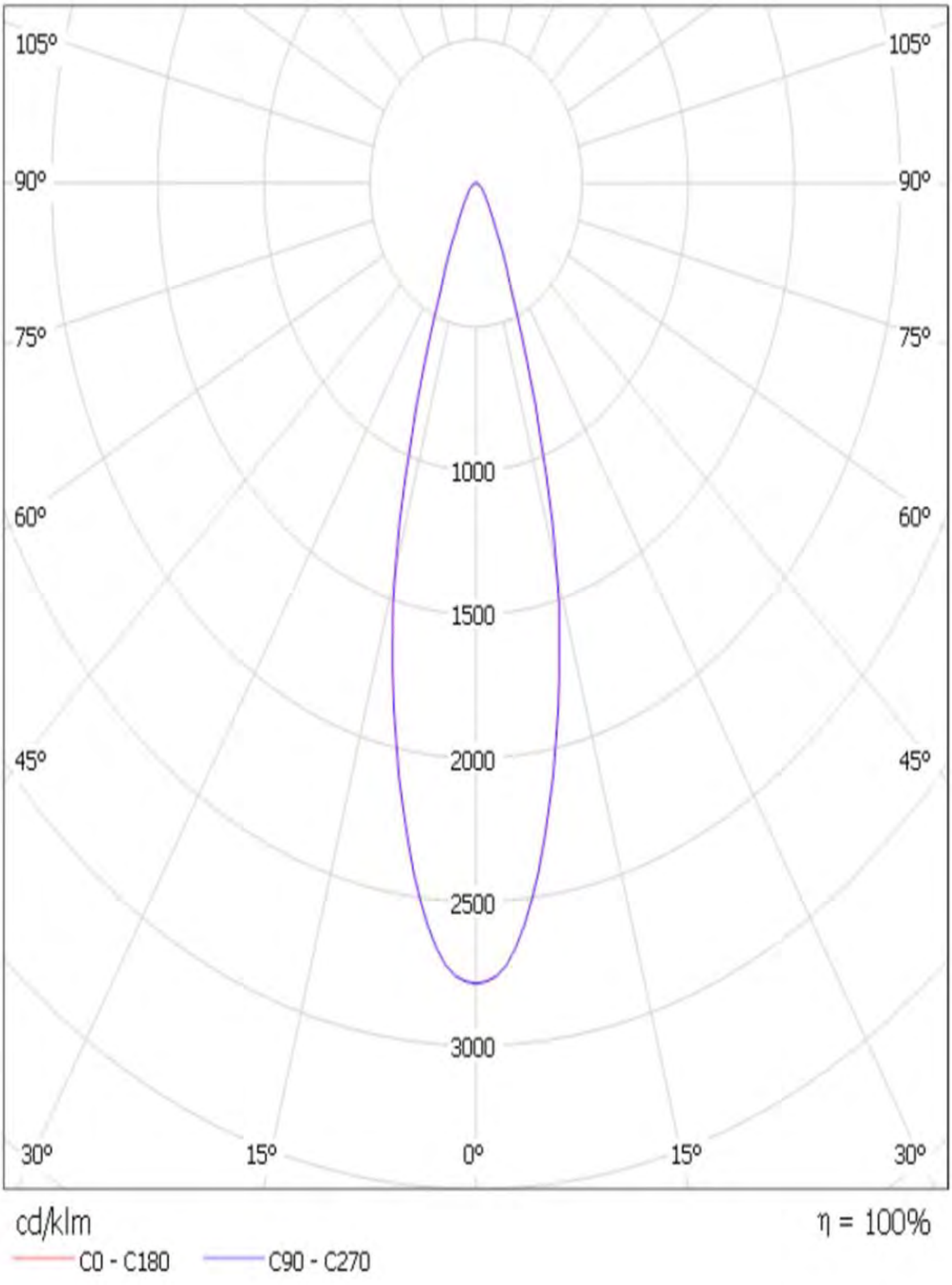

Figure 2-2 Hadar HDL 106 LED LDC (Polar) at 100% utilisation efficiency

2.1.4 Beam Spread

The beam angle is the spread of light that is emitted from the luminaire (both transverse and axial) that contains greater than 50 per cent of the luminous flux (lumens). The beam angle spread of light is the most intense source of emitted light.

The field angle is the additional spread of light (from 50 per cent to 10 per cent of the available luminous flux) that falls outside the main beam angle.

For a fully shielded luminaire, the amount of light (candela) that is emitted above 80 degrees (from the astronomical horizon) is not limited, whereas for a full cut-off luminaire, the amount of light (candela) that is emitted above 80 degrees is limited to 10 per cent of the available candela.

Light Emissions

3.1 Light Source Emissions

Light emissions from the onshore infrastructure[5] will arise from the consumption of electrical energy for artificial lighting, in addition to light emissions from the Foundation Project. The categories of 'Normal Lighting' and 'Task Lighting' were used for modelling purposes from onshore infrastructure. The definitions of Normal and Task lighting used for modelling purposes are provided in Table 3-1.

Table 3-1 Task and Normal Lighting Definition

	Normal Lighting	Task Lighting
Model input	Assumed illuminance of 20 lux average is continuously 'ON' and is used for safe ingress and egress from buildings/structures and spaces. Illuminance from filtered fluorescent lighting providing a SPD predominantly in the > 500 nm wavelengths.	Assumed illuminance of 50 lux (average) minimum is normally 'OFF' and switched on only when required for inspection and maintenance purposes. Illuminance with 'natural' (unfiltered) fluorescent light in locations west of Road U04, and with filtered fluorescent light in locations east of Road U04.

3.2 Spectral Power Distribution

Electric light sources emit light with both intensity and a spectral power distribution (SPD). The SPD is a visual profile of the colour characteristics of a specific light source. An artificial light source emits different amounts of energy at each wavelength across the visual spectrum. The sum of the energies contained by each wavelength is equivalent to the intensity of the light emitted. The typical (unfiltered) SPD for fluorescent light is shown in Figure 3-1. All fluorescent lights east of Road U04 will be fitted with a filter, generating a SPD similar to that shown in Figure 3-2. The SPD for monochromatic ("yellow") LED light sources (peak intensity at 587 nm) is shown in Figure 3-3.

The emitted light is subject to attenuation in the atmosphere through absorption and scattering. High energy (short wavelength) parts of the spectrum are typically attenuated at a greater rate than low energy (long wavelength) parts of the spectrum. Consequently, the visible spectrum typically becomes redder with increased distance from source. However, for distances less than five kilometres, the shift in wavelength intensity is typically imperceptible. Emitted light is also subject to attenuation and absorption by surfaces on which it is incident.

3.2.1 Electric Lighting

For the GTP, both normal and task lighting will be required. Normal illumination is provided by standard 'natural' warm-white fluorescent tubes nominally fitted with an egg yolk yellow filter (such as the Lee 768 filter) to reduce the energy output in the blue and green end of the fluorescent spectrum.

Task lighting for the GTP is provided by full spectrum fluorescent lighting in areas west of Road U04. In locations east of Road U04, the warm-white fluorescent tubes are nominally fitted with an egg yolk yellow filter (such as the Lee 768 filter) to reduce the energy output in the blue and green end of the

[5] This includes the Foundation Project and Fourth Train Proposal

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fluorescent spectrum. Task lighting may also be provided by monochromatic ("yellow") LED luminaires.

The spectral power distribution (SPD) curves for the full spectrum fluorescent light source, the light source fitted with the yellow filter, and the monochromatic light source, are shown in Figure 3-1, Figure 3-2 and Figure 3-3, respectively.

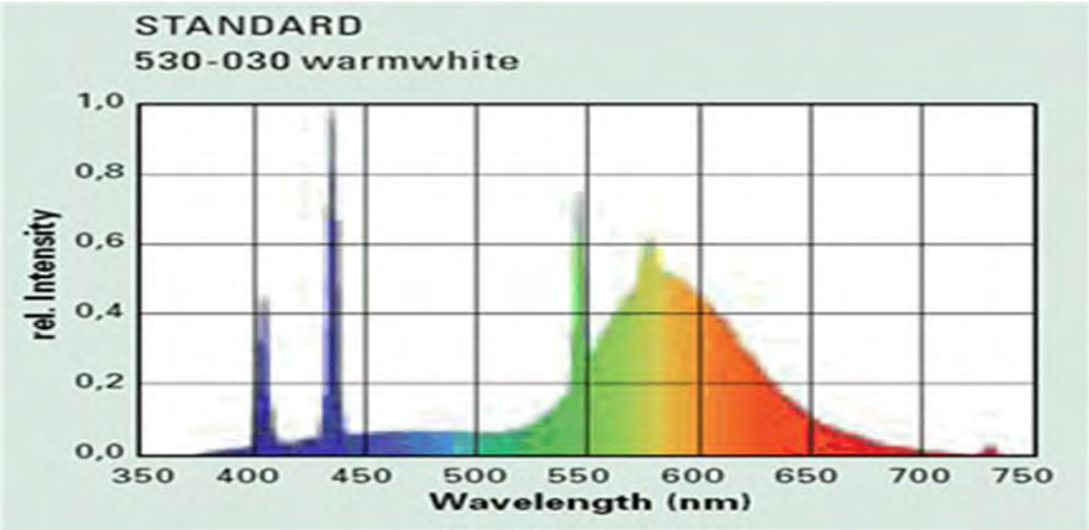

Figure 3-1 Full Spectral Power Distribution Histogram

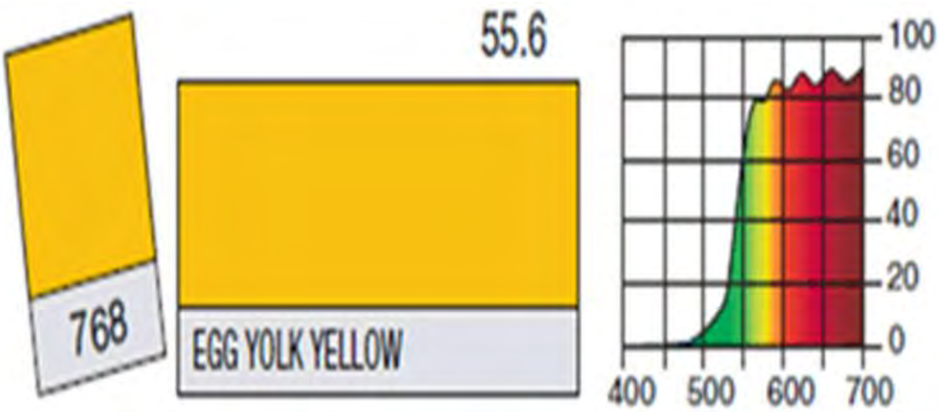

Figure 3-2 Spectral Power Distribution through Yellow Filter 768

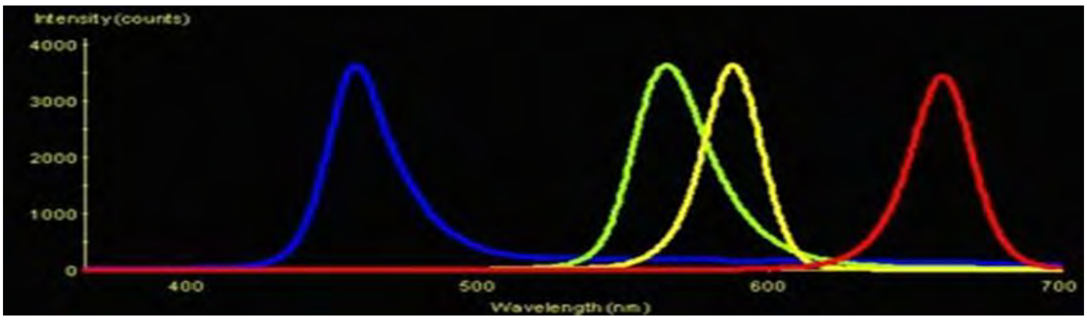

Figure 3-3 Spectral Signature of LEDs Yellow Peak Emission @ 587 nm

Task lighting in specific areas of the GTP may also be illuminated by LED flood lights. However, given the narrow beam angle associated with LED lighting (with associated reduced light spill), and use of the Lumen Method for average illumination of the task areas, it is assumed that the entire GTP is illuminated with fluorescent lighting. The SPD of light sources has been modelled for both filtered and unfiltered light.

Appendix C, Chart C-1 to Chart C-16, show the SPD versus distance and atmospheric attenuation of the fluorescent lighting to be used on the GTP, both with and without the egg yolk yellow filtering.

3.3 Light Dispersion

The GTP proposes to use direct lighting of task areas. Such lighting will typically lose approximately 10 per cent of the light output as upward emitted light, 80 per cent will be emitted downwards and approximately 10 per cent will be lost as heat absorption. Light emitted downwards will illuminate objects both directly and indirectly, from reflection and atmospheric dispersion.

Light Modelling

This chapter describes the light estimation methodology and modelling scenarios for the GTP infrastructure.

4.1 Light Estimation Methodology

For the purposes of modelling light spill, the Lumen Method[6] has been used. This method assumes that a uniform light intensity (lux levels) is present in all work areas. The method was chosen to undertake the light modelling as specific locations for each light source were not provided at the time the modelling was undertaken. Depending on whether normal or task lighting has been used, light sources are mounted either 2.5 m or 3.0 m above the work area, respectively.

Shielding of light by design/equipment/area/buildings within the GTP, and the topography of the site and coastline, have been taken into account to determine areas where shadowing may occur.

The light modelling undertaken assumes the amount of illumination varies inversely with the square of the distance from the point source (refer Appendix D, section D.1). Both axial and transverse light output from the light source have been accounted for, when developing the isolux contours. Primary reflectance from various surfaces, including the concrete, crushed stone, earth (dry) or galvanised steel infrastructure have been included, with attenuation of intensity due to surface albedo effects (Refer to Appendix E).

As this report is for lateral dispersion of light only, vertical dispersion of light has not been modelled.

Modelling assumptions are presented in section 4.1.1. Modelling was undertaken for various scenarios as described in section 4.1.2.

4.1.1 Light Modelling Assumptions

For modelling light emissions, it is assumed that:

- All lighting lux levels are based on the values[7] given in the Chevron Basis of Design for Lighting[8]:
  - Normal lighting – 20 lux average and normally 'ON';
  - Task lighting – 50 lux minimum, with a 1:3 averaging factor. Hence the minimum illumination levels for task lighting is 50 lux, with a maximum of 150 lux (average);
  - The Area Task Lighting system will consist of full spectrum (warm white) lighting which is normally 'OFF' and only switched on to provide the necessary task lighting, when required; and
  - Perimeter roads, roads outside of congested process plant areas of the GTP shall be delineated by LED solar powered road studs. However, these are expected to have a negligible effect on the lux levels produced, so have been omitted from the modelling study.
- Normal lighting to be installed at 2.5 m above structures/areas and Task lighting to be installed 3.0 m above structures/areas;
- All LNG trains are identical;
- Light intercepted by infrastructure, such as light from the LNG Storage Tank relief platform being blocked from directly reaching the coastline by the position of the pump platform on the LNG Storage tank, results in shadowing (removal of light) at the coastline;
- Lighting designated in the supplied drawings, which have lighting normally switched 'OFF', have been modelled as such;

[6] Lumen Method – assumes a uniform luminaire layout for the provision of lateral illuminance.
[7] URS has not independently verified the data provided by Chevron.
[8] G1-TE-E-0000-PDB0002, Rev. 2, August 2009.

4 Light Modelling

- Axial luminance represents less than 6 per cent of total emitted lumens from a luminaire at vertical inclination angles greater than 80 degrees, and is assumed to be the only emitted light that may reach the coastline directly;
- Transverse luminance represents less than 10 per cent of total emitted lumens at vertical inclination angles greater than 80 degrees, and is assumed to be the only emitted light that may reach the coastline directly;
- Primary reflectance only from surfaces has been assumed, to model worst case;
- Management measures, as defined in the Basis of Design for Lighting[9] document, have been taken into account for modelling. For example, where lights are normally switched 'OFF', they have been modelled accordingly.

4.1.2 Light Modelling Scenarios

The five (5) modelling scenarios for the GTP are shown in Table 4-1.

Table 4-1 Modelling Scenarios for the GTP Project

Scenario	Description	Model Assumption
Option A – Normal Operations	Normal operations for four identical LNG trains. Lighting levels set for normal operations as defined in the *Basis of Design for Lighting*[8].	Average lighting levels of 20 lux for LNG Trains #1 to 4.
Option B (a) – Single Train Maintenance (All Areas)	LNG Train #4 under maintenance, whilst three other LNG trains operating in normal mode. Task lighting provided for LNG Train #4.	Includes normal lighting which is normally 'ON' for all facilities, area task lighting in all areas of LNG Train #4.
Option B (b) – Single Train Maintenance (Two Areas only)	LNG Train #4 under maintenance, whilst three other LNG trains operating in normal mode. Task lighting provided for LNG Train #4.	Only two modules within LNG Train #4 are illuminated to 50 lux min, with a 1:3 averaging ratio. Modules selected were End Flash Gas Compressor Module and the Dehydration and Mercury Removal Module.
Option C – LNG Storage Tank Rooftop Maintenance	Normal operations for four LNG trains and maintenance works on LNG Storage Tank #3 (rooftop).	Average lighting levels of 20 lux for LNG Trains #1 to 4. LNG Storage Tank #3 rooftop illuminated to a minimum lighting level of 50 lux (filtered spectrum).
Option D – Maintenance Works in General Utilities Area	Normal operations for four LNG trains and maintenance works in the general utilities area.	Average lighting levels of 20 lux for LNG Trains #1 to 4. General utilities area illuminated to a minimum lighting level of 50 lux (filtered spectrum).

As a result of the 1:3 averaging factor, average illuminance of 50 lux, 100 lux and 150 lux, respectively, have been modelled for Options B to D to show the predicted light intensity at the SERLs, resulting from increasing the intensity of the light source.

[9] G1-TE-E-0000-PDB0002

4.1.3 Option C

The LNG storage tanks have an elevation (of the light source during maintenance) of 65.8 m AHD. This elevation allows light to directly illuminate those sections of the coastal beaches that have fringing sand dunes less than approximately 12 m AHD elevation. The consequence of reduced fringing sand dunes is that light can spill onto four of the six beaches investigated, although as the distance from the source diminishes, so too does the intensity of the illuminance.

Model Outputs

5.1 Modelling Results

In the model outputs (refer Appendix F), infrastructure coloured yellow represents illumination under normal lighting conditions (20 lux average). Infrastructure coloured green represents illumination under task lighting conditions. Task lighting has been considered for illumination at each of 50 lux, 100 lux and 150 lux average illumination intensity.

Isolux contours are referenced against equivalent natural illumination sources (refer to Appendix D, Table D-3), such as:

- 500 x 10^{-4} lux, equivalent illumination of a quarter moon, clear night sky with airglow.
- 10 x 10^{-4} lux, equivalent illumination of a moonless, clear night sky with airglow.
- 1 x 10^{-4} lux, equivalent illumination of a moonless, overcast night sky.

The figures in Appendix F show isolux contours extending laterally from the infrastructure and diminishing both due to distance and albedo diminished reflectance from different surface finishes.

5.1.1 Scenario A – Normal Operations

Appendix F, Figure F-1 shows four (4) LNG trains, and associated facilities, under normal lighting conditions.

5.1.1.1 Intensity

The isolux contours diminish to less than 10 x 10^{-4} lux within 100 metres from the source structures.

Indirect, lateral light spill intensity, resulting from atmospheric scattering, at the six (6) potential SERLs is predicted to be less than 4.0 x 10^{-4} lux, and typically less than 0.2 x 10^{-4} lux, after reflectance from surface finishes. LNG Storage Tank #3, with lighting in the normally switched 'OFF' illumination mode, has no material impact (shadowing or cumulative enhancement) on light spill from the four LNG trains in normal operation.

5.1.1.2 Wavelength Distribution

Wavelengths (λ) absorbed by and reflected from surface finish materials generate a composite SPD (filtered) as shown in Appendix C, Chart C-7. The reflected light SPD at greater than 100 metres from the source has a slight red bias, with all individual wavelength intensities less than 1.7 x 10^{-4} lux, and typically less than 0.5 x 10^{-4} lux. The typical cumulative intensity for $\lambda < 560$ nm is less than 0.02 x 10^{-4} lux, with a peak at 0.5 x 10^{-4} lux.

5.1.2 Scenario B - B(a) – Single Train Maintenance (All Areas)

Appendix F, Figure F-2 to Figure F-4 show LNG Trains #1, 2 and 3, and associated facilities, illuminated under normal lighting conditions. Task lighting is switched 'ON' in all areas of LNG Train #4. This scenario has been modelled for the three task illumination intensities, i.e. 50 lux, 100 lux and 150 lux (average).

5.1.2.1 Intensity

The isolux contours diminish to less than 10 x 10^{-4} lux within 100 metres from the structures at 50 lux illumination, and within 150 metres from the structures at 100 lux and 150 lux average illumination intensity.

5 Model Outputs

Indirect, lateral light spill intensity, resulting from atmospheric scattering, at the six (6) potential SERLs is predicted to be less than 6.0 x 10^{-4} lux, and typically less than 1.0 x 10^{-4} lux, after reflectance from surface finishes. LNG Storage Tank #3, with lighting in normally switched 'OFF' illumination mode, has no shadowing or cumulative enhancement of light spill from the three LNG trains in normal operation and the one LNG train under maintenance.

5.1.2.2 Wavelength Distribution

Wavelengths (λ) absorbed by and reflected from surface finish materials generate composite SPDs (unfiltered) for each of the illumination intensities, as shown in Appendix C, Chart C-8. Reflected light at greater than 150 metres from the source has a neutral SPD with all individual wavelength intensities less than 1.6 x 10^{-4} lux, and typically less than 0.4 x 10^{-4} lux. The typical cumulative intensity for $\lambda <$ 560 nm is less than 0.5 x 10^{-4} lux, with a peak at 2.5 x 10^{-4} lux.

5.1.3 Scenario B - B(b) – Single Train Maintenance (Two Areas Only)

Appendix F, Figure F-5 to Figure F-7 show LNG Trains #1, 2, 3 and 4, and associated facilities, illuminated under normal lighting conditions. Task lighting is switched 'ON' in the End Flash Gas Compressor Module and the Dehydration and Mercury Removal Module on LNG Train #4 only. This scenario has been modelled for the three task illumination intensities, i.e. 50 lux, 100 lux and 150 lux (average).

5.1.3.1 Intensity

The isolux contours diminish to less than 10 x 10^{-4} lux within 100 metres from the structures at 50 lux average illumination intensity, and within 150 metres from the structures at 100 lux and 150 lux average illumination intensity.

Indirect, lateral light spill intensity, resulting from atmospheric scattering, at the six (6) potential SERLs is predicted to be less than 6.0 x 10^{-4} lux, and typically less than 1.0 x 10^{-4} lux, after reflectance from surface finishes. LNG Storage Tank #3, with lighting in normally switched 'OFF' illumination mode, has no shadowing or cumulative enhancement of light spill from the four LNG trains in normal operation and one LNG train under maintenance in two areas only.

5.1.3.2 Wavelength Distribution

Wavelengths (λ) absorbed by and reflected from surface finish materials generate composite SPDs (Natural) for each of the illumination intensities, as shown in Appendix C, Chart C-8. Reflected light at greater than 150 metres from the source has a neutral SPD with all individual wavelength intensities less than 1.6 x 10^{-4} lux, and typically less than 0.4 x 10^{-4} lux. The typical cumulative intensity for $\lambda <$ 560 nm is less than 0.5 x 10^{-4} lux, with a peak at 2.5 x 10^{-4} lux.

5.1.4 Option C – LNG Tank #3, Rooftop Maintenance

Appendix F, Figure F-8 to Figure F-10 show all four (4) LNG trains and associated facilities illuminated under normal lighting conditions. LNG Storage Tank #3 has rooftop task lighting switched 'ON' to undertake maintenance works. The scenario has been modelled for the three task illumination intensities, i.e. 50 lux, 100 lux and 150 lux (average).

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5.1.4.1 Intensity

Due to the elevation of the LNG Storage Tank #3, the task lighting is directly visible from Bivalve Beach at a predicted illuminance of less than 20 x 10^{-4} lux. Task lighting is also directly visible from the shoreline at Yacht Club Beach (South) at a predicted illumiance of less than 0.3 x 10^{-4} lux.

At Terminal and Inga Beaches, the predicted indirect illuminance is less than 2 x 10^{-4} lux and less than 3 x10^{-4} lux, respectively

Task lighting is not visible from the base of the sand dunes at Yacht Club Beach (North and South).

5.1.4.2 Wavelength Distribution

The SPD (filtered) for light spill visible at the potential SERLs, are shown in Appendix C, Chart C-9. Direct illumination from source has a slight red bias, with illuminance of less than 8.3 x 10^{-4} lux for all individual wavelength (λ) intensities, and typically less than 0.2 x 10^{-4} lux. The typical cumulative intensity for λ < 560 nm is less than 0.5 x 10^{-4} lux, with a peak at 2.5 x 10^{-4} lux.

5.1.5 Option D – Maintenance Works in General Utilities Area

Appendix F, Figure F-11 to Figure F-13 show LNG Trains #1, 2, 3 and 4, and associated facilities, illuminated under normal lighting conditions. Task lighting is switched ‘ON’ to undertake maintenance works in the general utilities area, including the waste water treatment plant (WWTP). The scenario has been modelled for the three task illumination intensities, i.e. 50 lux, 100 lux and 150 lux (average).

5.1.5.1 Intensity

The isolux contours diminish to less than 10 x 10^{-4} lux within 100 metres from the structures at 50 lux average illumination intensity, and within 150 metres from the structures at 100 lux and 150 lux average illumination intensity.

Indirect, lateral light spill intensity, resulting from atmospheric scattering, at the six (6) potential SERLs is predicted to be less than 4.0 x 10^{-4} lux, and typically less than 0.5 x 10^{-4} lux, after reflectance from surface finishes. LNG Storage Tank #3, with lighting in normally switched ‘OFF” illumination mode, has no shadowing or cumulative enhancement of light spill from the four LNG trains in normal operation and maintenance works in the general utilities area, including the waste water treatment plant (WWTP).

5.1.5.2 Wavelength Distribution

Wavelengths (λ) absorbed by and reflected from surface finish materials generate composite SPDs (Natural) for each of the illumination intensities, as shown in Appendix C, Chart C-10. Reflected light at greater than 150 metres from the source has a slight red bias SPD with all individual wavelength intensities less than 1.7 x 10^{-4} lux, and typically less than 0.5 x 10^{-4} lux. The typical cumulative intensity for λ < 560 nm is less than 0.05 x 10^{-4} lux, with a peak at 0.5 x 10^{-4} lux.

5.2 Spectral Power Distribution (SPD)

The individual spectral power intensities by colour group is shown in Table 5-1. The results indicate that for filtered light the long wavelengths (> 560 nm) are approximately an order of magnitude higher than the intensity of the shorter wavelengths (< 560 nm), indicating that the filtered light starts out yellow and becomes redder after reflection off surfaces and atmospheric particles.

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For unfiltered light, the SPD is more neutral, indicating that the white light becomes slightly more yellow after reflection off surfaces and atmospheric particles.

SPD for each of the SERLs have been graphed (refer Appendix C, Chart C-1 to Chart C-6).

Table 5-1 Spectral Power Distribution for each SERL

Inga	λ < 560 nm			λ > 560 nm				λ < 560 nm	λ > 560 nm	Total	
	violet	blue	green	yellow	orange	red		lux			Ratio
A	0.000E+00	5.858E-07	1.179E-05	1.611E-05	2.994E-05	4.159E-05	filtered	1.238E-05	8.763E-05	1.000E-04	7.1
B(a)	8.967E-05	1.775E-05	1.033E-04	1.269E-04	1.304E-04	3.193E-05	unfiltered	2.107E-04	2.893E-04	5.000E-04	1.4
B(b)	7.174E-05	1.420E-05	8.264E-05	1.016E-04	1.043E-04	2.555E-05	unfiltered	1.686E-04	2.314E-04	4.000E-04	1.4
C	0.000E+00	1.757E-06	3.537E-05	4.832E-05	8.981E-05	1.248E-04	filtered	3.713E-05	2.629E-04	3.000E-04	7.1
D	0.000E+00	1.757E-06	3.537E-05	4.832E-05	8.981E-05	1.248E-04	filtered	3.713E-05	2.629E-04	3.000E-04	7.1
YCBN											
	violet	blue	green	yellow	orange	red					
A	0.000E+00	1.156E-07	2.342E-06	3.210E-06	5.988E-06	8.343E-06	filtered	2.458E-06	1.754E-05	2.000E-05	7.1
B(a)	1.741E-05	3.535E-06	2.071E-05	2.554E-05	2.633E-05	6.467E-06	unfiltered	4.166E-05	5.833E-05	1.000E-04	1.4
B(b)	1.741E-05	3.535E-06	2.071E-05	2.554E-05	2.633E-05	6.467E-06	unfiltered	4.166E-05	5.833E-05	1.000E-04	1.4
C	0.000E+00	3.467E-07	7.027E-06	9.629E-06	1.796E-05	2.503E-05	filtered	7.374E-06	5.262E-05	6.000E-05	7.1
D	0.000E+00	3.467E-07	7.027E-06	9.629E-06	1.796E-05	2.503E-05	filtered	7.374E-06	5.262E-05	6.000E-05	7.1
YCBS											
	violet	blue	green	yellow	orange	red					
A	0.000E+00	5.702E-08	1.164E-06	1.599E-06	2.995E-06	4.186E-06	filtered	1.221E-06	8.780E-06	1.000E-05	7.2
B(a)	1.014E-05	2.112E-06	1.246E-05	1.541E-05	1.595E-05	3.929E-06	unfiltered	2.472E-05	3.529E-05	6.001E-05	1.4
B(b)	8.453E-06	1.760E-06	1.038E-05	1.284E-05	1.329E-05	3.274E-06	unfiltered	2.060E-05	2.941E-05	5.000E-05	1.4
C	0.000E+00	1.711E-07	3.491E-06	4.798E-06	8.985E-06	1.256E-05	filtered	3.662E-06	2.634E-05	3.000E-05	7.2
D	0.000E+00	1.711E-07	3.491E-06	4.798E-06	8.985E-06	1.256E-05	filtered	3.662E-06	2.634E-05	3.000E-05	7.2
D'Island											
	violet	blue	green	yellow	orange	red					
A	0.000E+00	5.625E-08	1.156E-06	1.594E-06	2.995E-06	4.199E-06	filtered	1.212E-06	8.787E-06	9.999E-06	7.3
B(a)	3.282E-06	7.008E-07	4.163E-06	5.164E-06	5.364E-06	1.326E-06	unfiltered	8.146E-06	1.185E-05	2.000E-05	1.5
B(b)	3.282E-06	7.008E-07	4.163E-06	5.164E-06	5.364E-06	1.326E-06	unfiltered	8.146E-06	1.185E-05	2.000E-05	1.5
C	0.000E+00	1.125E-07	2.311E-06	3.187E-06	5.990E-06	8.397E-06	filtered	2.424E-06	1.757E-05	2.000E-05	7.3
D	0.000E+00	1.125E-07	2.311E-06	3.187E-06	5.990E-06	8.397E-06	filtered	2.424E-06	1.757E-05	2.000E-05	7.3
Bivalve											
	violet	blue	green	yellow	orange	red					
A	0.000E+00	2.355E-06	4.729E-05	6.450E-05	1.197E-04	1.661E-04	filtered	4.964E-05	3.503E-04	4.000E-04	7.1
B(a)	1.089E-04	2.134E-05	1.238E-04	1.520E-04	1.559E-04	3.813E-05	unfiltered	2.541E-04	3.460E-04	6.001E-04	1.4
B(b)	1.089E-04	2.134E-05	1.238E-04	1.520E-04	1.559E-04	3.813E-05	unfiltered	2.541E-04	3.460E-04	6.001E-04	1.4
C	0.000E+00	1.180E-05	2.366E-04	3.227E-04	5.987E-04	8.304E-04	filtered	2.484E-04	1.752E-03	2.000E-03	7.1
D	0.000E+00	2.355E-06	4.729E-05	6.450E-05	1.197E-04	1.661E-04	filtered	4.964E-05	3.503E-04	4.000E-04	7.1
Terminal											
	violet	blue	green	yellow	orange	red					
A	0.000E+00	2.343E-08	4.717E-07	6.442E-07	1.198E-06	1.663E-06	filtered	4.951E-07	3.505E-06	4.000E-06	7.1
B(a)	1.793E-06	3.550E-07	2.066E-06	2.539E-06	2.608E-06	6.387E-07	unfiltered	4.214E-06	5.786E-06	1.000E-05	1.4
B(b)	1.793E-06	3.550E-07	2.066E-06	2.539E-06	2.608E-06	6.387E-07	unfiltered	4.214E-06	5.786E-06	1.000E-05	1.4
C	0.000E+00	1.173E-06	2.360E-05	3.222E-05	5.987E-05	8.314E-05	filtered	2.477E-05	1.752E-04	2.000E-04	7.1
D	0.000E+00	1.172E-07	2.358E-06	3.221E-06	5.988E-06	8.317E-06	filtered	2.475E-06	1.753E-05	2.000E-05	7.1

The charts indicate that Scenario B and Scenario C generate the most intense light spill at all SERLs. The order of impact of light spill at the SERLS, for wavelengths less than 560 nm is:

- Bivalve Beach $< 2.5 \times 10^{-4}$ lux (Scenario C)
- Inga Beach $< 2.1 \times 10^{-4}$ lux (Scenario B)
- Yacht Club Beach (North) $< 0.42 \times 10^{-4}$ lux (Scenario B)
- Terminal Beach $< 0.25 \times 10^{-4}$ lux (Scenario C)

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- Yacht Club Beach (South) < 0.25 x 10^{-4} lux (Scenario B)
- Double Island < 0.12 x 10^{-4} lux (Scenario B)

The ratio in the last column of Table 5-1 is wavelengths > 560 nm compared to wavelengths < 560 nm. For a ratio of 7.1 (typical), the red end of the spectrum is approximately seven times more intense than the blue end of the spectrum.

Findings and Conclusions

6.1 Light Model Findings

The beam angles for luminaires used at the FTP are typically less than 80 degrees. Light emittance from luminaires at vertical angles greater than 80 degrees carry for greater distances than lower angles, but represent less than 10 per cent of the total lumen output. The topography of the site is a significant factor in the modelling of light spill. The Gorgon Project site has been terraced and this has reduced the overall elevation of installed infrastructure and ensures that light will typically intersect the ground within 350 metres from the light source.

The light modelling indicates that lateral light spill (ground illumination) is primarily restricted to on-site locations within the Gorgon Project, although some direct light spill does occur. Indirect, lateral light spill from atmospheric scattering of infrastructure light sources, and from secondary reflection from concrete, crushed stone and dry bare earth (worst case scenario), will typically result in the reflected light intensity being reduced by up to 90 per cent.

The anticipated light spill intensity at the defined potentially sensitive environmental receptor locations results from direct light spill and atmospheric scattering of reflected light and generates an illuminance intensity less than 20 x 10^{-4} lux for all task lighting scenarios between 20 lux and 150 lux (average), and typical illuminance intensity less than 0.5 x 10^{-4} lux, as presented in Table 6-1.

Table 6-1 Predicted Illuminance (lux) for Modelled Scenarios

SERL	Option A	Option B(a)	Option B(b)	Option C	Option D
			x 10^{-4} lux		
Bivalve Beach	< 4.0	< 6.0	< 6.0	< 20	< 4.0
Terminal Beach	< 0.4	< 1.0	< 1.0	< 2.0	< 2.0
Inga Beach	< 1.0	< 5.0	< 5.0	< 3.0	< 3.0
Yacht Club Beach (North)	< 0.2	< 1.0	< 1.0	< 0.6	< 0.6
Yacht Club Beach (South)	< 0.1	< 0.6	< 0.6	< 0.3	< 0.3
Double Island	< 0.1	< 0.2	< 0.2	< 0.2	< 0.2

NOTES:

500 x 10^{-4} lux is the equivalent illumination intensity of a Quarter moon, with airglow (refer Table D-2)

10 x 10^{-4} lux is the equivalent illumination intensity of a moonless clear night sky, with airglow (refer Table D-2).

1 x 10^{-4} lux is the equivalent illumination intensity of a moonless, overcast night sky (refer Table D-2).

6 Findings and Conclusions

6.1.1.1 Wavelength Power Distribution

The modelled SPD at the potentially sensitive environmental receptor locations show flat spectra with a small shift in intensity towards the orange-red end of the spectrum. Typical cumulative intensities for wavelengths less than 560 nm are less than 0.5 x 10^{-4} lux, although for light emitted onto Bivalve Beach, the cumulative intensity can be up to 2.5 x 10^{-4} lux for wavelengths less than 560 nm.

6.2 Light Model Conclusions

The highest light spill intensity predicted by the model is 20 x 10^{-4} lux. This intensity is essentially equivalent to the illuminance from airglow on a moonless, clear night. However, the visible point sources of light may need further consideration and management.

The majority of the coastline studied, where direct illumination does not occur, will be illuminated by atmospheric scattering of light generated from the Gorgon Project. This illumination represents less than 0.5 per cent of direct illumination for an equivalent distance. However, during maintenance lighting on the LNG Storage Tank #3, enhanced skyglow may occur that may partially diminish celestial light at the horizon east of the coastline.

The coastal topography investigated, on the eastern side of Barrow Island, tends to provide long, wide beaches with sand dunes rising abruptly (up to 25 per cent gradient) from the beaches. The sand dune gradient is lowest (7 per cent) at the northern end of Bivalve Beach. This lower gradient allows light to spill directly onto the front section of the beach. The next lowest sand dune gradient (9 per cent) on Bivalve Beach is at the southern end of the beach.

The sand dune gradient (19 per cent) at the southern end of Terminal Beach is much more abrupt. Consequently, it is unlikely that the barrier formed by the sand dunes will allow light to directly spill onto the southern end of Terminal Beach.

The coastal sand dunes provide an excellent barrier to direct light spill in the majority of sites studied.

At the light spill intensity predicted to be incident onto Bivalve Beach it is difficult to distinguish colour variation in the light source. However, as the model outputs presented in Appendix C indicate, the wavelength light intensities tend to be either flat, with no bias towards either the blue or red ends of the spectrum or have a red bias.

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Appendix A Bivalve Beach Transects

Appendix A - Bivalve Beach Transects

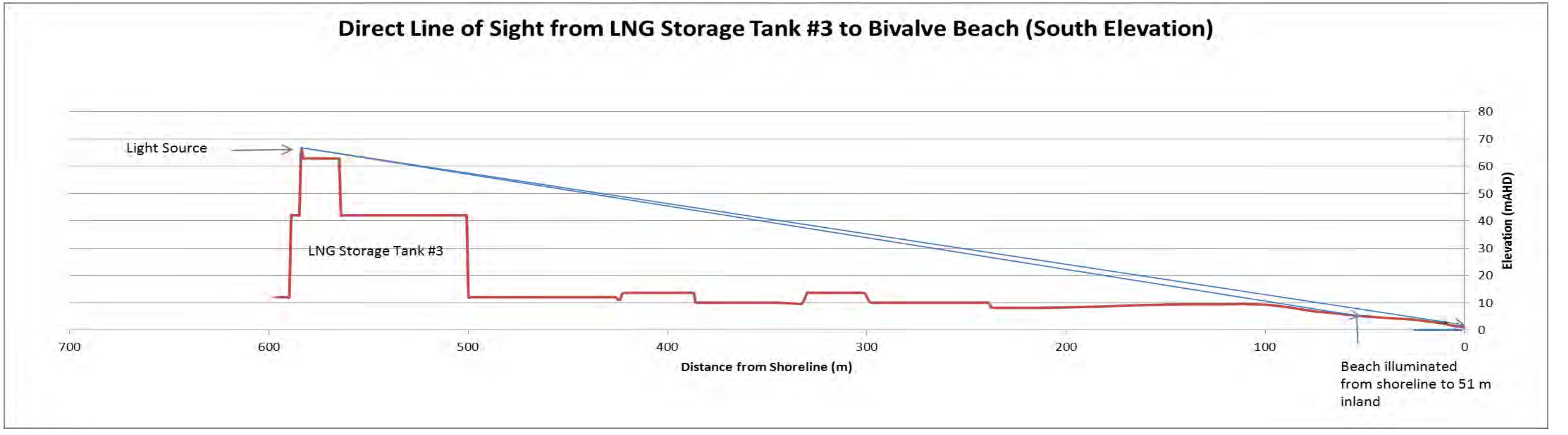


Plate A-1 Transect A-A

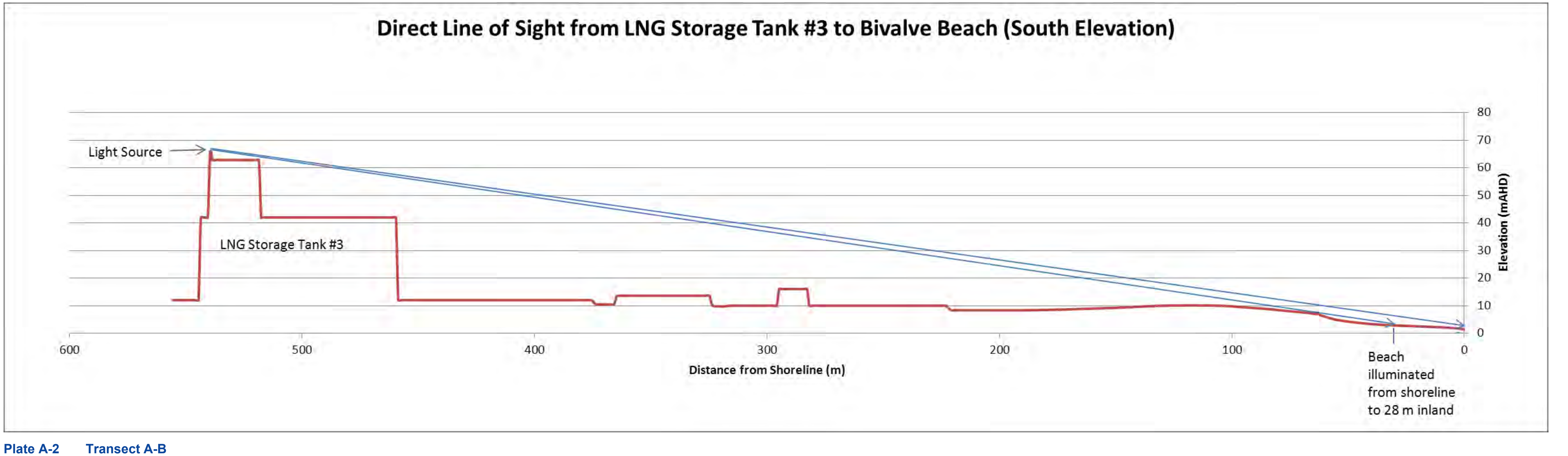


Plate A-2 Transect A-B

Appendix A - Bivalve Beach Transects

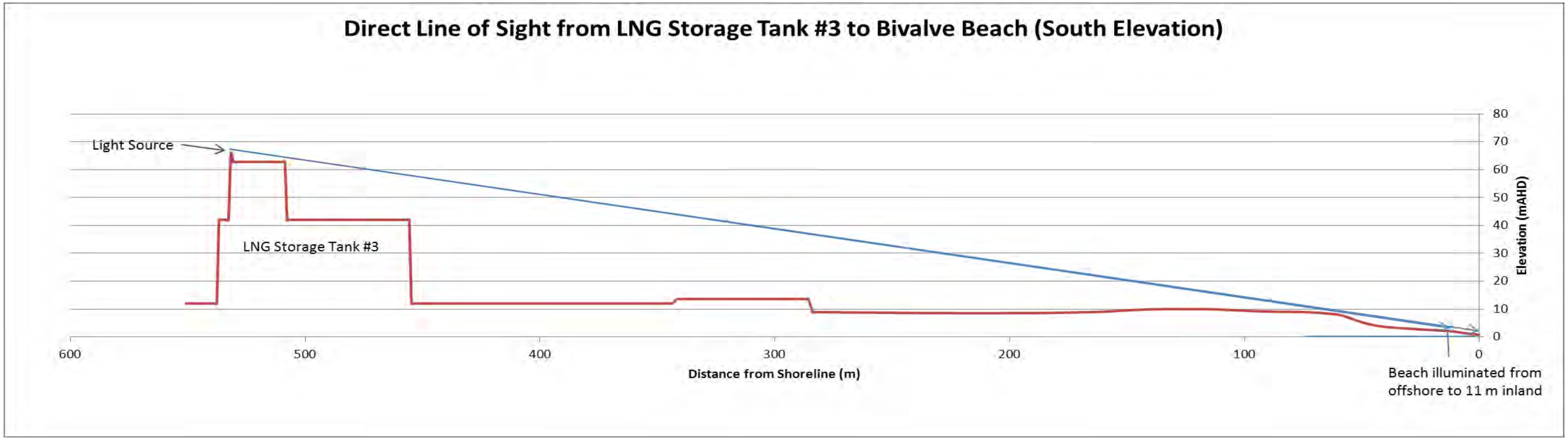


Plate A-3 **Transect A-C**

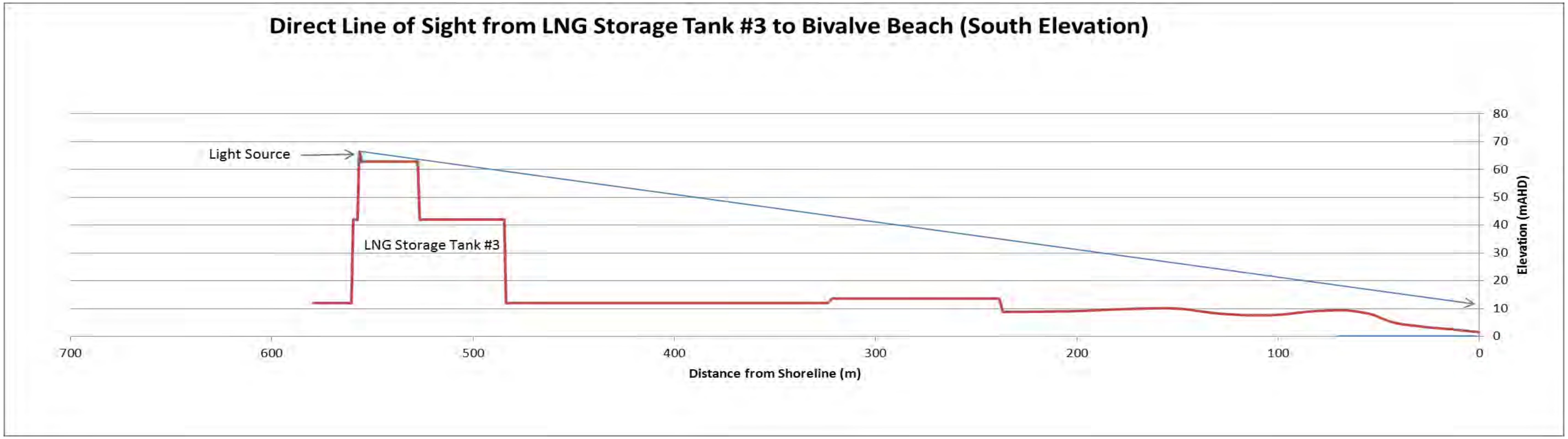


Plate A-4 **Transect A-D**

Appendix A - Bivalve Beach Transects

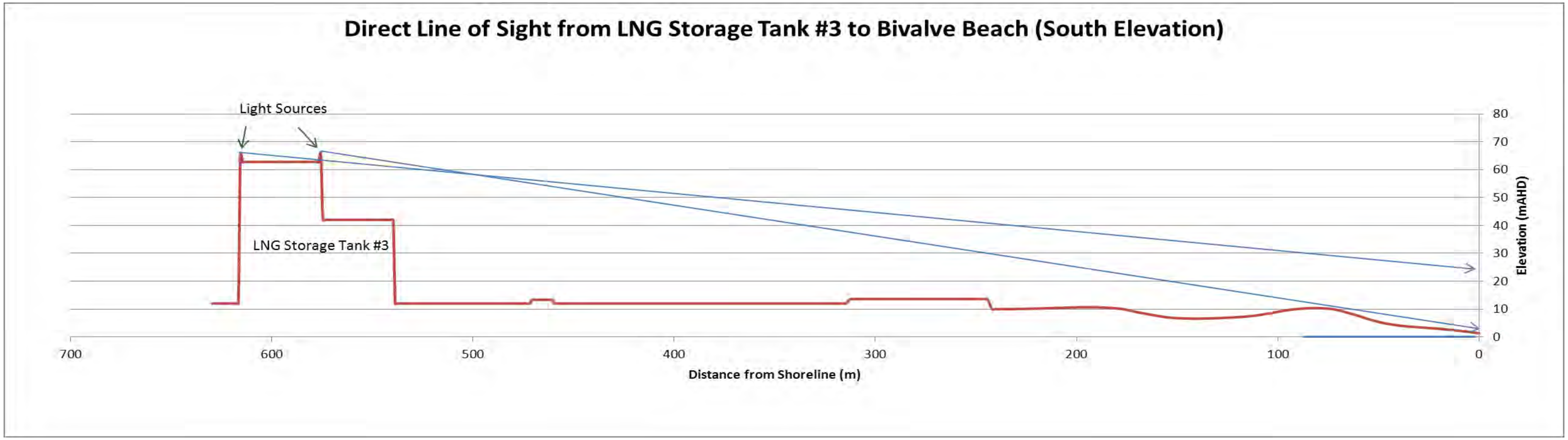


Plate A-5 Transect A-E

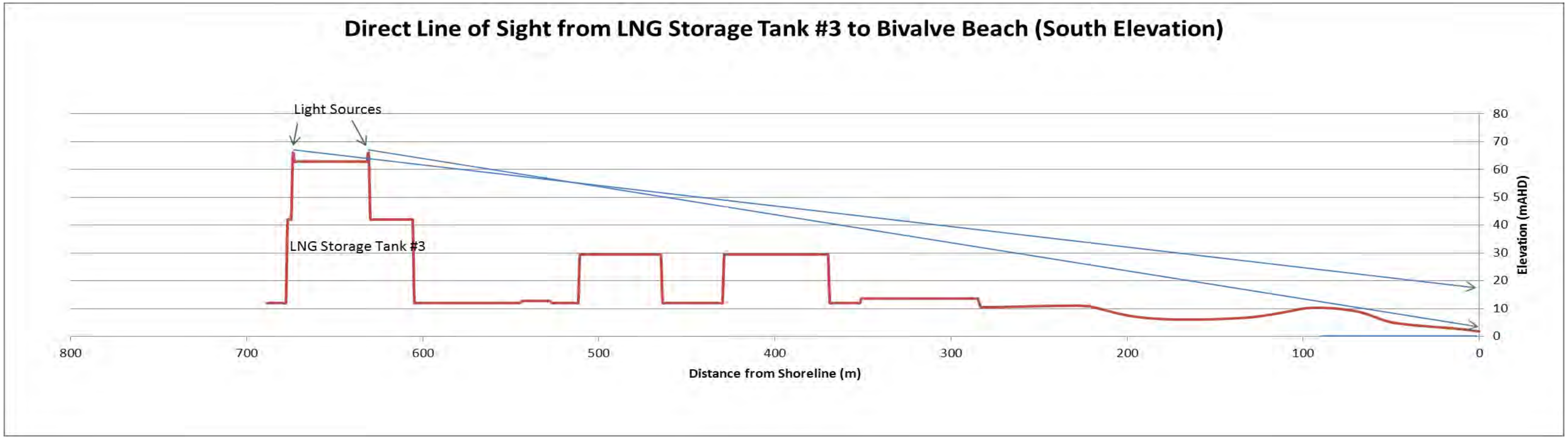


Plate A-6 Transect A-F

Appendix A - Bivalve Beach Transects

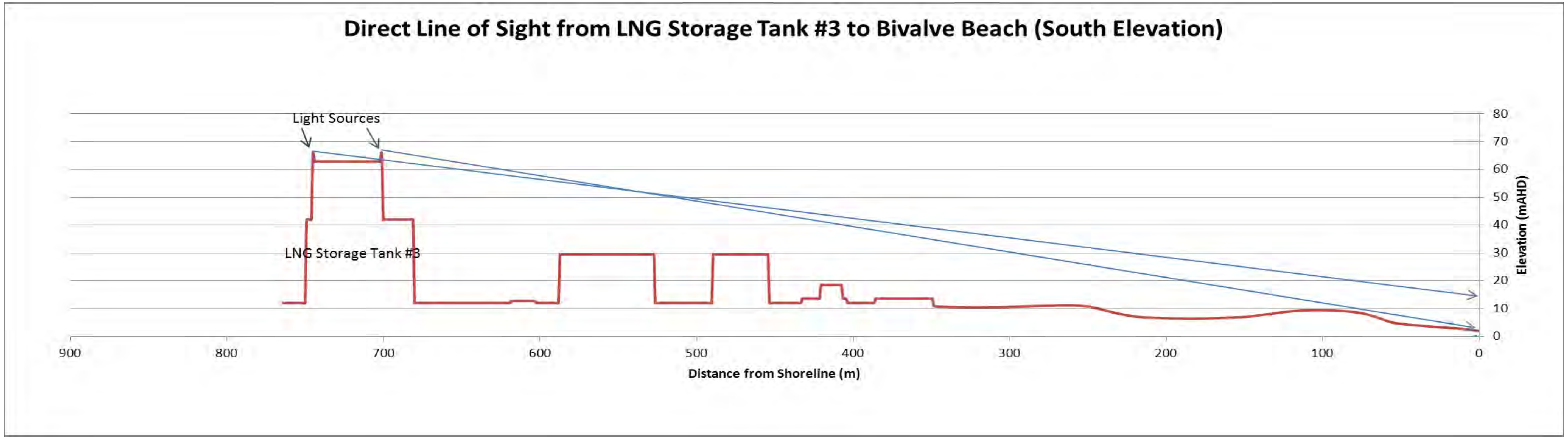


Plate A-7 Transect A-G

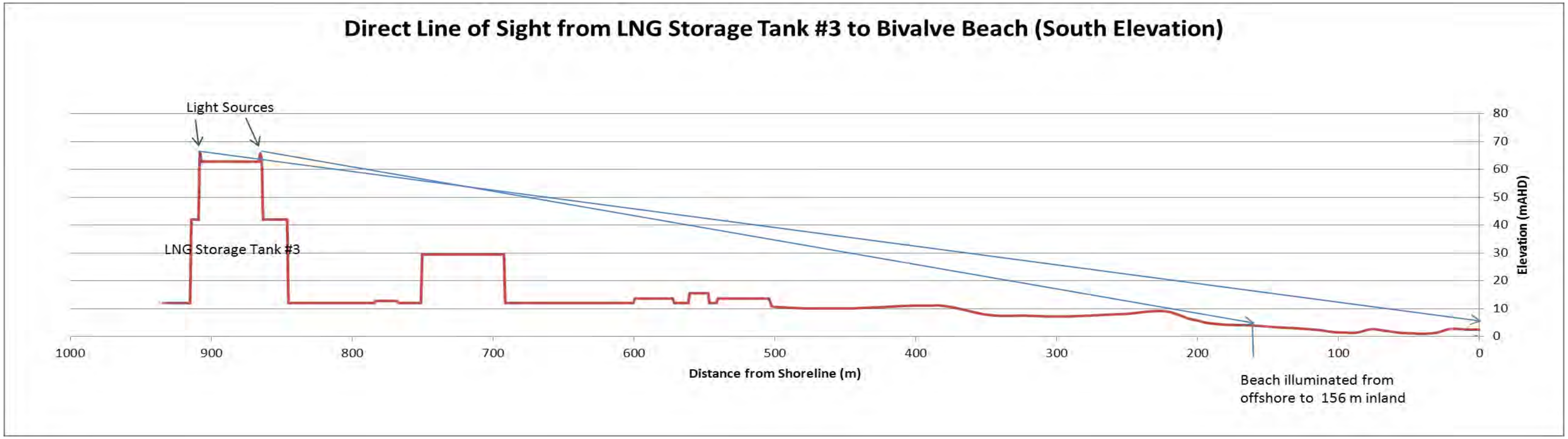
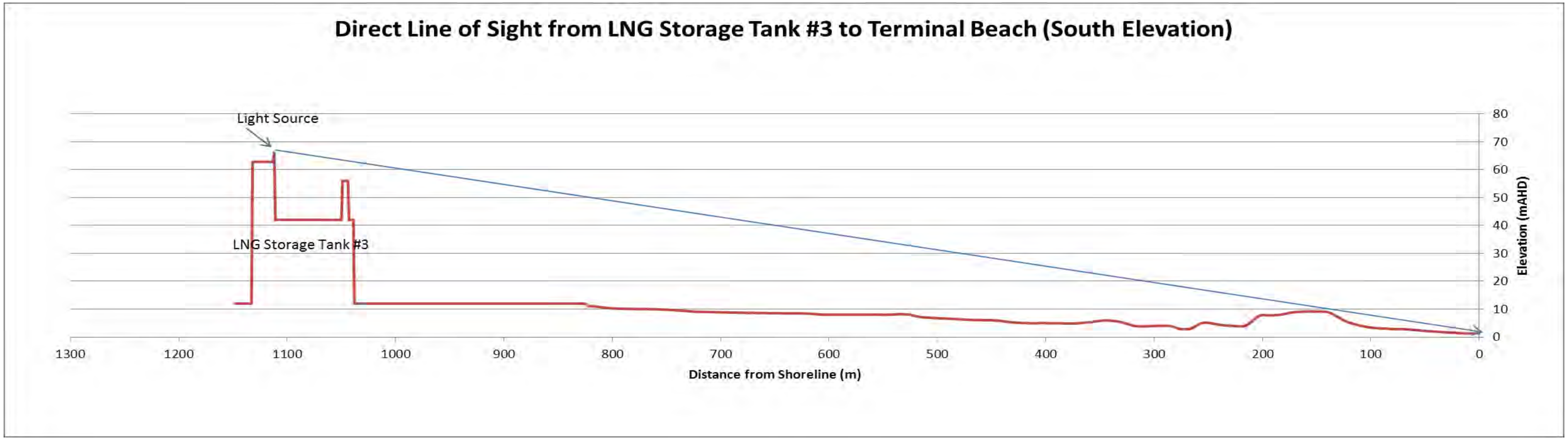


Plate A-8 Transect A-H

Appendix B Terminal Beach Transects

Appendix B - Terminal Beach Transects



PlateAppendix B-1 Transect A-A

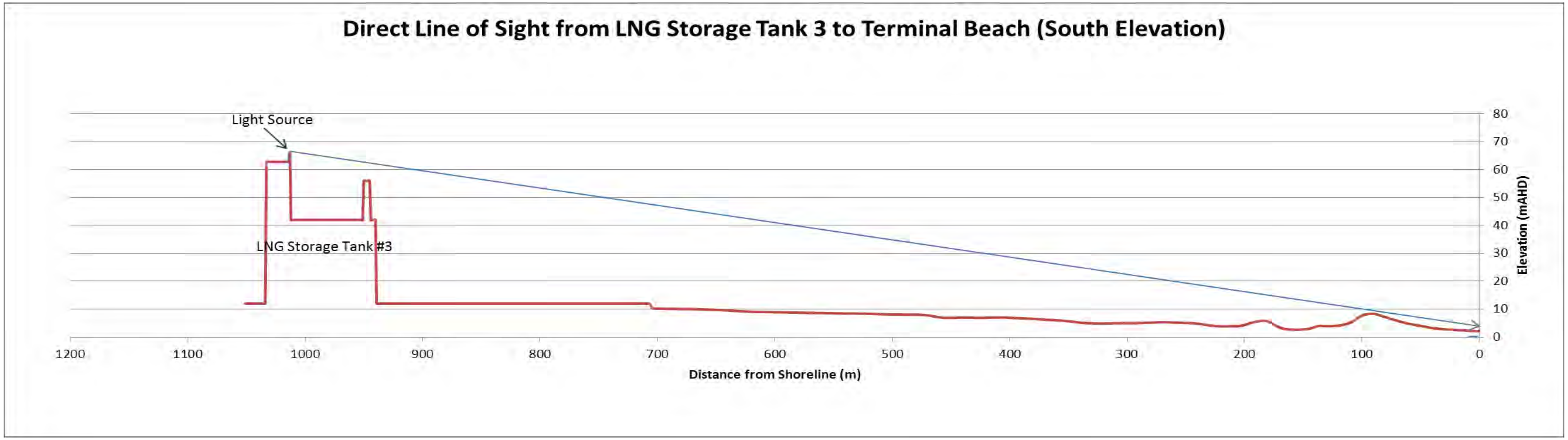


Plate Appendix B-2 Transect A-B

Appendix B - Terminal Beach Transects

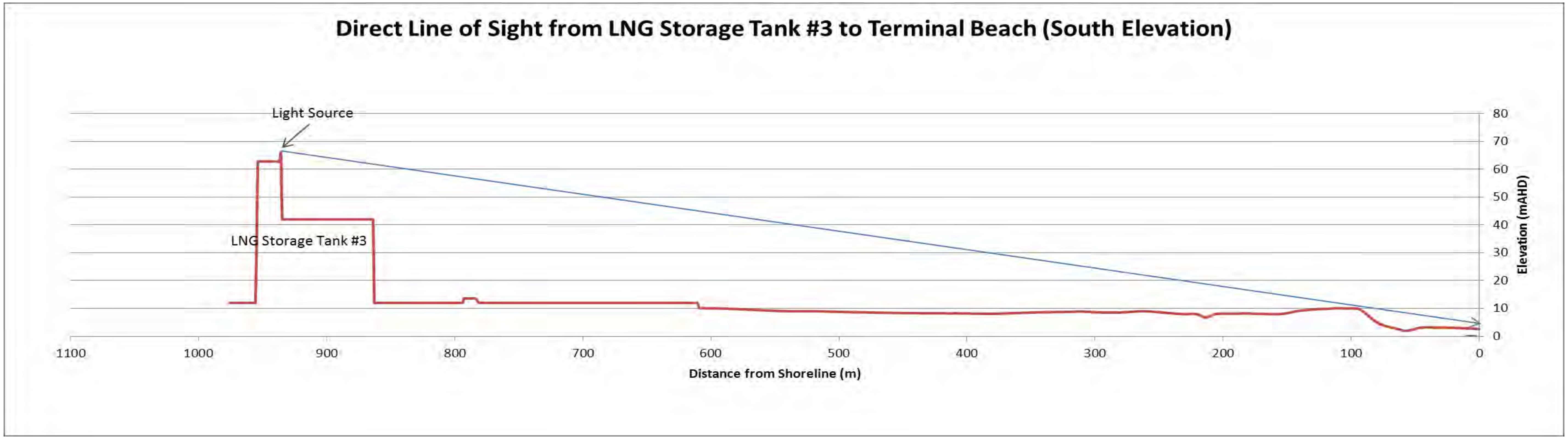


Plate Appendix B-3 **Transect A-C**

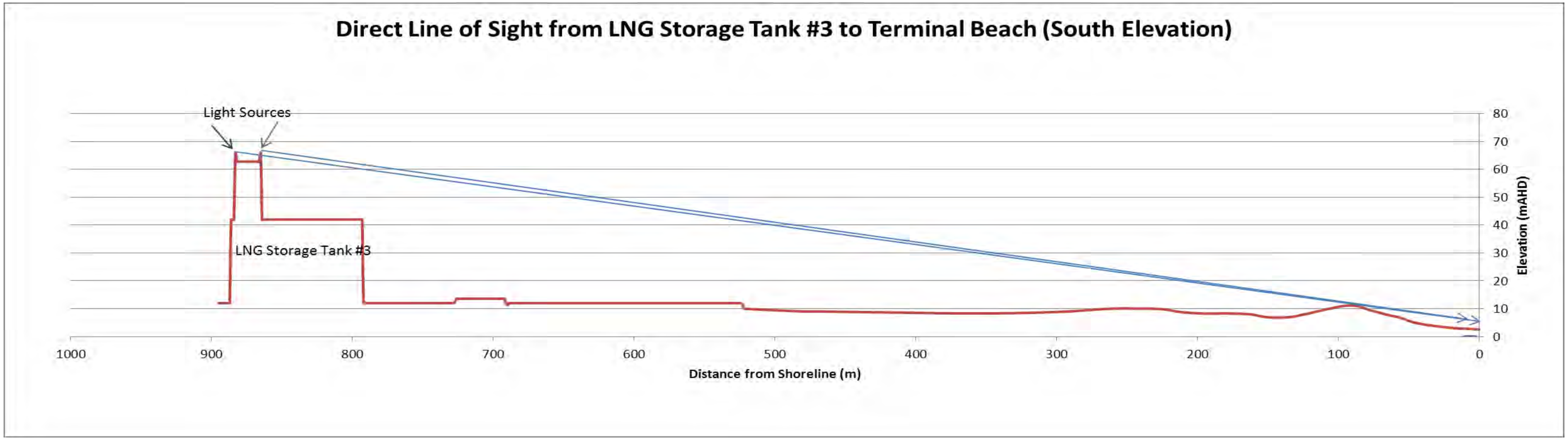


Plate Appendix B-4 **Transect A-D**

Appendix B - Terminal Beach Transects

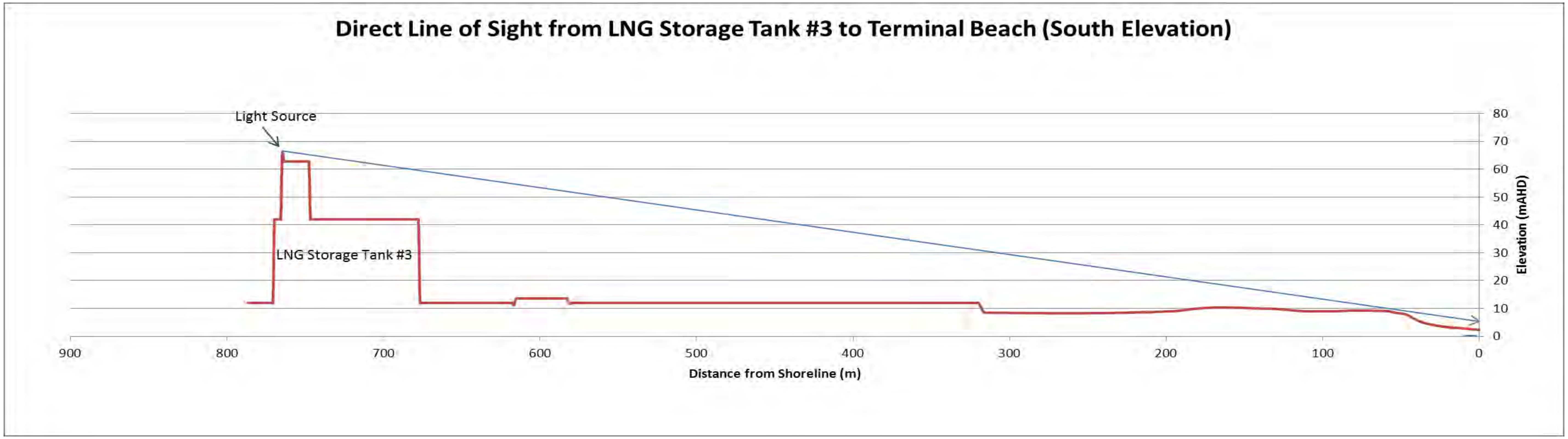


Plate Appendix B-5 Transect A-E

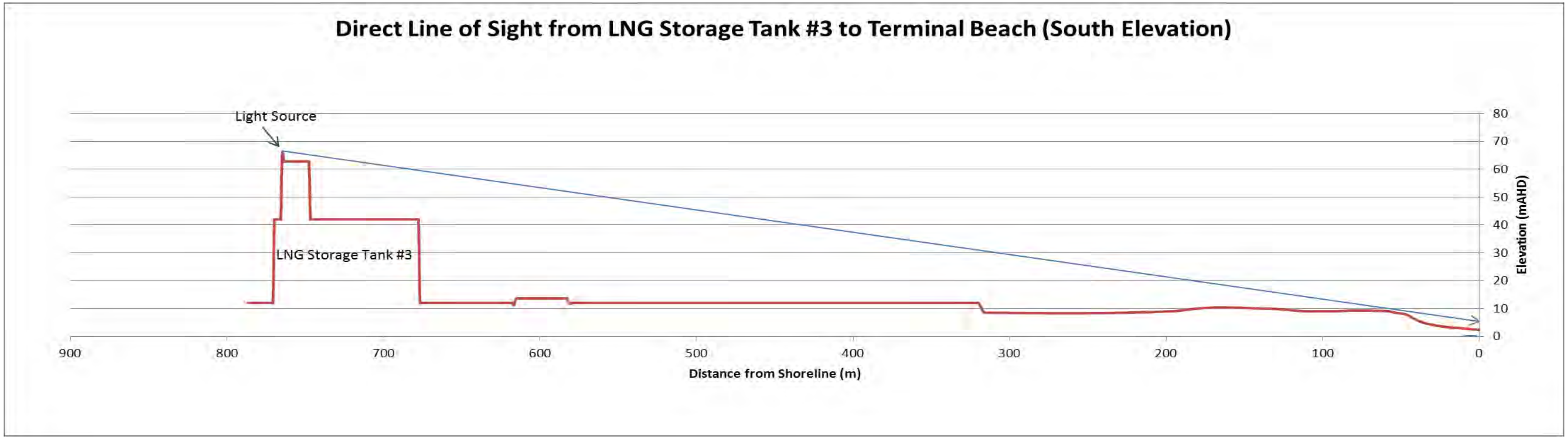


Plate Appendix B-6 Transect A-F

Appendix B - Terminal Beach Transects

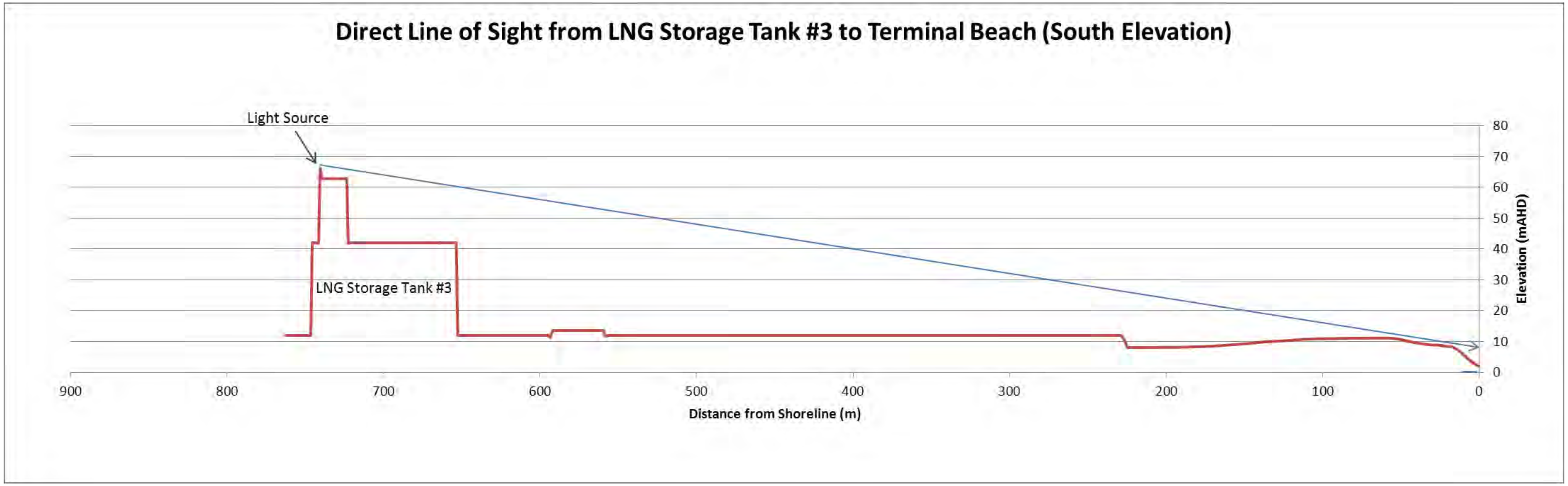


Plate Appendix B-7 **Transect A-G**

Appendix C Spectral Power Distribution

Appendix C - Spectral Power Distribution

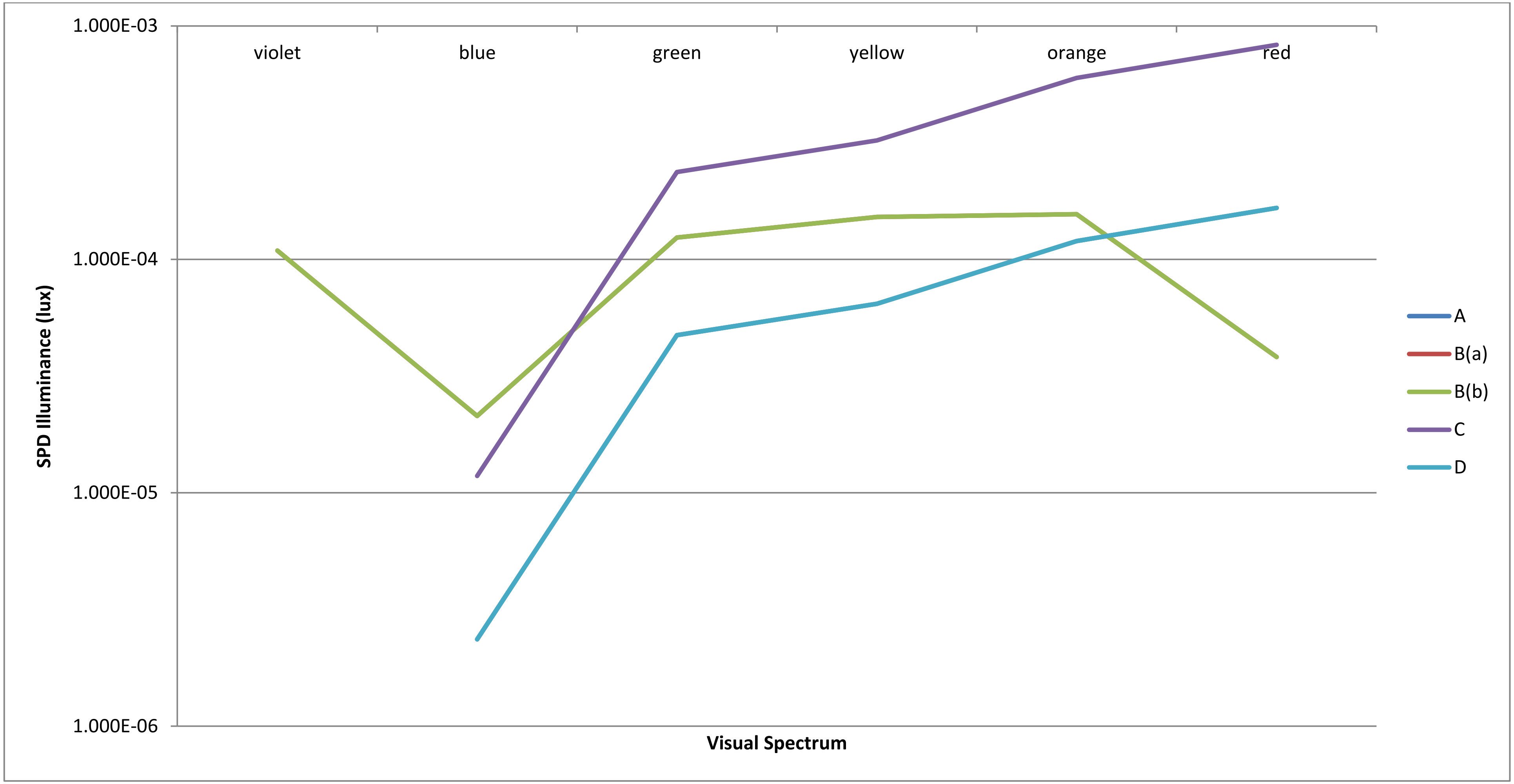


Chart C-1 SPD at Bivalve Beach for each Scenario Modelled: A (average 20 lux), B(a) to D (average 150 lux)

Appendix C - Spectral Power Distribution

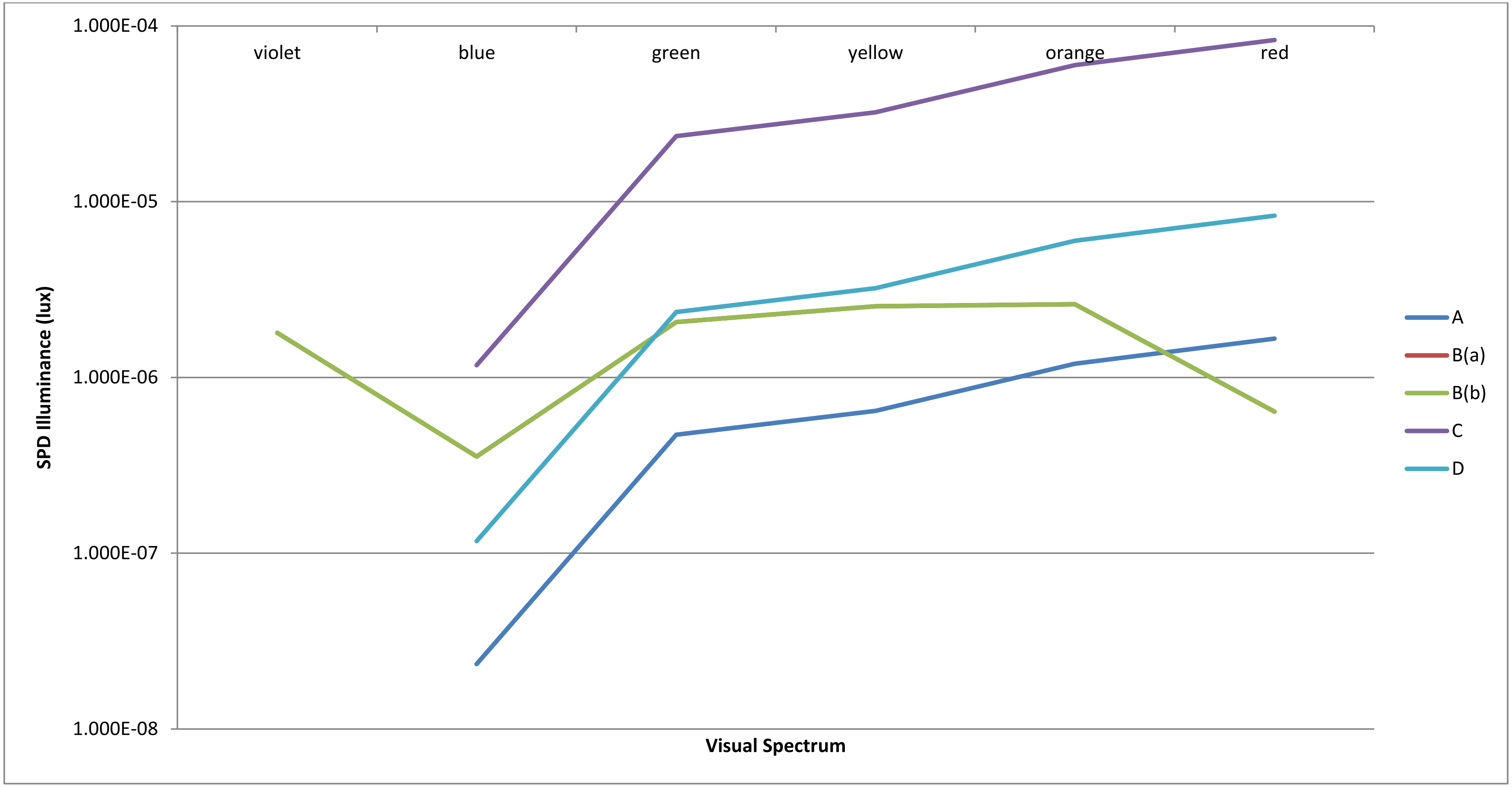


Chart C-2 SPD at Terminal Beach for each Scenario Modelled: A (average 20 lux), B(a) to D (average 150 lux)

Appendix C - Spectral Power Distribution

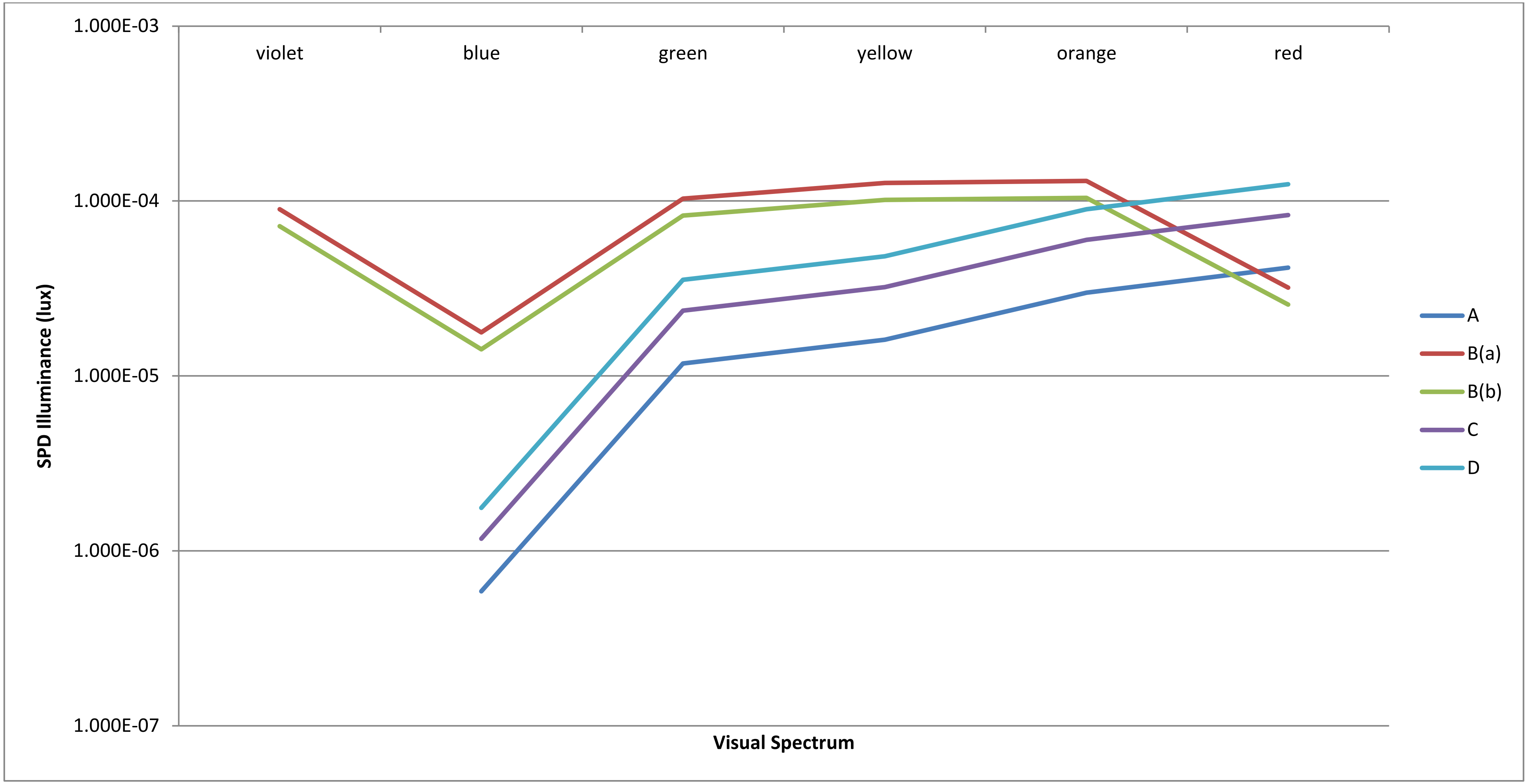


Chart C-3 **SPD at Inga Beach for each Scenario Modelled: A (average 20 lux), B(a) to D (average 150 lux)**

Appendix C - Spectral Power Distribution

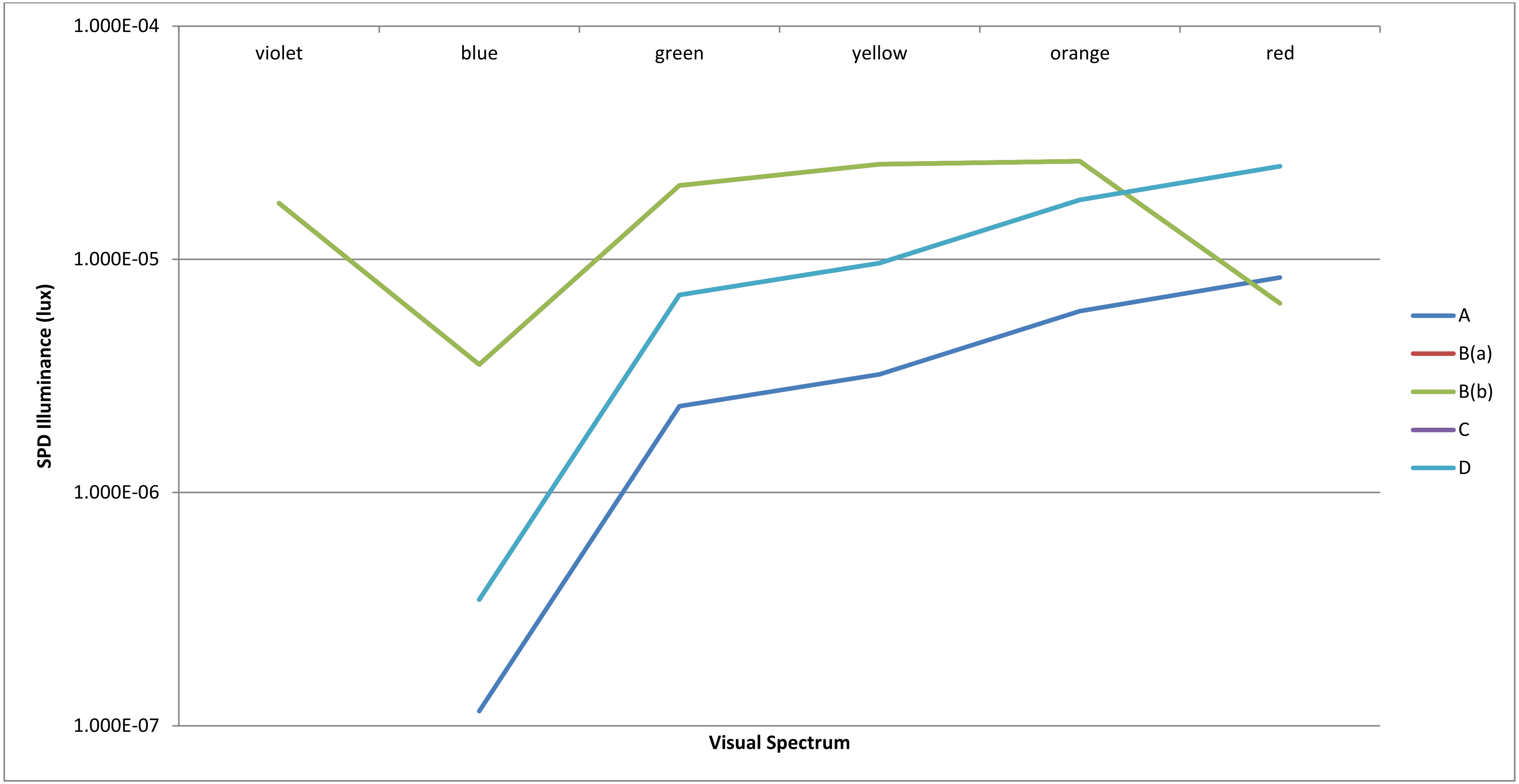


Chart C-4 SPD at Yacht Club Beach North for each Scenario Modelled: A (average 20 lux), B(a) to D (average 150 lux)

Appendix C - Spectral Power Distribution

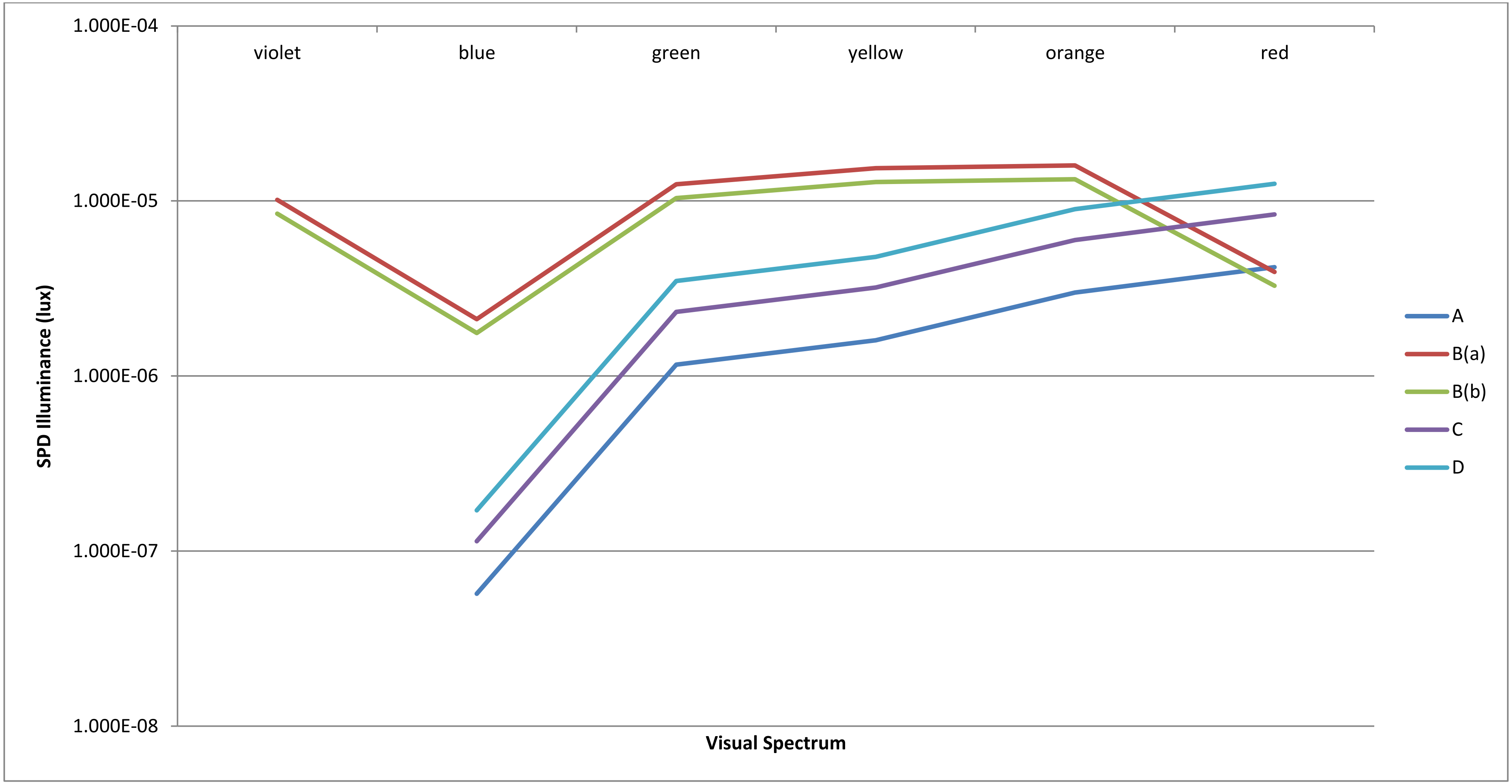


Chart C-5 SPD at Yacht Club Beach South for each Scenario Modelled: A (average 20 lux), B(a) to D (average 150 lux)

Appendix C - Spectral Power Distribution

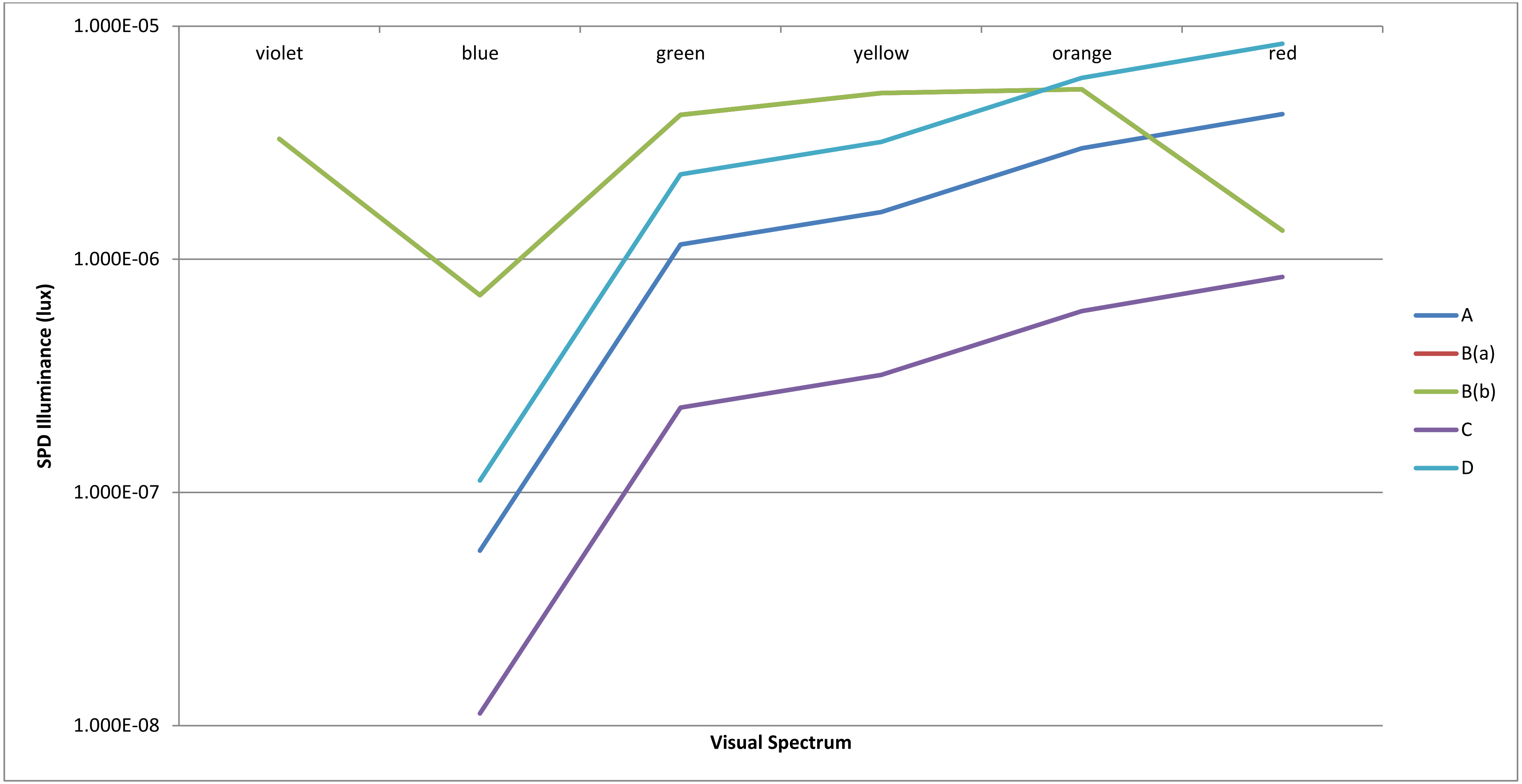


Chart C-6 SPD at Double Island for each Scenario Modelled: A (average 20 lux), B(a) to D (average 150 lux)

Appendix C - Spectral Power Distribution

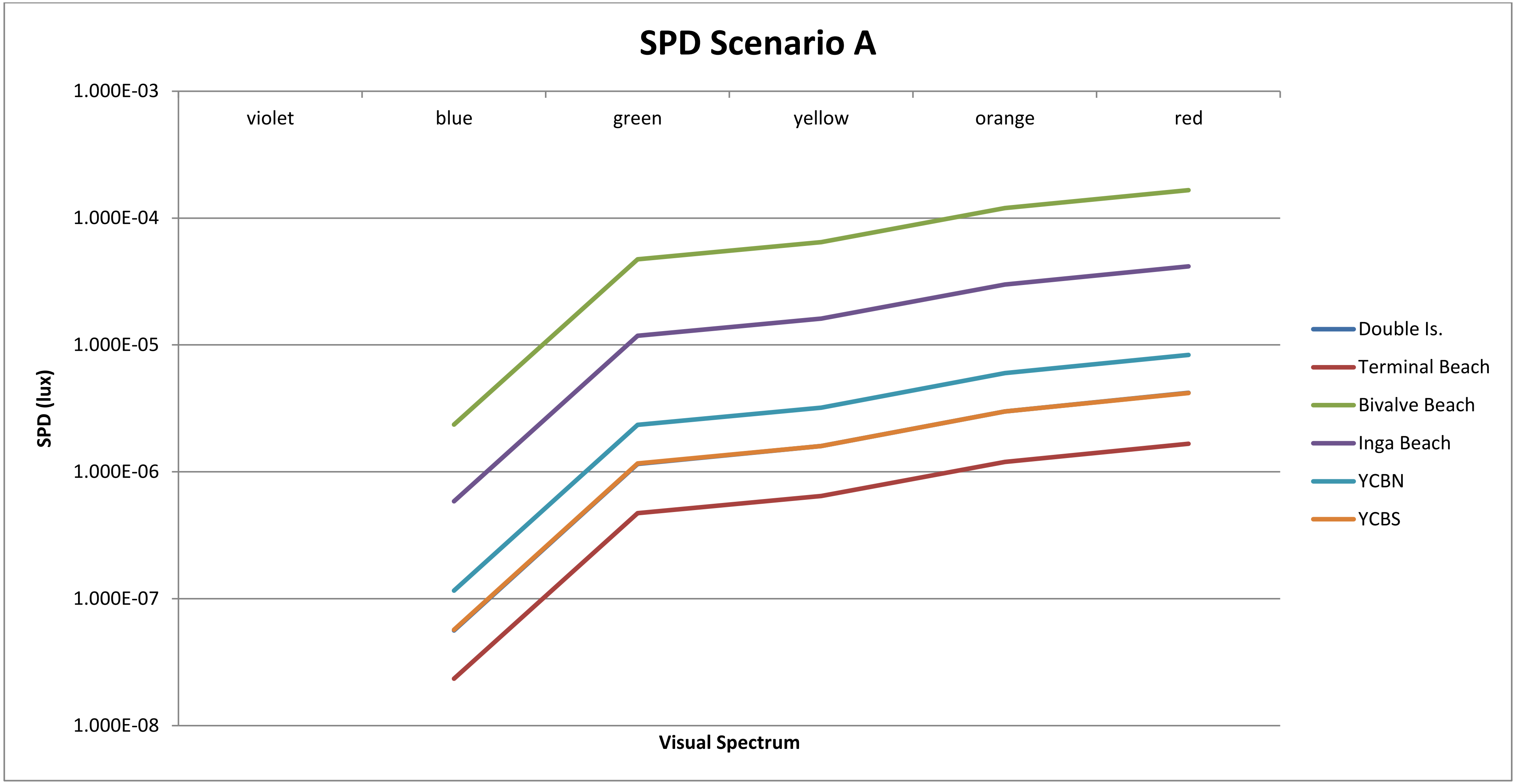


Chart C-7 SPD Scenario A (20 lux average illumination)

Appendix C - Spectral Power Distribution

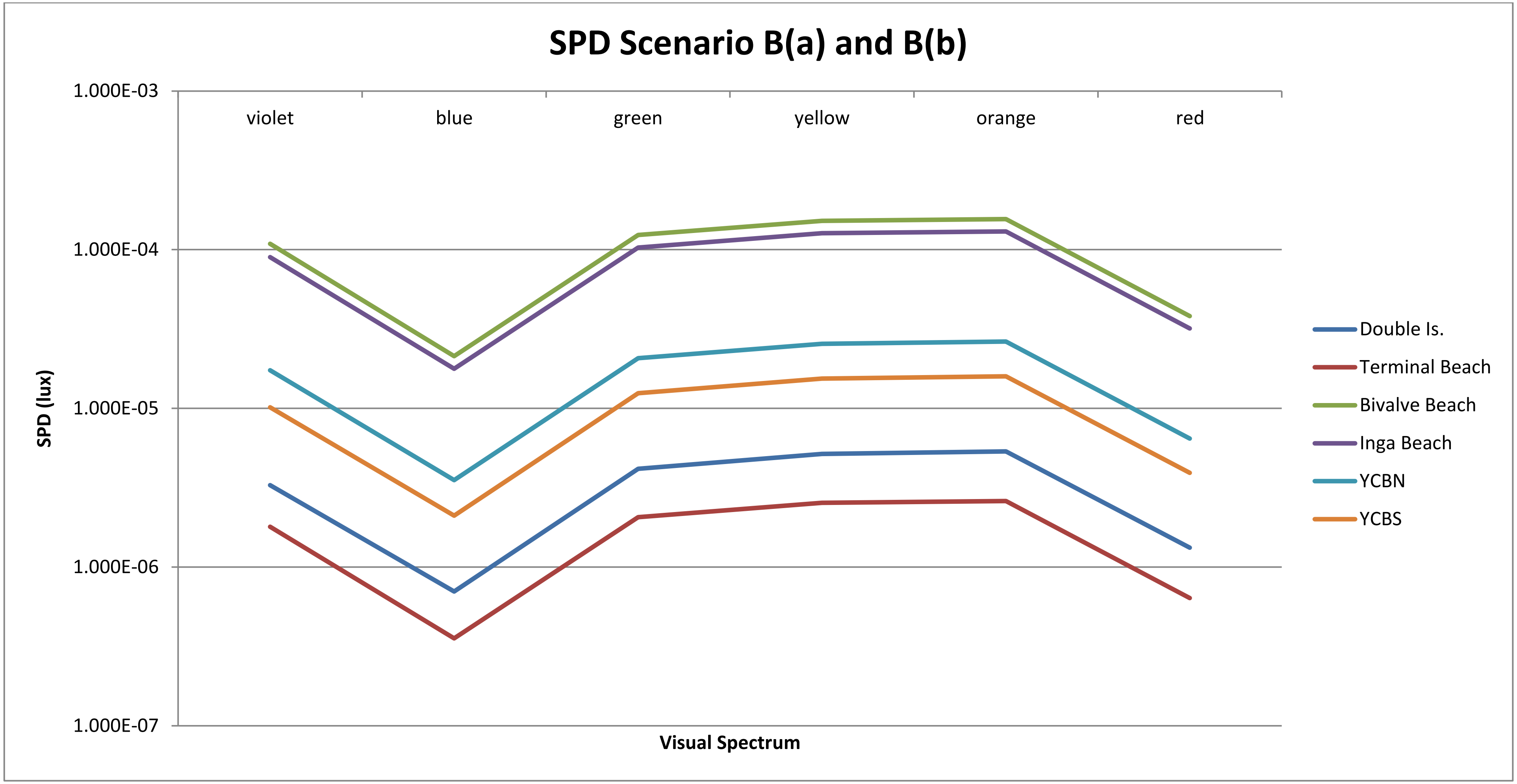


Chart C-8 SPD Scenario B (a) and B(b) (150 lux average illumination)

Appendix C - Spectral Power Distribution

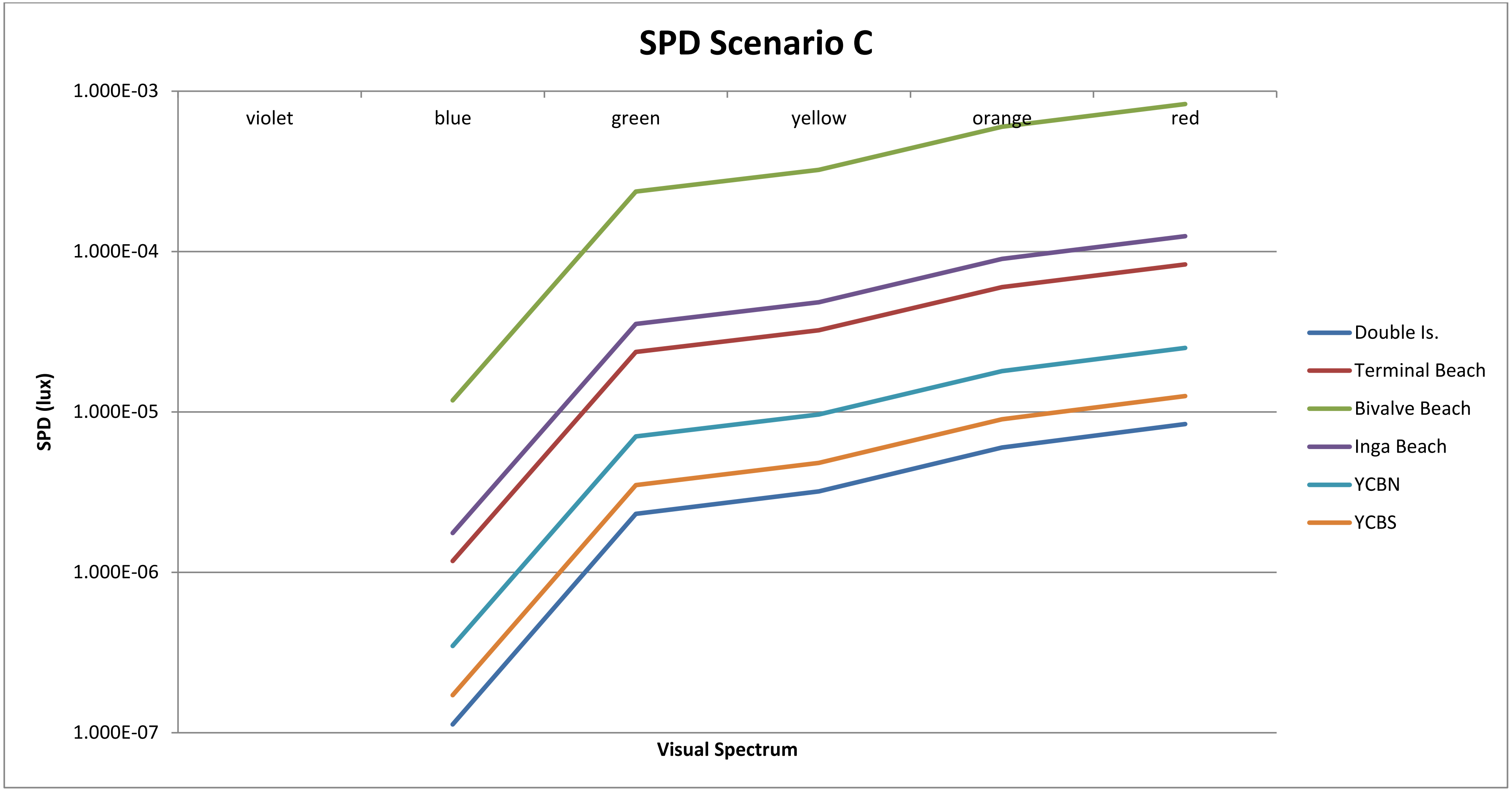


Chart C-9 SPD Scenario C (150 lux average illumination)

Appendix C - Spectral Power Distribution

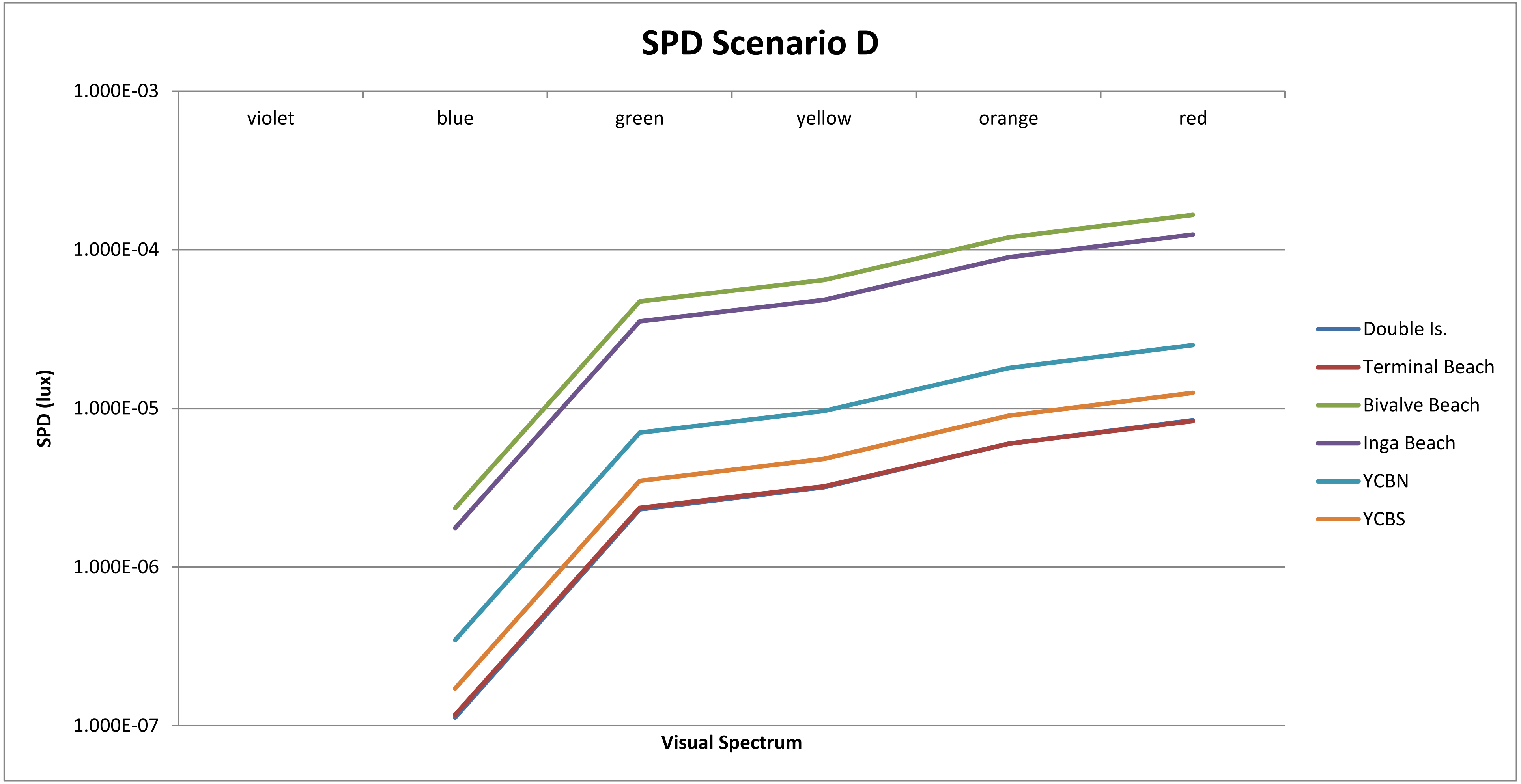


Chart C-10 SPD Scenario D (150 lux average illumination)

Appendix C - Spectral Power Distribution

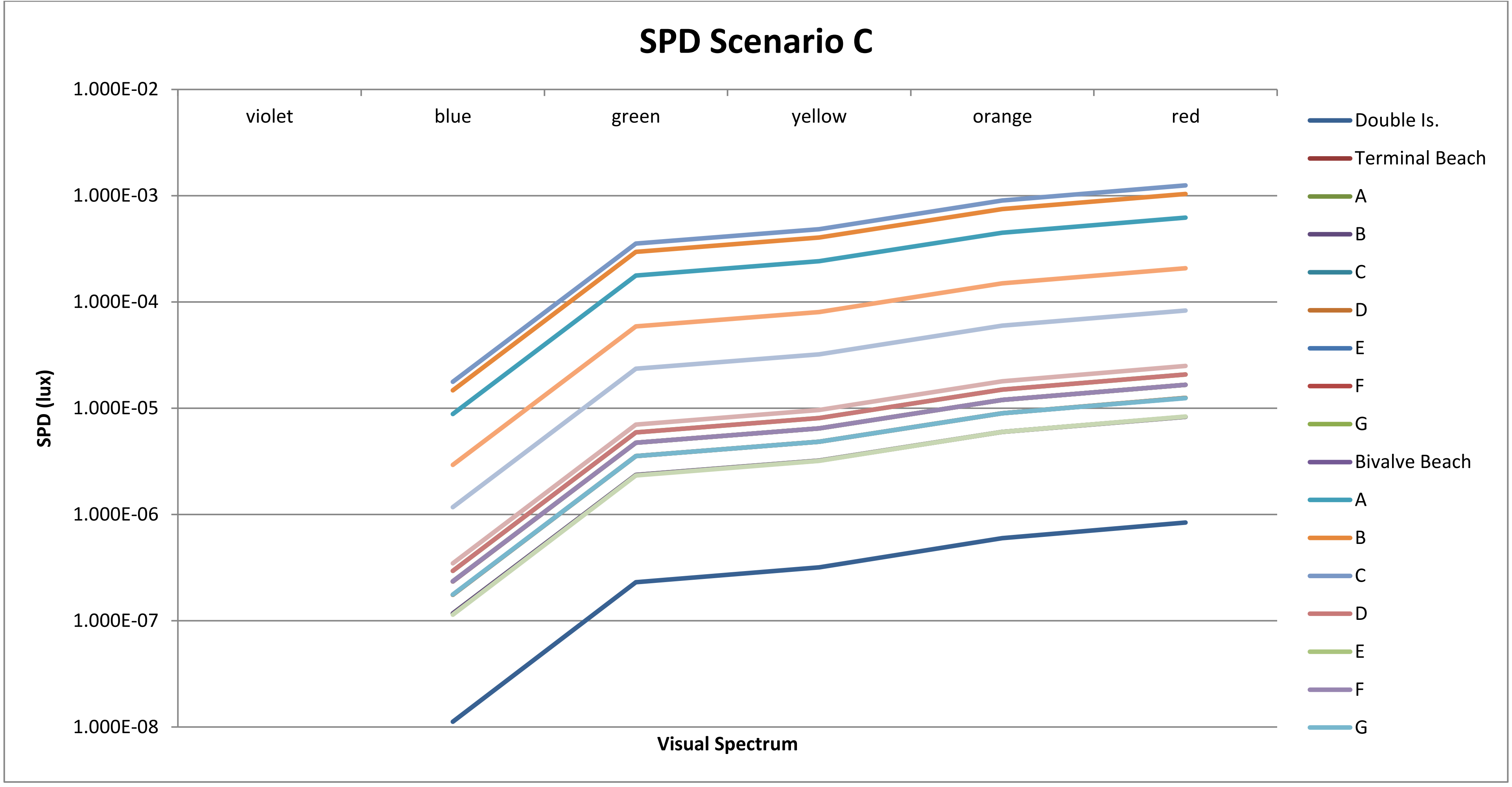


Chart C-11 SPD Scenario C (150 lux average illumination) – Worst Case Scenario

Appendix D Light Theory

Light emissions are electromagnetic (EM) radiation capable of producing a visual sensation. EM radiation consists of photons (packets of energy) that may be high energy-short wavelength (high frequency) and/ or low energy-long wavelength (low frequency). Depending upon the source of the EM emission, the wave may or may not contain photons in the visible spectrum (refer Plate D-1[10]).

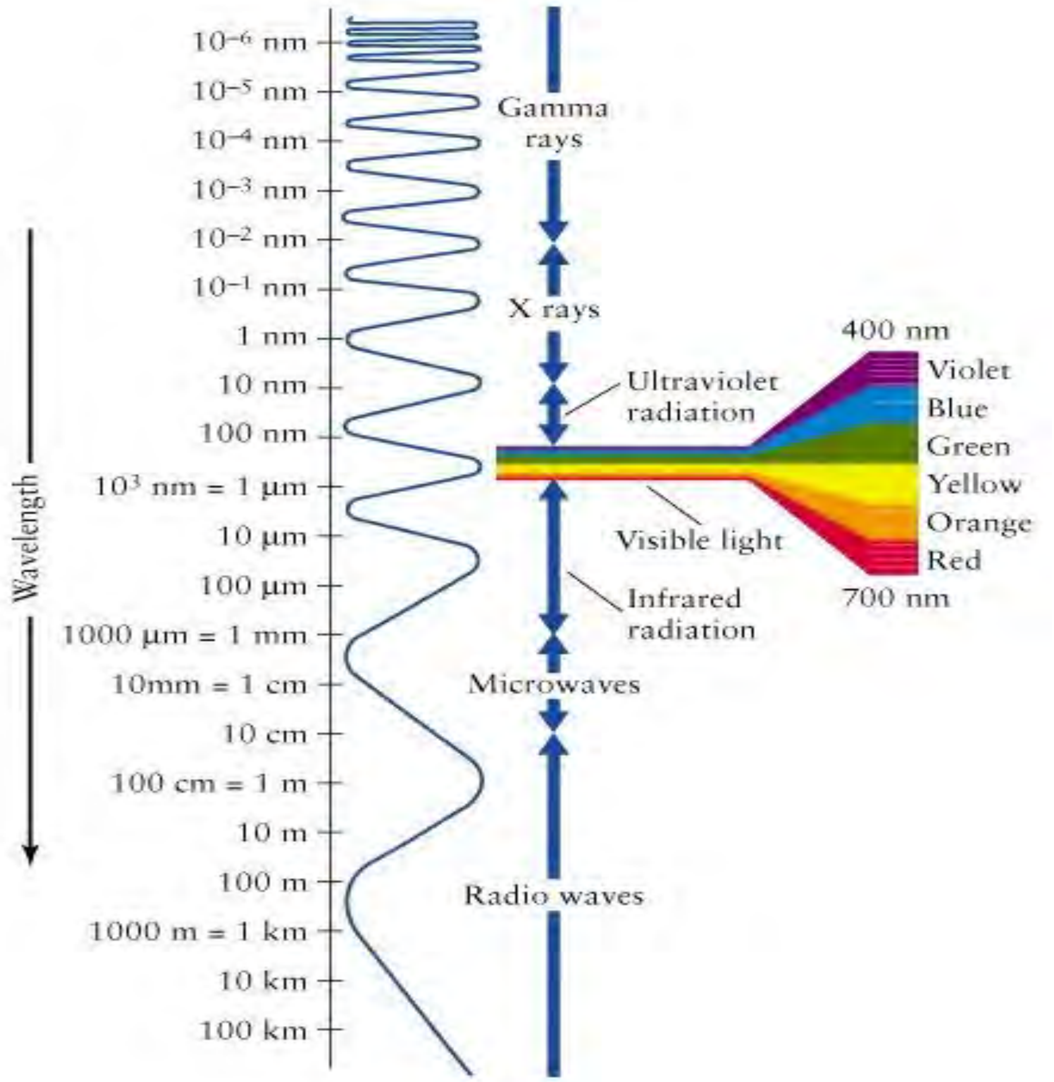


Plate D-1 Wavelengths of Electromagnetic Radiation

The visible spectrum consists of EM radiation with wavelengths greater than 3.8 x 10^{-7} metres (ultra-violet) and less than 7.0 x 10^{-7} metres (infra-red), as described in Table D-1.

Table D-1 Visible Light Spectrum

Wavelength λ – nm	<370	370-455	455-492	492-577	577-597	597-622	622-730	>730
Perceived Colour	ultraviolet	Violet	Blue	Green	yellow	Orange	Red	infra-red

[10] http://eosweb.larc.nasa.gov/EDDOCS/Wavelengths_for_Colors.html

Appendix D - Light Theory

D.1 Photometric Units

The terminology and units used in understanding light are shown in Table Appendix D-2. Although the physical light intensity is measured in radiometric units, its human perception is measured in photometric units.

Table Appendix D-2 Terms and Units

Quality		Unit
Luminous flux		Lumen (lm)
Luminous intensity		Candela (cd = lm/sr)
Luminance		cd/m^2 or millilambert (mL = 10/π cd/m^2)
Illuminance	General	Lux (lm/m^2)
	Retinal	Troland (cd/m^2 per mm^2 pupil area

D.2 Sensation of Brightness[11]

The human eye can respond to a large (up to ten orders of magnitude) range of light intensity. The eye brightness change (ΔI) response is not linear, proportional to the light input, but is proportional to the initial intensity (I_o) level. The brightness response changes for both of the eye's photoreceptors – rods (low light intensity response) and cones (bright-light response) and is reasonably accurately depicted in Plate D-2.

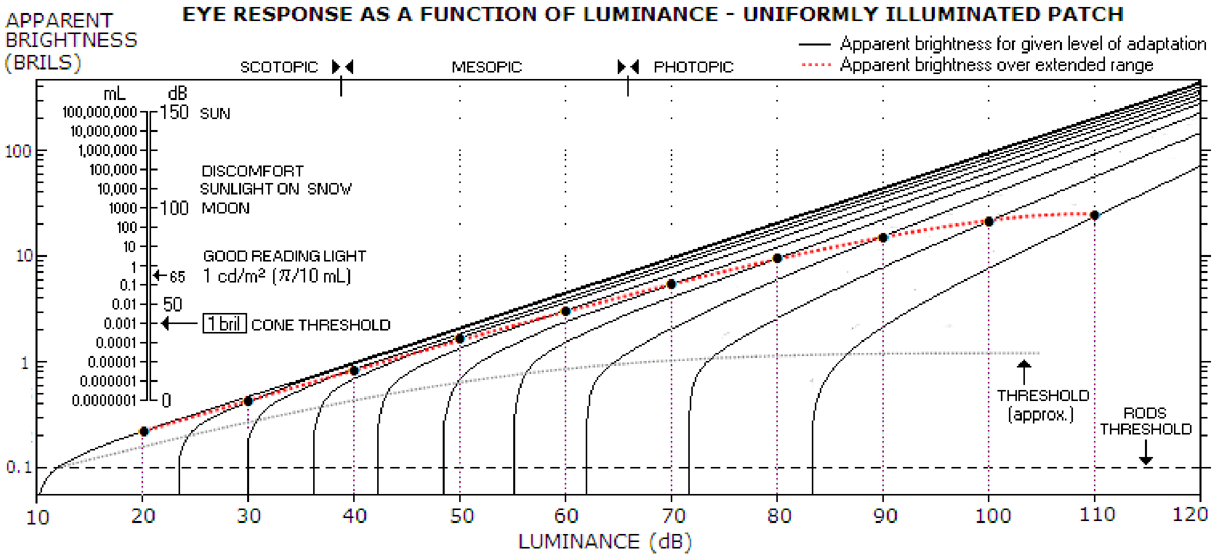


Plate D-2 Eye Brightness Response over Range of Intensities

Plate D-2 shows the human eye brightness response over the range of intensities, from the photopic threshold to the level of discomfort (based on *Brightness function: Effects of adaptation*, Stevens and Stevens, 1963). Luminance is given in decibels (dB), with 0 dB set at 10^{-7} millilamberts (mL), or 0.31

[11] www.telescope-Optics.net/eye light-intensity response.htm

Appendix D - Light Theory

μcd/m^2 (since the value in decibels is given by 10log(I/I_t), where **I** is some arbitrary intensity equal to or larger than the threshold intensity **I_t** (any 10 dB differential implies a 10-fold change in intensity or, for **x** as the dB differential, the corresponding intensities ratio is $10^{0.1x}$). Apparent brightness is given in brils (*bril* is a unit of psychological scale introduced by S.S. Stevens, defined as apparent brightness resulting from a 5-degree white patch of 40dB – equal to 0.001mL, or 0.000314 cd/m^2 - luminance seen by dark-adapted eye in a brief exposure). Each individual plot is a form of **$B=k(I-I_t)^a$** power function - so logB=alog(I-I_t)+logk) - with the constants **k** and **a** varying with the change in luminance, so that the curve fits experimental data for given level of adaptation (i.e. luminance level). Adding threshold intensity **I_t** to the power function results in the straight line of a power function plot on a log-log graph quickly turning down when approaching the threshold level. As the luminance increases, the intercept **k** decreases (from 10 at fully dark-adapted eye), resulting in lowering of the straight portion of the plot; at the same time, the exponent **a** increases, resulting in steeper slope of the straight portion (from 0.33 near the rods threshold, to 0.44 for 84 dB threshold. While a sufficient change in luminance intensity inevitably causes a shift in the adaptation level, with the corresponding change in the threshold level, the plate suggests that any given luminous intensity will appear brighter the lower the level of initial adaptation, but the rate of increase in apparent brightness, with the intensity, is higher for a higher level of adaptation. Interpolating through the points of apparent brightness, for each adaptation level plot, forms a non-power curve that describes eye brightness response over an extended range of luminous intensities (dotted red).

The main three modes of eye function under different illuminance levels, **photopic** (bright light), **scotopic** (low light conditions) and **mesopic** (intermediary), result from the specific response of its photoreceptor cells, cones and rods. Their activity is specific to retinal illuminance level, which is determined by the brightness level of the object observed, as well as brightness of the background and surroundings.

Depending on their spectral sensitivity, cones belong to either **L** (long-wavelengths sensitive), **M** (mid-wavelengths sensitive) or **S** (short-wavelengths sensitive) cones. By combining their separate inputs, the brain creates colours. The illuminance level determines the level of activity of cones and rods, and with it main characteristics of human vision are shown in Plate D-3.

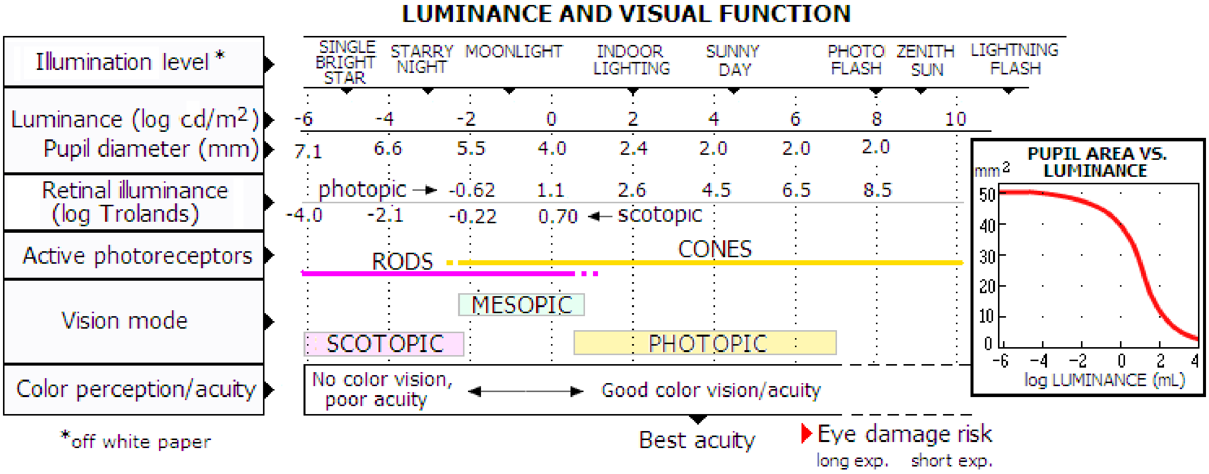


Plate D-3 Eye Spectral Response[12]

[12] www.telescope-optics.net/eye_spectral response.htm

Appendix D - Light Theory

Due to different modes of operation, size and distribution, cones and rods have different level of retinal illuminance for a given input: photopic (cone) retinal illuminance is proportional to a weighted sum of the photons absorbed by **L**- and **M**-cones, while for the scotopic (rod) illuminance is proportional to the number of photons absorbed by rods (based on Hood and Finkeistein, 1984).

Typical natural illuminance levels used in this assessment, to compare the modelled illuminance levels against, are presented in Table D-3[13].

Table D-3 Typical Natural Luminance Levels (lux)[14]

Illuminance lux (lm/m^2)	Example
10^{-4} lux	Moonless, overcast night sky
2×10^{-3} lux	Moonless clear night sky with airglow
10^{-2} lux	Quarter moon
2.7×10^{-1} lux	Full moon
1	Deep Twilight
10	Twilight
10^{2} lux	Very dark day
10^{3} lux	Overcast day
$1\text{-}2 \times 10^{4}$ lux	Full daylight (not direct sunlight)
$1\text{-}1.3 \times 10^{5}$ lux	Direct sunlight

D.1 Light and Distance

The illuminance (lux), from a point light source, spreads out uniformly in all directions such that, as you move away from the source, less light reaches you. The intensity, at a given distance from the light source, will be equal to the power output of the light source divided by the surface area of a sphere, through which the light has spread (refer Plate D-4[15]).

The amount of illumination received by a sensor (or eye) varies inversely with the square of the distance from the point source. So if the distance from a point source (R) is doubled, the intensity falls off by a factor of four. Tripling the distance decreases the intensity by a factor of nine, and so on. As the distance from a point source increases, the intensity of the light decreases at a rate inversely proportional to R^2.

D.1.1 Attenuation of Light

Light travelling through the atmosphere and striking objects is attenuated (diminished) through reflection, scattering and absorption. Atmospheric aerosols scatter and absorb light radiation, depending upon their size and chemical composition. Incident light striking objects is both reflected and absorbed. In this report reflectance is assumed to be diffuse (Lambertian).

[13] Austin, R.H et al, A method for calculating moonlight illuminance at the earth's surface
[14] W.E.K. Middleton, Vision Through The Atmosphere (1952)
[15] http://www.pasco.com/file_downloads/experiments/pdf-files/glx/physics/34-Inverse-square-SV.pdf

Appendix D - Light Theory

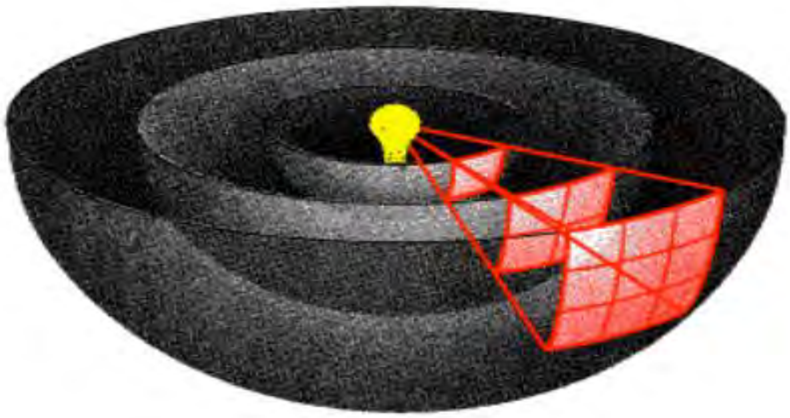


Plate D-4 Correlation between Light Intensity and Distance

D.2 Light Pollution

Light pollution, also known as photo-pollution or luminous pollution, encompasses both excessive and misdirected artificial outdoor lighting[16]. Whilst the term "light pollution" has been in use for a number of years, in most circumstances it has referred to the degradation of human views of the night sky (hiding stars). Light pollution is defined as excessive and/or stray artificial light emitted from poorly designed and aimed lighting installations for advertising, business, security and street lighting[17].

D.3 Reflectivity of Materials

The albedo of a material is the ratio of the light reflected by the material to the total amount of light it receives, and is measured on a scale from zero (for no reflecting power, such as a perfectly black surface) to 1 (for perfect reflection, such as a mirror). Table D-4 provides the reflectance values for the materials used at the Gorgon Project.

Table D-4 Reflectance from Site Materials

Material Surface	Reflectance
Earth (dry)[18]	0.27
Concrete[19]	0.17
Blue metal (crushed stone)	0.22
Galvanised steel[20]	0.70

The reflectance of each wavelength, within the SPD of the materials listed in Table D-4, is presented in Table D-5.

[16] An Introduction to Light Pollution, Hans Vanderknyff
[17] Light Pollution: Definition, legislation, measurement, modelling and environmental effects
[18] http://www.lehighcement.com/Education/PDFs/Solar%20(Albedo%20from%20M.%20VanGeem)%200910021.pdf
[19] http://www.lehighcement.com/Education/PDFs/Solar%20(Albedo%20from%20M.%20VanGeem)%200910021.pdf
[20] http://www.atmos.washington.edu/~earth/earth1/Climate_Sensitivity.pdf

Appendix D - Light Theory

For light modelling purposes, the materials used in the Gorgon Project, as shown in Table D-4 have been used to determine the reflectance and the change in SPD for light emitted from infrastructure light sources.

The data in Table D-5 indicates that materials such as soil (dry), crushed stone and concrete tend to absorb high energy wavelengths (< 550 nm) and reflect low energy wavelengths, changing the SPD towards the red end of the spectrum. Materials such as galvanised steel tend to reflect incident light evenly across the spectrum, resulting in a spectrum that remains consistent with the incident light.

Table D-5 Reflected Wavelengths (Spectral Power Distribution) from On-site Materials

Wavelength (nm)	400	450	500	550	600	650	700
Soil (dry)	15%	18%	20%	23%	25%	27%	29%
Crushed stone	12%	14%	16%	19%	23%	24%	25%
Galvanised steel	72%	73%	75%	75%	75%	73%	72%
Concrete	12%	14%	16%	17%	19%	19%	20%

Appendix E Reflected Light Attenuation

Illuminance (E) arising from normal lighting (Scenario A), task lighting on LNG Train #4 (Scenario B) and task lighting on the General Utilities Area (Scenario D) are subject to attenuation due to primary, diffuse reflection from surfaces with low albedos (reflectance) and the distance travelled through the atmosphere. The highest albedo (α) is for white paint on the LNG storage tanks (0.9), diminishing to galvanised steel (0.7), dry soil (0.27) and clean concrete (0.17). Luminance (L) from these surfaces is also subject to secondary interception and attenuation in the atmosphere. The primary reflection of light from infrastructure with an elevation of 45 m AHD, and a beam angle of 124 degrees (shielded fluoro) within the Gorgon Project is shown in Figure E-1 below:

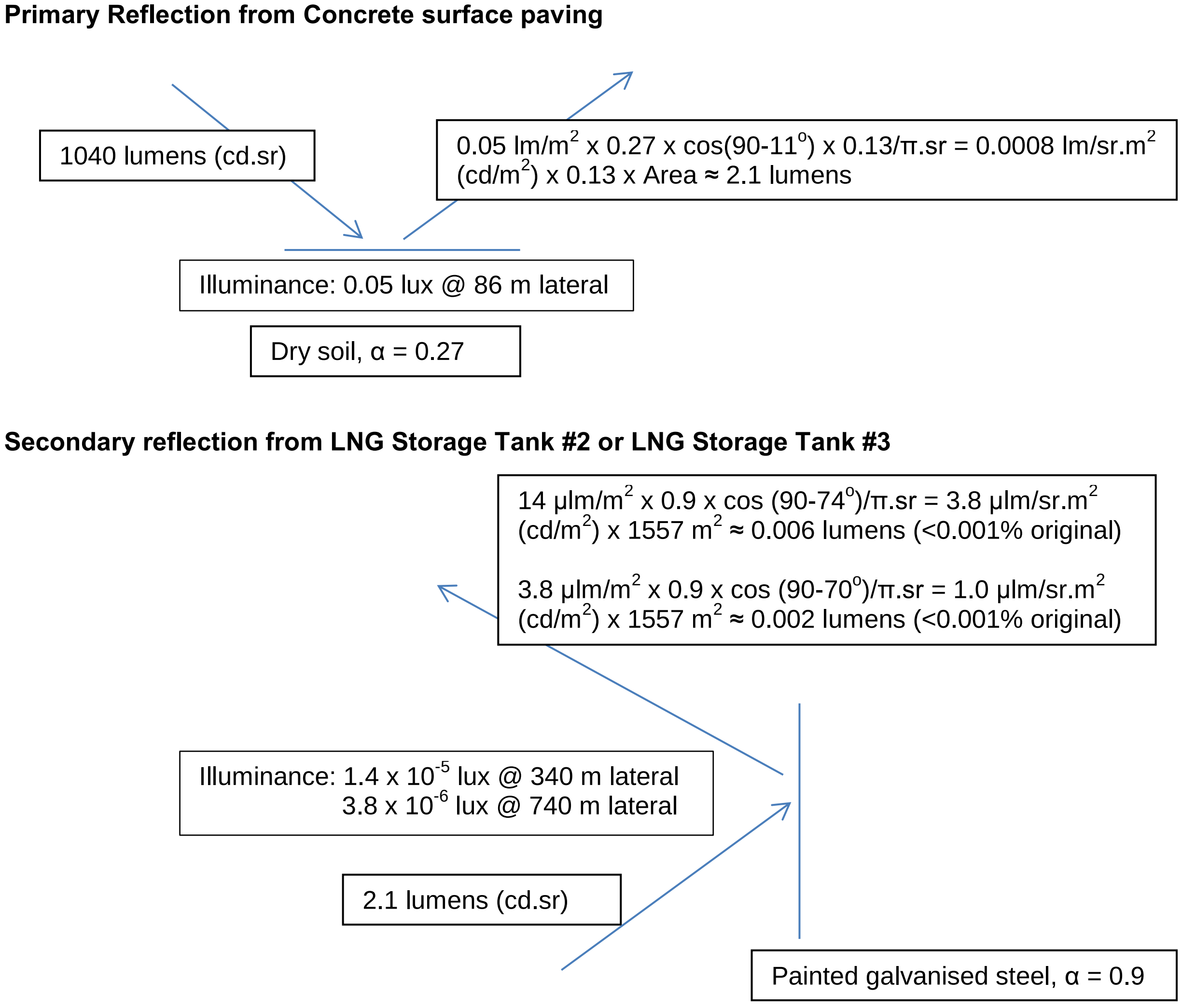


Figure E-1 Example Attenuation of Reflected Light

Light spill from LNG Train #4 that reflects from dry earth may travel a lateral distance of 340 metres before intercepting LNG Storage Tank #2 or 740 metres before intercepting LNG Storage Tank #3. Reflected light from the white painted storage tank (albedo ~ 0.9) will be approximately 6×10^{-3} lumens. This light would travel a minimum lateral distance of 580 metres to Bivalve Beach (Location C) and 1000 metres to Terminal Beach (Location G). Light intensity will have diminished to less than 10^{-9} lux at Bivalve Beach and less than 5×10^{-10} lux at Terminal Beach.

Appendix E - Reflected Light Attenuation

Light spill from LNG Train #4 that reflects from dry earth may travel a lateral distance of 740 metres before intercepting LNG Storage Tank #3, located north of the Condensate Storage tanks. Reflected light from the white painted storage tank (albedo ~ 0.9) will be approximately 2×10^{-3} lumens. This light would travel a minimum lateral distance of 400 metres to Bivalve Beach (Location A) and 650 metres to Terminal Beach (Location G). Light intensity will have diminished to less than 10^{-9} lux at Bivalve Beach and less than 5×10^{-9} lux at Terminal Beach.

Appendix F FTP Model Outputs

Appendix F - FTP Model Outputs

Figure F-1 Option A - Normal Operations (Illumination @ 20 Lux Average)

Coordinate System: GDA 1994 MGA Zone 50

Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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GORGON LIGHT EMISSIONS STUDY

OPTION A - NORMAL OPERATIONS (ILLUMINATION @ 20 LUX AVERAGE)

URS

FOURTH TRAIN PROPOSAL

File No: 42908243-ES-106_RC.mxd   Drawn: RNM   Approved: MW   Date: 20/05/2013

Figure: F-1   Rev. C   A3

Appendix F - FTP Model Outputs

Figure F-2 Option B(a)(i) – Single Train Maintenance (Task Illumination @ 50 Lux Average)

Coordinate System: GDA 1994 MGA Zone 50

Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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GORGON LIGHT EMISSIONS STUDY

OPTION B(a)(i) – SINGLE TRAIN MAINTENANCE (TASK ILLUMINATION @ 50 LUX AVERAGE)

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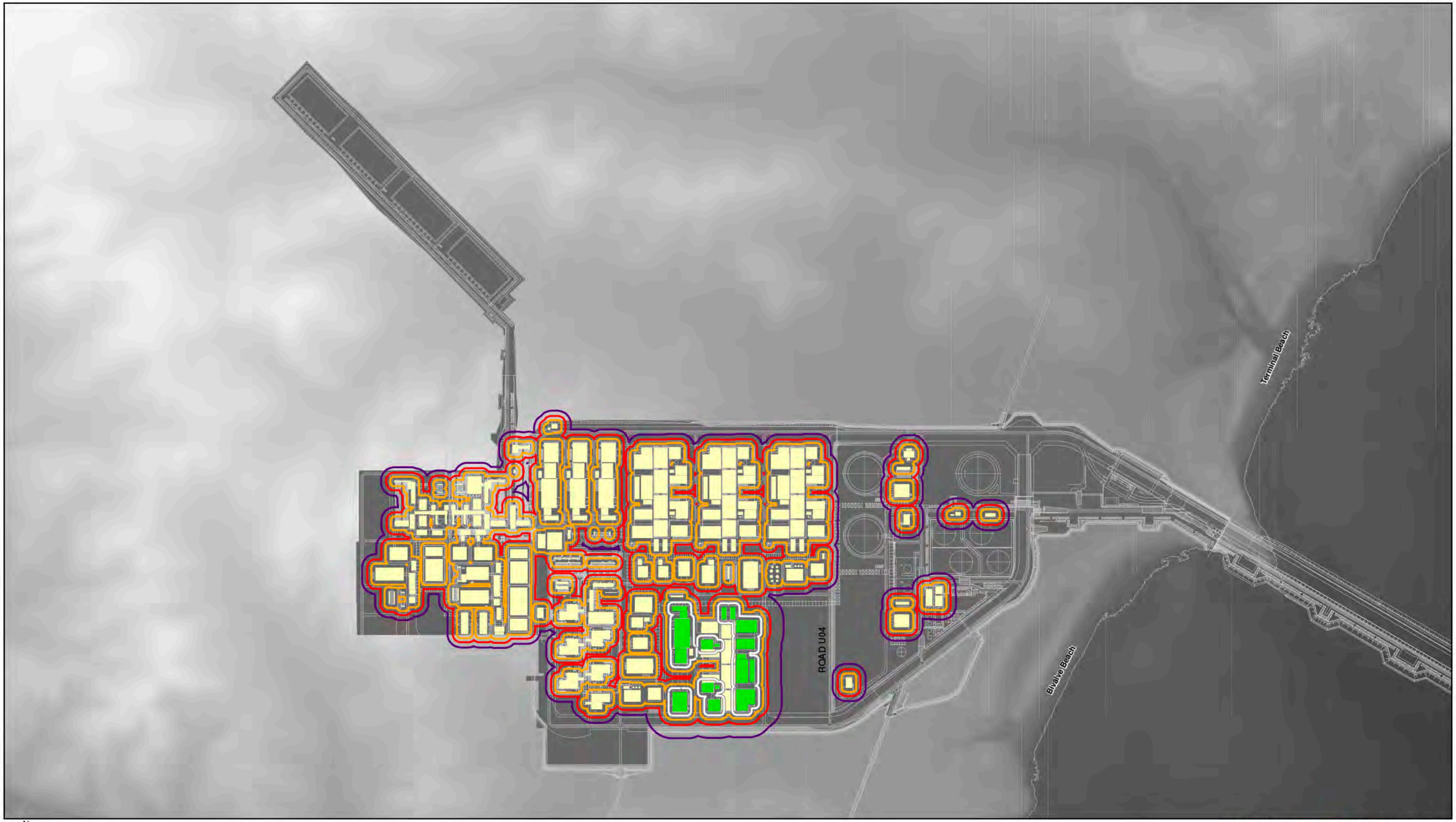
File No: 42908243-ES-107_RC.mxd | Drawn: RNM | Approved: MW | Date: 20/05/2013

Figure: F-2 | Rev. C | A3

Appendix F - FTP Model Outputs

Figure F-3 Option B(a)(ii) – Single Train Maintenance (Task Illumination @ 100 Lux Average)



Coordinate System: GDA 1994 MGA Zone 50

Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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GORGON LIGHT EMISSIONS STUDY

OPTION B(a)(ii) - SINGLE TRAIN MAINTENANCE (TASK ILLUMINATION @ 100 LUX AVERAGE)

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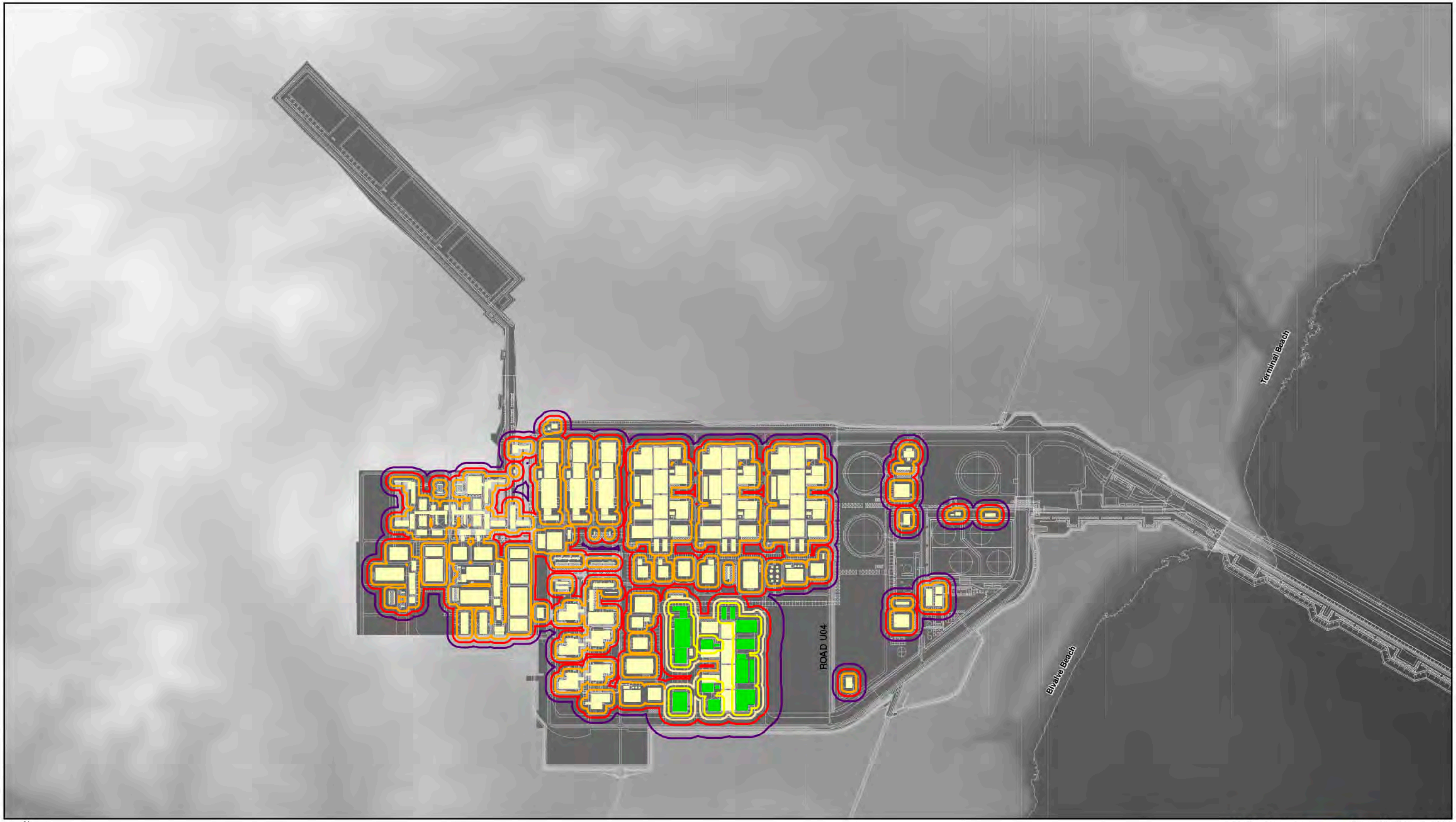
FOURTH TRAIN PROPOSAL

File No: 42908243-ES-108_RC.mxd | Drawn: RNM | Approved: MW | Date: 20/05/2013

Figure: F-3 | Rev. C | A3

Appendix F - FTP Model Outputs

Figure F-4 Option B(a)(iii) – Single Train Maintenance (Task Illumination @ 150 Lux Average)



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Scale at A3: 1:10,000

0 100 200 300 400 Meters

Coordinate System: GDA 1994 MGA Zone 50

Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

Isolux Contours

- 1×10^{-3}
- 2×10^{-2}
- 3×10^{-1}
- 1×10^{0}
- 2×10^{0}

Normal Lighting is 'ON'
Task Lighting is 'ON'
Infrastructure

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GORGON LIGHT EMISSIONS STUDY

**OPTION B(a)(iii) -
SINGLE TRAIN MAINTENANCE
(TASK ILLUMINATION @ 150 LUX AVERAGE)**

URS

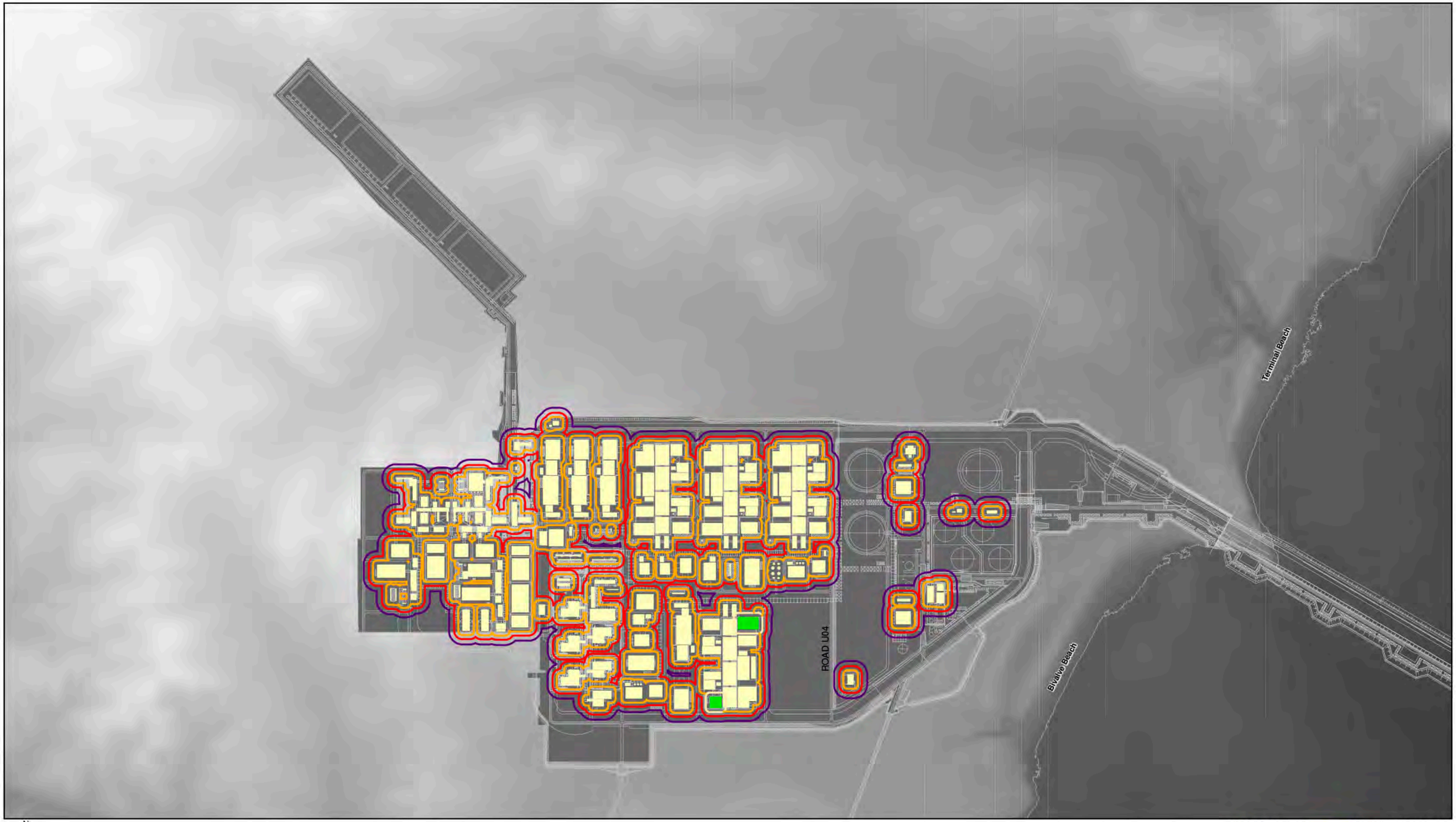
FOURTH TRAIN PROPOSAL

Figure: **F-4**

File No: 42908243-ES-109_RC.mxd Drawn: RNM Approved: MW Date: 20/05/2013 Rev. C A3

Appendix F - FTP Model Outputs

Figure F-5 Option B(b)(i) – Single Train Maintenance (2 x Task Areas Illuminated @ 50 Lux Average)



Coordinate System: GDA 1994 MGA Zone 50

Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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GORGON LIGHT EMISSIONS STUDY

OPTION B(b)(i) – OPTION SINGLE TRAIN MAINTENANCE (2 X TASK AREAS ILLUMINATED @ 50 LUX AVERAGE)

URS

FOURTH TRAIN PROPOSAL

Figure: F-5

File No: 42908243-ES-110_RC.mxd Drawn: RNM Approved: MW Date: 20/05/2013 Rev. C A3

Appendix F - FTP Model Outputs

Figure F-6 Option B(b)(ii) – Single Train Maintenance (2 x Task Areas Illuminated @ 100 Lux Average)

Coordinate System: GDA 1994 MGA Zone 50
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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GORGON LIGHT EMISSIONS STUDY

OPTION B(b)(ii) - SINGLE TRAIN MAINTENANCE (2 X TASK AREAS ILLUMINATED @ 100 LUX AVERAGE)

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FOURTH TRAIN PROPOSAL

Figure: F-6

File No: 42908243-ES-111_RC.mxd | Drawn: RNM | Approved: MW | Date: 21/05/2013 | Rev. C | A3

Appendix F - FTP Model Outputs

Figure F-7 Option B(b)(iii) – Single Train Maintenance (2 x Task Areas Illuminated @ 150 Lux Average)

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Scale at A3: 1:10,000

0 100 200 300 400 Meters

Coordinate System: GDA 1994 MGA Zone 50

Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

Isolux Contours

- $1x10^{-3}$
- $2x10^{-2}$
- $3x10^{-1}$
- $1x10^{0}$
- $2x10^{0}$

- Normal Lighting is 'ON'
- Task Lighting is 'ON'
- Infrastructure

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GORGON LIGHT EMISSIONS STUDY

OPTION B(b)(iii) - SINGLE TRAIN MAINTENANCE (2 X TASK AREAS ILLUMINATED @ 150 LUX AVERAGE)

URS

FOURTH TRAIN PROPOSAL

Figure: F-7

File No: 42908243-ES-112_RC.mxd Drawn: RNM Approved: MW Date: 20/05/2013 Rev. C A3

Appendix F - FTP Model Outputs

Figure F-8 Option C(i) – LNG Storage Tank Rooftop Maintenance (Illumination @ 50 Lux Average)

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Scale at A3: 1:10,000
0 100 200 300 400 Meters

Isolux Contours
- $1x10^{-3}$
- $2x10^{-2}$
- $3x10^{-1}$
- $7x10^{-1}$

- Normal Lighting is 'ON'
- Task Lighting is 'ON'
- Infrastructure

Coordinate System: GDA 1994 MGA Zone 50
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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GORGON LIGHT EMISSIONS STUDY

OPTION C(i) - LNG STORAGE TANK ROOFTOP MAINTENANCE (ILLUMINATION @ 50 LUX AVERAGE)

URS

FOURTH TRAIN PROPOSAL

Figure: F-8

File No: 42908243-ES-127.mxd Drawn: RNM Approved: MW Date: 21/05/2013 Rev. A A3

Appendix F - FTP Model Outputs

Figure F-9 Option C(ii) – LNG Storage Tank Rooftop Maintenance (Illumination @ 100 Lux Average)

Coordinate System: GDA 1994 MGA Zone 50

Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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GORGON LIGHT EMISSIONS STUDY

OPTION C(ii) - LNG STORAGE TANK ROOFTOP MAINTENANCE (ILLUMINATION @ 100 LUX AVERAGE)

URS

FOURTH TRAIN PROPOSAL

File No: 42908243-ES-128.mxd Drawn: RNM Approved: MW Date: 21/05/2013

Figure: F-9

Rev. A A3

Appendix F - FTP Model Outputs

Figure F-10 Option C(iii) – LNG Storage Tank Rooftop Maintenance (Illumination @ 150 Lux Average)

Scale at A3: 1:10,000

0 100 200 300 400 Meters

Coordinate System: GDA 1994 MGA Zone 50

Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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GORGON LIGHT EMISSIONS STUDY

OPTION C(iii) - LNG STORAGE TANK ROOFTOP MAINTENANCE (ILLUMINATION @ 150 LUX AVERAGE)

URS

FOURTH TRAIN PROPOSAL

File No: 42908243-ES-129.mxd Drawn: RNM Approved: MW Date: 21/05/2013

Figure: **F-10**

Rev. A A3

Appendix F - FTP Model Outputs

Figure F-11 Option D(i) – Maintenance Works in General utilities Area (Illumination@ 50 Lux Average)

Coordinate System: GDA 1994 MGA Zone 50

Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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GORGON LIGHT EMISSIONS STUDY

OPTION D(i) - MAINTENANCE WORKS IN GENERAL UTILITIES AREA (ILLUMINATION @ 50 LUX AVERAGE)

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FOURTH TRAIN PROPOSAL

Figure: F-11

File No: 42908243-ES-116_RC.mxd Drawn: RNM Approved: MW Date: 20/05/2013

Rev. C A3

Appendix F - FTP Model Outputs

Figure F-12 Option D(ii) – Maintenance Works in General utilities Area (Illumination@ 100 Lux Average)

Coordinate System: GDA 1994 MGA Zone 50
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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GORGON LIGHT EMISSIONS STUDY

OPTION D(ii) - MAINTENANCE WORKS IN GENERAL UTILITIES AREA (ILLUMINATION @ 100 LUX AVERAGE)

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FOURTH TRAIN PROPOSAL

File No: 42908243-ES-117_RC.mxd Drawn: RNM Approved: VW Date: 20/05/2013

Figure: F-12

Rev. C A3

Appendix F - FTP Model Outputs

Figure F-13 Option D(iii) – Maintenance Works in General utilities Area (Illumination@ 150 Lux Average)

Scale at A3: 1:10,000
0 100 200 300 400 Meters

Coordinate System: GDA 1994 MGA Zone 50
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

Isolux Contours
- $1x10^{-3}$
- $2x10^{-2}$
- $3x10^{-1}$
- $1x10^{0}$
- $2x10^{0}$

Normal Lighting is 'ON'
Task Lighting is 'ON'
Infrastructure

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GORGON LIGHT EMISSIONS STUDY

OPTION D(iii) - MAINTENANCE WORKS IN GENERAL UTILITIES AREA (ILLUMINATION @ 150 LUX AVERAGE)

URS

FOURTH TRAIN PROPOSAL

Figure: F-13

File No: 42908243-ES-118_RC.mxd Drawn: RNM Approved: MW Date: 20/05/2013 Rev. C A3

Appendix G Additional Investigation

Due to the proximity of the LNG Storage Tank #3 to both Terminal and Bivalve Beaches, these two SERLs have been investigated in greater detail than the other SERLs, during the modeling of Scenario C. In order to achieve this, the beaches have been subdivided into smaller transects (refer to Figure G-1 and Figure G-2 for transect details) to more accurately model the impact of light spill at these locations resulting from changes in coastline topography. The results of the light spill modelling are discussed in terms of illuminance levels at each of these segmented locations.

The MGA Zone 50 coordinates for the identified potentially sensitive environmental receptor locations at Bivalve Beach and Terminal Beach, and their distance to the LNG Storage Tank #3 are shown in Table G-1.

Table G-1 Bivalve Beach and Terminal Beach Distances from LNG Storage Tank #3

Bivalve Beach			Terminal Beach		
Beach Length (m)	Easting	Northing	Beach Length (m)	Easting	Northing
779	339 617	7 700 071	582	340 261	7 701 056
From Shoreline @	Distance to Light Source (m)		From Shoreline @	Distance to Light Source (m)	
Location A	584		Location A	1,112	
Location B	540		Location B	1,013	
Location C	532		Location C	936	
Location D	556		Location D	883	
Location E	615		Location E	820	
Location F	674		Location F	765	
Location G	745		Location G	741	
Location H	865		-	-	

8.1.1 Option C – LNG Tank #3, Rooftop Maintenance

Figure G-3 to Figure G-5 show all four (4) LNG trains and associated facilities illuminated under normal lighting conditions. LNG Storage Tank #3 has rooftop task lighting switched 'ON' to undertake maintenance works. The scenario has been modelled for the three task illumination intensities, i.e. 50 lux, 100 lux and 150 lux (average).

8.1.1.1 Intensity

Light modelling for Scenario C worst case, predicts that light spill will directly illuminate the northern and southern end of Bivalve Beach (Locations A, B, C and H), Inga Beach, Yacht Club Beach (South) and Double Island, when task lighting is switched 'ON' for maintenance works. Indirect illumination of the SERLs will also occur due to atmospheric scattering of reflected light. The light spill intensity is presented in Table G-2.

Due to the location of LNG Storage Tank #3, when task lighting averages 150 lux, the direct light spill, incident upon Inga Beach, is predicted to have an intensity of less than 2×10^{-4} lux.

Appendix G - Additional Investigation

There is no direct, lateral light spill onto Terminal Beach. Illuminance, resulting from atmospheric scattering of light, is predicted to have an intensity of less than 2.0 x 10^{-4} lux, after reflectance from surface finishes.

Direct, lateral light spill onto Bivalve Beach at:

- Location A is predicted to have an intensity of less than 15 x 10^{-4} lux;
- Location B is predicted to have an intensity of less than 25 x 10-4 lux;
- Location C is predicted to have an intensity of less than 30 x 10^{-4} lux; and
- Location H is predicted to have an intensity of less than 0.5 x 10^{-4} lux.

Indirect, lateral light spill intensity, resulting from atmospheric scattering of light, at the other locations on Bivalve Beach is predicted to be less than 0.5 x 10^{-4} lux after reflectance from surface finishes.

Task lighting is directly visible from the shoreline at Yacht Club Beach (South) at a predicted intensity less than 0.2 x 10^{-4} lux, and from the southern beach at Double Island at a predicted intensity of less than 0.02 x 10^{-4} lux Task lighting is not visible from the base of the sand dunes at Yacht Club Beach (North and South).

Table G-2 LNG Tank #3 Rooftop Maintenance Model Outputs (Light Spill) for Terminal and Bivalve Beaches[21]

Location	Bivalve Beach	Terminal Beach
	x 10^{-4} lux	
A	< 15	< 0.2
B	< 25	< 0.2
C	< 30	< 0.3
D	< 0.5	< 0.3
E	< 0.4	< 0.4
F	< 0.4	< 0.4
G	< 0.3	< 0.5
H	< 5.0	-

NOTE: 500 x 10^{-4} lux is the equivalent illuminance intensity of a Quarter moon, with airglow (refer Table D-3)

10 x 10^{-4} lux is the equivalent illuminance intensity of a moonless clear night sky, with airglow (refer Table D-3).

1 x 10^{-4} lux is the equivalent illuminance intensity of a moonless, overcast night sky (refer Table D-3).

8.1.1.2 Wavelength Power Distribution

The SPD (filtered) for light spill visible at the potential SERLs, are shown in Appendix C, Chart C-9. Direct illumination from source has a slight red bias, with illuminance of less than 12.5 x 10^{-4} lux for all individual wavelength (λ) intensities, and typically less than 0.2 x 10^{-4} lux. The typical cumulative intensity for λ < 560 nm is less than 0.05 x 10^{-4} lux, with a peak at 3.7 x 10^{-4} lux.

[21] See Figure G-1 **Error! Reference source not found.**and Figure G-2 for map of locations A through H

Appendix G - Additional Investigation

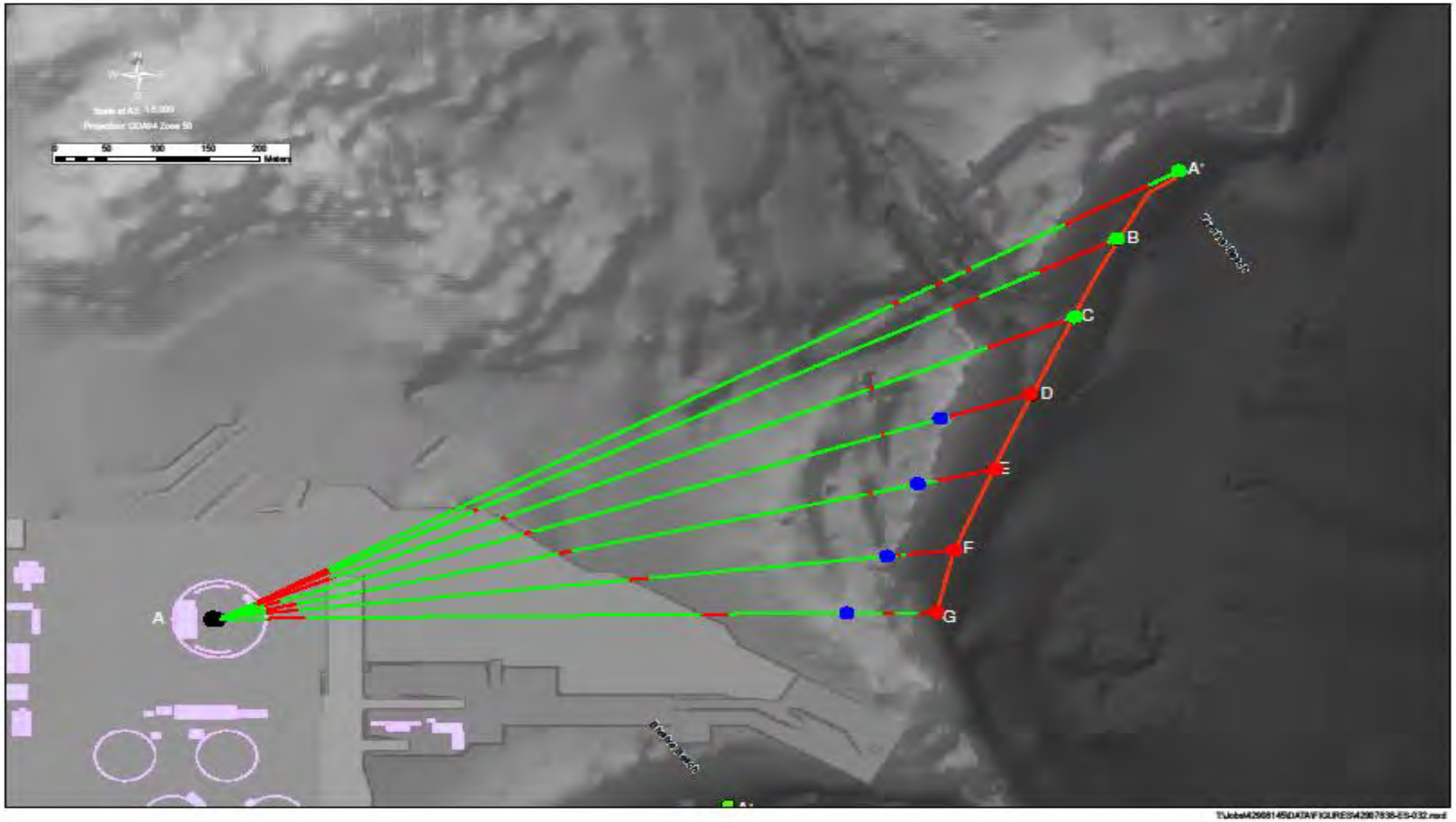

Figure G-1 Location of Modelled Transects to SERLs on Terminal Beach

Appendix G - Additional Investigation

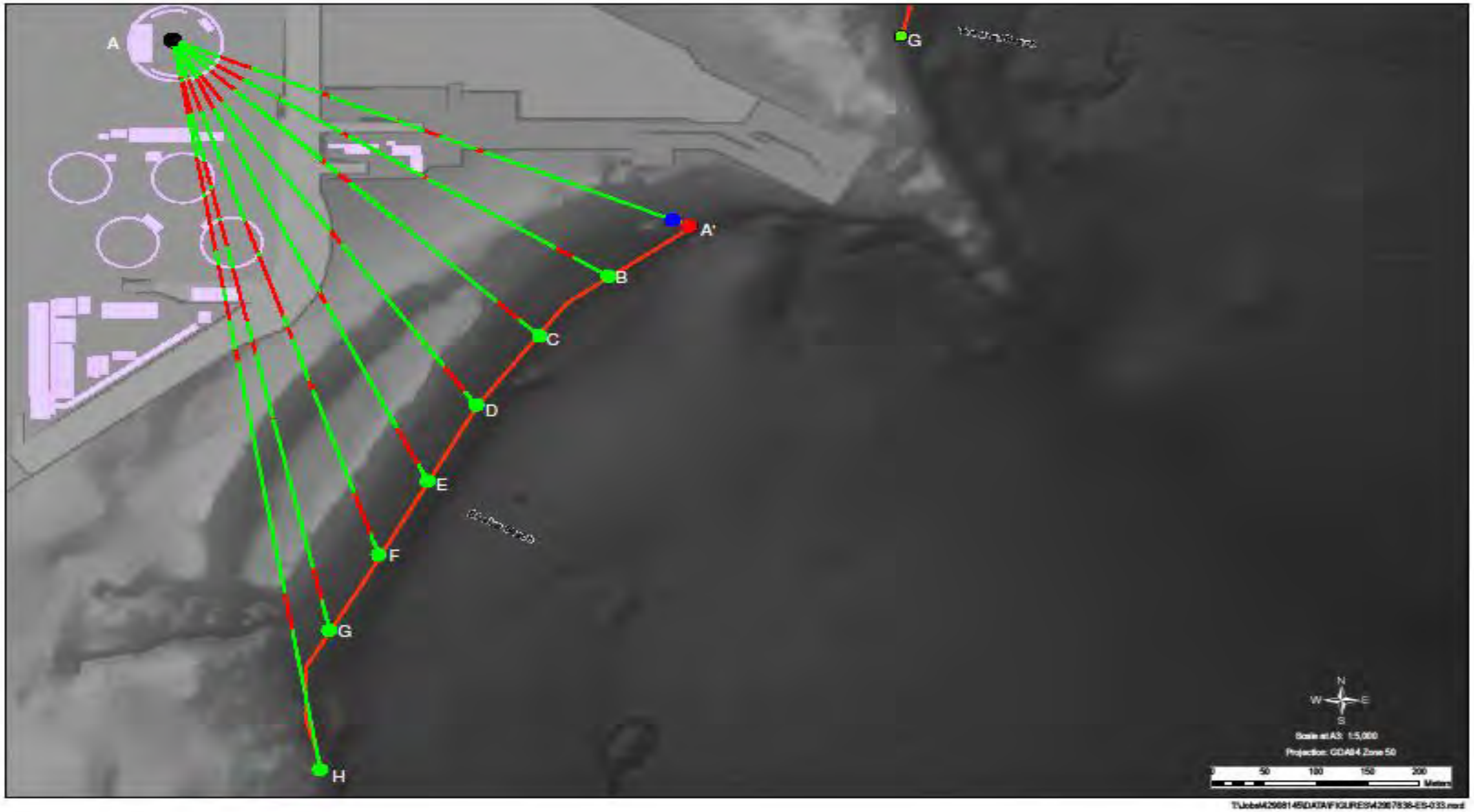

Figure G-2 Location of Modelled Transects to SERLs on Bivalve Beach

Appendix G - Additional Investigation

Figure G-3 Option C(i) Additional Investigation – LNG Storage Tank Rooftop Maintenance (Illumination @ 50 Lux Average)

Coordinate System: GDA 1994 MGA Zone 50

Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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GORGON LIGHT EMISSIONS STUDY

OPTION C(i) - LNG STORAGE TANK ROOFTOP MAINTENANCE (ILLUMINATION @ 50 LUX AVERAGE)

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FOURTH TRAIN PROPOSAL - ADDITIONAL INVESTIGATION SCENARIO

File No: 42908243-ES-113_RC.mxd Drawn: RNM Approved: MW Date: 20/05/2013

Figure: G-3

Rev. C A3

Appendix G - **Additional Investigation**

Figure G-4 Option C(ii) Additional investigation – LNG Storage Tank Rooftop Maintenance (Illumination @ 100 Lux Average)

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Scale at A3: 1:10,000

0 100 200 300 400 Meters

Coordinate System: GDA 1994 MGA Zone 50

Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

Isolux Contours

- 5×10^{-4}
- 1×10^{-3}
- 2×10^{-2}
- 3×10^{-1}
- 7×10^{-1}

- Normal Lighting is 'ON'
- Task Lighting is 'ON'
- Infrastructure

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GORGON LIGHT EMISSIONS STUDY

OPTION C(ii) - LNG STORAGE TANK ROOFTOP MAINTENANCE (ILLUMINATION @ 100 LUX AVERAGE)

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FOURTH TRAIN PROPOSAL - ADDITIONAL INVESTIGATION SCENARIO

Figure: G-4

File No: 42908243-ES-114_RC.mxd Drawn: RNM Approved: MW Date: 20/05/2013 Rev. C A3

Appendix G - Additional Investigation

Figure G-5 Option C(iii) Additional Investigation – LNG Storage Tank Rooftop Maintenance (Illumination @ 150 Lux Average)

Coordinate System: GDA 1994 MGA Zone 50

Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

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GORGON LIGHT EMISSIONS STUDY

OPTION C(iii) - LNG STORAGE TANK ROOFTOP MAINTENANCE (ILLUMINATION @ 150 LUX AVERAGE)

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FOURTH TRAIN PROPOSAL - ADDITIONAL INVESTIGATION SCENARIO

File No: 42908243-ES-115_RC.mxd Drawn: RNM Approved: MW Date: 21/05/2013

Figure: G-5 Rev. C A3

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Appendix D4: Cumulative Noise Impact Study for the Gorgon Expansion Project Barrow Island LNG Plant

CHEVRON AUSTRALIA PTY LTD

CUMULATIVE NOISE IMPACT STUDY

For The

GORGON EXPANSION PROJECT
BARROW ISLAND LNG PLANT

Document No.: G4-TE-H-0000-REPW002

Revision:	0	1	2	3
Prepared by:	D Nicholls	R Tipping	R Tipping	R Tipping
Reviewed by:	J Richards	J Richards	J Richards	J Richards
Approved by:	A Bunn	D Grist	D Grist	A Robertson
CVX Approved by:		C Richardson	C Richardson	C Richardson
Revision Date:	18/01/2012	23/03/2012	21/05/2012	7/11/2012
Issue Purpose:	IFI	IFI	IFI	IFI

KBR

Chevron

SUMMARY OF DOCUMENT REVISIONS			
Rev. No.	**Date Revised**	**Section Revised**	**Revision Description**
0	18/01/12	-	First Issue
0A	21/02/12	ALL	Inclusion of CO2 re-injection case
1	23/03/12	ALL	Inclusion of client comments
2	21/05/2012	Executive Summary	Re-wording of summary to improve clarity at the request of client
2A	28/09/2012	ALL	Modelling revised due to Phase 2C layout. and revised CO2 vent data/location
3	7/11/2012	ALL	Inclusion of Client Comments

Table of Contents

1. EXECUTIVE SUMMARY

This Document provides the Cumulative Noise Impact Study for the operation of a four-train LNG facility at Barrow Island.

The study has considered both the operation of the plant during normal operating conditions and also during start-up.

It has been assumed that the noise control measures that were implemented in the Gorgon Foundation Project (GFP) will also be implemented in the Gorgon Expansion Project (GEP). Where additional equipment is to be installed, it is assumed to be identical to the Foundation Project equipment. However, it is intended that this will be reviewed at FEED and where practicable noise mitigation be implemented

Currently, for Train 4, it is intended that CO_2 originating from the feed gas and removed in the Acid Gas Removal Unit (AGRU) is to be re-injected. At the time of implementation of the GEP, the average amount of CO_2 in the feed gas to the plant will have decreased as new fields coming onstream are anticipated to have a low CO_2 content. The CO_2 injection facilities provided as part of the GFP will have spare capacity that can be utilised to dispose of CO_2 from train 4 (CO_2 Disposal Study, G4-TE-P-0000-REPW015 (Ref 22)).

In addition, modelling has also been performed to consider the case when the capability to re-inject CO_2 is unavailable and CO_2 removed in the AGRU of Train 4 is disposed of through atmospheric venting. The modelling within this study has assumed that this will occur through an unsilenced vent. Additional dispersion and noise modelling has been performed, external to this report, to confirm that the vent height is adequate. It is recommended that during FEED the requirement and practicability of a silencer should be investigated further.

The study has concluded that during normal operation of the four-train plant, when CO_2 is being re-injected, the 50 dB(A) contour lies within 2 km of the Plant boundary. In situations where the CO_2 is vented to atmosphere, this increase is negligible, and the contour remains within 2 Km of the Plant boundary.

Of the scenarios modelled in Case 4 for start-up of Train 4 and normal operation of Trains 1, 2 and 3, it has been found that noise levels are highest when gas is being routed through 114-HCV-0156 and into the dry flare header (Case 4A). The predicted 50 dB(A) noise contour for Case 4A is very close (almost identical) to that calculated for the start-up of Train 3 and normal operation of Trains 1 and 2 during the GFP. For both these scenarios the 50 dB(A) noise contour extends approximately 8km from the Plant boundary. It must be remembered that these predicted levels are only applicable during Commissioning and Start-up.

Break-in noise levels within the accommodation blocks is predicted to be less than the levels quoted within AS 2107, this being 30-35 dB(A). Break-in noise is defined as the external noise transmitted through the building façade.

2. INTRODUCTION

2.1 Background

The Gorgon Expansion Project (GEP) relates to the accelerated development of recent offshore gas resource finds via a fourth LNG train (T4) and associated infrastructure. The GEP facilities are to be located within the existing Gas Treatment Plant's footprint.

Barrow Island is located off the coast of Western Australia and is classified as a Class A Nature Reserve. There are no permanent residents on Barrow Island. However, many protected fauna live on, or in the water surrounding Barrow Island. Public access to the Island is restricted. Currently, there is only one industrial site which is operated by Chevron Australia Pty Ltd. This site includes the production and export facilities and a camp for workers' accommodation. The Chevron Australia Camp is located about 5.0 km south of the proposed Gorgon LNG site. The proposed Gorgon Construction Village, providing accommodation for workers during the construction phase of the Gorgon LNG facilities, is located approximately 3.6 km south from the LNG facilities site.

2.2 Regulatory Requirements and Study Objectives

For the GEP, an Environmental Impact Assessment (EIA) document is being prepared for the cumulative impacts from the GFP's three LNG trains and the GEP's Train 4 and associated infrastructure. The EIA document will include the results of the Cumulative Noise Impact Study for a four train development.

The objectives of the study are to:

- Determine whether the cumulative noise levels from the operational 4-train LNG plant will be significantly different to those predicted for the 3-train LNG plant. Based on this determination, either:
    - Update the predictions of noise levels associated with occupational health and safety and protection of the white-winged fairy wren made in the EPC Noise Report for the Gorgon Project Barrow Island LNG Plant (G1-TE-H-0000-REP1013) to account for the 4-train LNG Plant, or
    - Advise whether additional modeling is required to achieve this and undertake the modeling.

The Cumulative Noise Impact Study results will be used by Chevron Australia to determine impacts on sensitive terrestrial and marine fauna on and around Barrow Island. The Environmental Protection (Noise) Regulations have been confirmed by the Department of Environment and Conservation as not applicable to Barrow Island. However, the Noise Study needs to be undertaken in accordance with the EPA Guidance Statement No. 8 – The Assessment of Environmental Factors, Environmental Noise, and any other relevant guidelines or legislation [Ref 1].

2.3 Study Scope

The focus of the Cumulative Noise Impact Study for the GEP is on operational phase noise emissions. The same noise reduction measures as specified for the GFP should be assumed to be present for the GEP. The purpose, initially, is to establish, through calculation, whether (and if so, how) the addition of the GEP will result in any significant change to the noise levels/contours compared to the 3-Train LNG plant for the following sensitive receptors:

- LNG site boundary, 100m, 500m, 1000m and 2000m distances from LNG boundary

- Existing Chevron Camp
- Construction Village

Some assumptions have been made to be consistent with the GFP EPC Noise Report for the Gorgon Project Barrow Island LNG Plant (G1-TE-H-0000-REP1013) [Ref 2] and these are summarized in Section 4.

2.4 Abbreviations

AGRU	Acid Gas Removal Unit
CSU	Commissioning and Start-up
dB(A)	Decibels (A-weighted)
EIA	Environmental Impact Assessment
EP	Expansion Plant
EPA	Environmental Protection Agency
EPC	Engineering Procurement and Construction
FEED	Front End Engineering Design
GEP	Gorgon Expansion Project
GFP	Gorgon Foundation Project
LNG	Liquefied Natural Gas
MEG	Mono-ethylene glycol
MW	Mega Watt
PCV	Pressure Control Valve
PNMS	Plant Noise Modelling Software
SoundPlan	Noise Modelling Software

3. NOISE LIMITS

3.1 General

It has been assumed, for the purposes of this noise study, that the noise limits which are applicable to the GFP will also be applicable to the GEP.

Noise limits for the GFP are summarised below [See Ref 2].

3.2 In-Plant Noise

Where feasible, noise levels within the Work Area shall not exceed 82 dB(A) during normal operation of the plant, including start-up, shut down and maintenance activities. The Work Area Limit is equivalent to $L_{Aeq, 8h}$ of 85 dB(A) for personnel with a work-shift duration of 12 hours.

Areas of the plant where it is not practical, using accepted noise abatement techniques, to comply with the work area sound pressure limit shall, with owner's approval, be designated as "Restricted Areas".

In agreed "Restricted Areas", suitable warning signs shall be erected and hearing protection provided and required to be used.

The sound pressure level anywhere in work areas during an emergency situation (including blowing of safety/relief valves) shall not exceed 115 dB(A).

3.3 Environmental Noise

The specification for Noise Control (Ref 21) specifies the Environmental Protection (Noise) Regulations 1997 as being applicable to the project. However, during EPC of the GFP, the Western Australia Department of Environment and Conservation made the following clarification to the Project on 27 May 2010 (See Appendix A):

> "*The Noise Regulations do not apply on Barrow Island as the Island is considered to be only one premises for the purposes of the Noise Regulations. The Regulations only apply where noise emissions from one premises affect another premises. There are no other premises affected by noise emitted from Barrow Island*"

In addition, property line noise limits have not been specified in any project specifications or in any regulations and therefore, none have been applied to the project.

The Gorgon Environmental Basis of Design (Ref 3) identifies the white-winged fairy wren as a local species of bird that may be impacted by plant noise and that any areas where the noise level exceeds 50 dB(A) may have an adverse impact on the white-winged fairy wren. The Project is required to produce the 50 dB(A) noise contour to indicate the extent of Barrow Island that is to be monitored for the impact of noise on the fairy wren.

4. NOISE MODELLING

4.1 Introduction

The noise modeling has been undertaken based on that carried out for the GFP. The GFP noise model was generated using the Plant Noise Modeling System (PNMS) software to generate the inputs to a SoundPlan software model.

The PNMS software follows the prediction methodology defined in EEMUA 140 (Ref 4) (the oil companies' European organization for environmental health and protection) and ISO 9613-2 (Ref 5) and was used to assemble a matrix of Sound Power Level input data. The SoundPlan software then used this PNMS data to calculate and graphically present both in-plant and community noise levels near the plant. Both in-plant and community noise predictions were performed using the ISO 9613-2 prediction method.

4.2 Operating Cases

Noise modelling has been undertaken for several cases and these can be separated into two main groups 'commissioning and start-up' and 'normal' operation.

At the time of implementation of the GEP, the average amount of CO_2 in the feed gas to the plant will have decreased as the new fields which are being developed are anticipated to have a lower CO_2 content. The CO_2 injection facilities provided as part of the GFP will have some spare capacity that can be utilized to dispose of CO_2 from train 4 (CO_2 Disposal Study, G4-TE-P-0000-REPW015 (Ref 22)).

In addition to the case described above, noise modelling has been performed to predict noise levels during disposal of CO_2 venting from Train 4 to atmosphere. This scenario occurs when the CO_2 compressors or associated wells and lines are not available, either following a trip or during planned maintenance. As some down-time for the compressors and CO_2 re-injection system for planned maintenance is inevitable, the noise from direct venting of CO_2 cannot be considered as an emergency activity. The noise performance of the main CO_2 vent should therefore be contrasted with noise limits for the normal operation of the plant.

'Normal operating' cases considered within this report:

- Case 1: Normal operations of Trains 1, 2 and 3
- Case 2: Normal operations of Trains 1, 2, 3 and 4 with CO2 Re-injection
- Case 3: Normal operation of Trains 1, 2, 3 and 4 with Venting of CO2 from Train 4

Commissioning and Start-up operations considered in this report can be summarised by the following cases:

- Case 4A: Gas flaring through 114-HCV-0156 into Dry flare stages and CO2 disposal to atmosphere during Train 4 AGRU and LNG process start-up, coinciding with Normal operations of Trains 1, 2 and 3
- Case 4B: Gas flaring through 111-HCV-0021 into Wet flare stages and CO2 disposal to atmosphere during Train 4 AGRU and LNG process start-up, coinciding with Normal operations of Trains 1, 2 and 3

4.3 Model Assumptions

For consistency with the GFP noise study, the same assumptions/inputs have been used and these are summarized below:

- Ground absorption – It was assumed that an acoustically "hard" ground is present for all areas over which sound is propagating (as identified in EPA Guidance Note No. 8).
- Air absorption – The model assumes air absorption based on ISO 9613-1 (Ref 6) data
- Barriers – LNG storage tanks (35m in elevation) were included in the model as barriers to sound propagation.
- Plant site topography – Topographical information for the plant was included in the model and obtained from the "Proposed Terrace Levels" Plot Plan (Ref 7). In-plant sound pressure level predictions were based on a Model grid spacing of 10m
- Topography between LNG Plant and sensitive receptors – there are no major terrain undulations between the LNG Plant and sensitive receptor locations. Terrain information obtained from the Australian Government's Digital Elevation Model (Ref 8) was combined with the "Proposed Terrace Levels" to create a Digital Ground Model. This has been included in all calculations

The following meteorological conditions were also assumed:

- Temperature – 15^{o}C (guidance taken from Ref 1)
- Relative Humidity – 50% (guidance taken from Ref 1)
- Atmospheric conditions – the ISO-9613 methodology implicitly assumes a sound propagation "worst case" atmospheric condition exists (temperature inversion)
  - Wind conditions – the ISO-9613 methodology implicitly assumes a sound propagation "worst case" wind condition exists, this being that the receiver experiences "moderate downwind conditions"

The 'SoundPlan' noise modelling software follows the calculation method defined in ISO 9613. Conservatism within the modelling is therefore defined within the standard. In addition any other variables have been specified within EPA Guidance Note 8 (Ref 1).

Some variation will occur between the equipment sound power levels within the model and the actual equipment levels at site. This being due to the error associated with practical acoustic measurements. However, due to the high number of sources within the model and the logarithmical nature of noise, this error can be considered to be negligible.

4.4 Gorgon Foundation Project (GFP) Assumptions

For consistency with the GFP noise study, the latest SoundPlan model for the EPC phase of the GFP has been used to calculate noise from all GFP sources.

4.5 Gorgon Expansion Project (GEP) Facilities Assumptions

The noise modeling for the GEP Facilities has been undertaken based on the following assumptions.

The GEP Facilities are based on the Conceptual Site Plan – Phase 2C (Drawing No. G4-TD-X-0000-GADW107 Rev B) (Ref 18).

Unit No.	Unit Description	Assumption for Noise Study
900	MEG Storage and Regeneration Facilities	Carbon copy of Jansz pipeline GFP facilities. Additional MEG Flash gas compressor included in model.
1000	Inlet receiving facilities	Additional Slugcatcher. Inlet processing facilities assumed to be carbon copy of GFP
1100	AGRU Reg/Amine Storage	Assumed same as GFP train 1 but no additional storage
1200	Dehydration	Carbon copy of GFP Train 1
1300	Mercury removal	Carbon copy of GFP Train 1
1400	Liquefaction	Carbon copy of GFP Train 1
1500	Refrigeration	Carbon copy of GFP Train 1
1600	Fractionation	Carbon copy of GFP Train 1
1900	CO2 Injection	No additional equipment added. It is considered that there is enough capacity within the GFP CO2 compressors Trains 1, 2 and 3 However, a transfer CO2 compressor has been added. The Process group has provided details of several options to the client. For the purposes of this modelling, it has been assumed that the largest compressor (6MW) will be required. This represents the worst case, with respect to noise. In addition there will be a vent on the compressor discharge, the noise level is likely to be similar to that generated by the AGRU vent. Process details are limited at this stage. The requirement for a silencer and the height of the vent outlet should be investigated at FEED, in an attempt to reduce the noise to ALARP.
TBA	AGRU Venting	When CO_2 Compressor unavailable CO_2 is disposed to atmosphere by venting at a rate of 206 t/hr. The CO_2 venting is assumed to be unsilenced and at a height of 72.5m (AHD)
2400	DOMGAS Processing	No additional facilities added for GEP
2500	DOMGAS Export and metering	No additional facilities added for GEP
3200	Refrigerant Storage	No additional facilities added for GEP
3300	Condensate Storage and Loading	No additional facilities added for GEP
3400	LNG Storage and Loading, plus BOG handling	A third LNG Storage tank has been added. As located in Conceptual Plot G4-TD-X-0000-GADW107 (Ref. 18) Additional BOG compressor added. Carbon copy

		of GFP
4000	Power Generation	Noise study assumes 1 additional GTG, same as GFP
4100	Heating Medium System	No additional Fired Heater added, Pumps and Trim coolers only. Copied from GFP model
4200	Recycle Gas Compression System	No additional equipment added
4300	Demin system	No additional equipment added
4400	Fuel Gas System	Assumed same as GFP (No equipment, not included in model)
4500	Service and Potable Water	No additional facilities added for GEP
4600	Tempered Water System	No additional equipment added
4700	Service and Instrument Air	Additional equipment added, carbon copy of GFP
4800	Nitrogen	Assumed same as GFP (Quiet equipment, not included in model)
4900	Diesel Storage and distribution	No additional facilities added for GEP
6000	Fire and Gas Protection	No additional facilities added for GEP
6200	Flare, Pressure Relief and Venting Systems	No additional facilities added for GEP
6400	Waste Water Facilities	No additional facilities except for stormwater holding basin, which is not noisy

Table 1 – GEP Facilities Assumptions

4.6 Acoustic Insulation

Acoustic Insulation has been assumed to be installed on the GEP Inlet facilities let-down station and all large pumps.

4.7 Gas Flaring and CO_2 Disposal to Atmosphere Assumptions

Noise generated by gas flaring and CO_2 disposal to atmosphere during commissioning and start-up of the GFP facilities has been predicted and is assessed in the "Commissioning and Start-Up Noise Study for the Gorgon Project" (Ref. 9).

The processes for gas flaring and CO_2 disposal to atmosphere during the start-up of Train 4 are assumed to be the same as for the GFP and are summarized below. The flare is located on an off-plot site to the North-west of the main facility, details of this can be seen in drawing G1-TD-X-0000-GAD0432, 'Overall Plot Plan Flare Area' (Appendix B) It is assumed that disposal of CO2 is to atmosphere.

During start-up the following valves are used to route gas into the flare header. The valves are operated sequentially.

- 010-HCV-3207
- 111-HCV-0021

- 114-HCV-0156
- 114-PCV-0041

111-HCV-0021, 114-HCV-0156 and 114-PCV-0041 are all used for routing gas to the flare during start-up of the AGRU&LNG trains. It has been identified that the highest sound power level for the flare occurs during routing of gas through 114-HCV-0156 into the dry flare stages. However, due to the location of both the dry and wet stages, routing through 111-HCV-0021 into the wet flare stages may have a larger effect on the environmental receptors to the north of the plant. For this reason both start-up flaring scenarios have been considered, as defined in section 4.2.

The following table lists the main parameters used in the noise modelling:

Parameter	Value	Source	Comments
Sound Power Level of Burner Tip	128 dB(A)	Ref 10	Per burner. Vendor data
Octave Band Spectrum of Burner Tip	Varies		Experience from previous project
Directivity of Burner Tip	Varies		Experience from previous project
No. of Burner Tips (total)	1558	Ref 10	Vendor data
Height of Burner Tips	2.5m	Ref 10	Above grade. Vendor data
Location of Burner Tips	Varies	Ref 10	Vendor GA drawing
Location of Foundation Flare		Ref. 11	Located North-West area of site
Terrace Heights (flare area)	21.5m, 23.5m and 25.5m	Ref. 12,13,14 and 15	Above sea level.
Gas Flow Rate to Dry Flare, through 114-HCV-0156	67 kg/s	Ref 16	Process datasheet G1-TE-P-6200-DSS2017. 14-HCV-0156 used to vent into flare header
No. of Stages used on Dry Gas Flare during Case 2 Flaring, through 114-HCV-0156	6	Ref 9	Calculated from vendor staging curves
Gas Flow Rate to Wet Flare, through 111-HCV-0021	65.9 kg/s	Ref 16	Process datasheet G1-TE-P-6200-DSS2017. 111-HCV-0021 used to vent into flare header
No. of Stages used on Wet Gas Flare during Case 2 Flaring, through 111-HCV-0021	5	Ref 9	Calculated from vendor staging curves
AGRU Vent outlet Train 4 Sound Power Level	127 dB(A)	Ref. 17 & Ref. 19	Assumed Low noise trim applied to valve and Acoustic insulation specified on Vent line.

Table 2 – Flare Noise Modeling Assumptions

Each burner tip was modelled as a point source. For simplicity and conservatism, it was assumed that:

1. The Flare radiation fence gave no noise reduction
2. The sound power level of the Indair tips was the same as the LRGO tips
3. The ground was hard and acoustically reflective (EPA Guidance Note No.8)

The reason for the first assumption is that acoustically, the radiation fence is virtually transparent due to the large openings in the fence that exist to ensure that adequate air can be drawn in to the burners when the flare is operating.

The reason for the second assumption is that the vendor has not supplied the noise data for the Indair tips. It is known that the Indair tips are quieter than the LRGO tips so a conservative assumption to make, in the absence of vendor data, is that the noise from the Indair tips is equal to the LRGO tips. Additionally, during startup flaring there are significantly more LRGO tips than Indair and so the noise from the LRGO tips will be dominant.

The noise modeling for the flare noise sources has not included the contribution from the control valves used to route gas into the flare headers. The control valves on the GFP included low-noise trims and their contribution was found to be negligible when compared to the expected noise level of the flare. It is assumed that similar valves will be purchased for the GEP.

The sound power level of the AGRU Vent outlet has been predicted using data provided by the process group. Under non-emergency venting, it is intended that CO_2 will be vented through a Pressure control valve (PCV). Noise calculations have been performed to predict the noise generated at the vent outlet. The location, process conditions and predicted noise level can be seen in the table below:

Parameter	**Value**	**Reference**
Flow rate	206 t/hr	Ref. 19
Sound Power Level	127 dB(A)	Ref. 17
Height of Outlet	72m (AHD	Train 4 AGRU layout assumed identical to GFP
Northing	308680	
Easting	1052510	

Table 3 – CO2 AGRU Vent Noise Modelling Assumptions

The height of the vent outlet has been assumed to be the same as the AGRU Vents within GFP, however calculations external to this report have confirmed that this height is adequate.

5. RESULTS

5.1 Normal Operation

The following table shows the predicted noise levels at the environmental receptors for Case 1 (Normal operation of Train 1, 2 and 3), Case 2 (Normal operation of Trains 1, 2 3 and 4 with CO_2 re-injection) and Case 3 (Normal operation of Trains 1, 2, 3 and 4 with CO_2 disposal to atmosphere). No flaring has been considered during normal operation, as the noise level from this is considered to be negligible when compared to the plant sound power level. Receptor locations are shown on Figure C-1 in Appendix C.

Environmental Receptor	**Case 1 (Normal operation of trains 1, 2 and 3)**	**Case 2 (Normal operation of trains 1, 2, 3 and 4) CO_2 reinjection for all Trains**		**Case 3 (Normal operation of trains 1, 2, 3 and 4) CO_2 Disposal to Atmosphere for Train 4**	
	Calculated Sound Pressure Level [dB(A)]	Calculated Sound Pressure Level [dB(A)]	Difference (from Case 1) [dB]	Calculated Sound Pressure Level [dB(A)]	Difference (from Case 1) [dB]
01. Chevron Australia Camp	45.4	47.1	1.7	47.4	2.0
02. Gorgon Construction Village	45.1	47.1	2.0	47.5	2.4
03. Airport	27.5	28.1	0.6	28.4	0.9
04. Town Point	59.4	60.9	1.5	61.0	1.6
05. Proposed LNG Plant	64.6	65.5	0.9	65.6	1.0
06. Old Airport	46.1	47.5	1.4	47.7	1.6
07. North-west of BWI	32.6	33.6	1.0	35.8	3.2
08. South-west of BWI	24.6	26.0	1.4	31.0	6.4
09. South-east of BWI	17.3	18.6	1.3	18.6	1.3
10. Northern end of BWI	22.7	23.8	1.1	24.4	1.7
17. Airport	27.3	29.1	1.8	32.6	5.3
18. Admin buildings	51.6	54.2	2.6	55.0	3.4

Table 4 – Calculated Sound Pressure Levels, Normal Operations

Noise contours at grade within the plant areas have been generated and are shown in Appendix C on Figure C-2 for Case 1, Figure C-3 for Case 2 and Figure C-4 for Case 3.

Noise contours have also been generated over the entire Barrow Island area and these are shown in Appendix C on Figure C-5 for Case 1, Figure C-6 for Case 2 and Figure C-7 for Case 3

5.2 Gas Flaring and CO_2 Disposal to Atmosphere during Train 4 AGRU and LNG Process Start-up

The following table shows the predicted noise levels at the environmental receptors for Case 4A (Gas flaring through 114-HCV-0156 into Dry flare stages and CO_2 disposal to atmosphere during Train 4 AGRU and LNG process start-up, coinciding with Normal operations of Trains 1, 2 and 3) and Case 4B (Gas flaring through 111-HCV-0021 into Wet flare stages and CO_2 disposal to atmosphere during Train 4 AGRU and LNG process start-up, coinciding with Normal operations of Trains 1, 2 and 3).

Environmental Receptor	Calculated Sound Pressure Level [dB(A)]				
	Case 1: Normal operation of train 1, 2 and 3)	**Case 4A: Routed through 114-HCV-0156 into Dry flare stages**	**Predicted Sound Pressure Level difference between Case 1 and Case 4A (Dry Flare)**	**Case 4B: Routed through 111-HCV-0021 into wet flare stages**	**Predicted Sound Pressure Level difference between Case 1 and Case 4B (Wet Flare)**
01. Chevron Australia Camp	45.4	52.6	7.2	50.9	5.5
02. Gorgon Construction Village	45.1	53.6	8.5	51.6	6.5
03. Airport	27.5	37.7	10.2	35.3	7.8
04. Town Point	59.4	63.3	3.9	62.0	2.6
05. Proposed LNG Plant	64.6	72.2	7.6	66.2	1.6
06. Old Airport	46.1	61.0	14.9	58.7	12.6
07. North-west of BWI	32.6	50.5	17.9	48.5	15.9
08. South-west of BWI	24.6	46.2	21.6	43.6	19.0
09. South-east of BWI	17.3	31.1	13.8	29.1	11.8
10. Northern end of BWI	22.7	43.1	20.4	43.8	21.1
17. Airport	27.3	46.8	19.5	43.6	16.3
18. Admin buildings	51.6	60.3	8.7	57.9	6.3

Table 5 – Calculated Sound Pressure Levels, Gas Flaring and CO2 disposal to atmosphere during Train 4 AGRU and LNG Process Start-up

Noise contours have also been generated over the entire Barrow Island area and these are shown in Appendix C on Figure C-8 for Case 4A Venting into the Dry flare and normal operation of Trains 1, 2 and 3 and Figure C-10 for Case 4B Venting into the Wet flare and normal operation of Trains 1, 2 and 3.

6. CONCLUSIONS

Modelling has been performed to predict noise levels at the environmental receptors and within the Plant after the implementation of the GEP. During 'normal operation', this being with CO_2 from Train 4 being re-injected, the predicted increase in noise levels at the Chevron Australia camp and the Gorgon Construction Village are 1.7 dB and 2.0 dB respectively. Modelling has been performed with the inclusion of the CO_2 Transfer Compressor, which has been assumed to be 6 MW.

In addition to this, modeling has been performed to predict noise levels generated by disposal of CO_2 from Train 4 to atmosphere. This scenario may arise, for example, when the CO_2 compressors are not available through maintenance.

The anticipated increase in sound pressure levels with the operation of the GEP with CO_2 disposal to atmosphere is 2.0 dB at the Chevron Australia Camp and 2.4 dB at the Gorgon Construction Village. However, the noise modeling has assumed an unsilenced vent to atmosphere. The vent height is assumed to be the same as the AGRU outlet within the GFP. However additional dispersion and noise modeling has been performed, external to this report, to confirm this height is acceptable. It is recommended that during FEED the requirement for a silencer should be investigated further.

During the start-up of Train 4, anticipated sound pressure levels are similar to those reported within the Foundation Projects CSU Noise Study Report (Ref. 9) for the start-up of Train 3.

The noise levels predicted at the accommodation camp represent the external noise levels close to the building façade. Typical Sound Reduction indices expected from such structures are within the region of 20-25 dB. With this level of transmission loss, the break-in noise levels within the accommodation blocks is predicted to be less than the levels quoted within AS 2107, this being 30-35 dB(A), even with the disposal of CO_2 to atmosphere through the GEP AGRU vent.

The 50 dB(A) contour has been calculated for normal operation of both the GFP and after the implementation of the GEP. A comparison of the contours can be seen in figure C-12. The 50 dB(A) contours for Cases 1 and 2 both lie within 2km of the plant boundary. The largest orthogonal distance between the Plant boundary and the 50 dB(A) contour for case 1 and case 2 is 1.75km and 2km, respectively. During periods when CO_2 is disposed of to atmosphere the 50 dB(A) contour also lies within 2km of the Plant boundary, with the largest orthogonal distance again being 2km.

During the start-up of Train 4, it has been found that noise levels are highest when gas is being routed through 114-HCV-0156 and into the dry flare header (Case 4A). The location of the 50 dB(A) noise contour is very close (almost identical) to that calculated for the start-up of Train 3, with the contour extending approximately 8km from the Plant boundary for both the start-up of Train 3 and Train 4. It must be remembered that these predicted levels are only applicable during Commissioning and Start-up.

It must be remembered that the noise modelling performed within this study has been based on a carbon copy principle of the GFP. During FEED there will be an opportunity to review this and assess the practicability of the implementation of noise mitigation measures, in an attempt to further reduce the impact of the GEP.

During the GFP noise review, it was accepted that the 'worst case' with respect to noise was during emergency flaring. Due to the dominance of the flare noise source over all other noise sources within the Plant, it is anticipated that the addition of the GEP will have negligible effect on the predicted emergency flaring noise contours.

7. APPLICABLE DOCUMENTS

7.1 References

1. Western Australia Environmental Protection Authority Guidance Note No. 8, May 2007
2. G1-TE-H-0000-REP-1013. "EPC Noise Report for the Gorgon Project Barrow Island LNG Plant".
3. The Gorgon Environmental Basis of Design
4. Engineering Equipment Material Users Association (EEMUA), Publication No. 140 "Guide to the use of Noise Procedure Specification (formerly OCMA Specification No. NWG 3, Rev 2)
5. ISO 9613-2:1996, "Acoustics – Attenuation of Sound During Propagation Outdoors, Part 2 – General Method of Calculation"
6. ISO 9613-1:1993, "Acoustics – Attenuation of Sound During Propagation Outdoors, Part 1 – Calculation of the Absorption of Sound by the Atmosphere"
7. "Proposed Terrace Levels" Plot Plan, G1-TD-C-6300-GRD1000 Rev D.
8. Australian Government Geoscience Australia, "Geodata 9 Second DEM and D8, Digital Ground Model Version 3 and Flow direction Grid", July 2008.
9. G1-TE-H-0000-REP1014. "Commissioning and Start-Up Noise Study for the Gorgon Project Barrow Island LNG Plant".
10. G1-TE-H-6200-REP1001, "Flare Noise Study".
11. G1-TD-X-0000-GAD0116, Overall Site Plot Plan
12. G1-TD-X-0000-GAD0438, Flare Area - Plot Plan (1 of 4)
13. G1-TD-X-0000-GAD0440, Flare Area - Plot Plan (2 of 4)
14. G1-TD-X-0000-GAD0444, Flare Area - Plot Plan (3 of 4)
15. G1-TD-X-0000-GAD0445, Flare Area - Plot Plan (4 of 4)
16. G1-TE-P-6200-DSS2017, "Process Datasheet for 0A-6204 Ground Flare Package"
17. JD531-NC-0001, Noise Calculation for CO2 Vent 1 to Atmosphere.
18. G4-TD-X-0000-GADW107 Rev B, Conceptual Site Plot Plan – Phase 2C.
19. Relief Loads for 11-RV-19A-E supplied by Process Dept
20. G1-TE-H-0000-TCN2005, Technical Note for Acid Gas Venting,
21. G1-TE-H-0000-SPC1001, Specification for Noise Control.
22. G4-TE-P-0000-REPW015, CO2 Disposal Study.

Appendix A

WA DEC CLARIFICATION

Russell Tipping

From:	Shannon Dolbel
Sent:	06 July 2010 10:23
To:	Wayne Seeto
Subject:	FW: Gorgon Gas Development - Noise
Follow Up Flag:	Follow up
Flag Status:	Red

Hi Wayne,

Please see advice below received from the DEC in relation to the Noise Regulations and Barrow Island. The noise section in the works approval for the Gas Treatment Plant will need to be re-written to take into account this advice. I'm currently focused on other approvals work at the moment but will re-write the section you reviewed to reflect the DEC's advice and send to you for review. This is likely to be in the next month or two.

Note DEC's advice that the EPA may nominate another standard and suggests AS 2107-2000 would be appropriate. This standard is not intended for the assessment of noise levels from transient or variable noises so I don't think this is applicable to emergency flaring or venting which would be irregular and intermittent.

Regards,
Shannon

Shannon Dolbel
Regulatory Approvals Coordinator
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Switch: +61 8 9278 4300
Fax: +61 8 9278 4400
Email: shannon.dolbel@kjv.com.au

From: Popoff-Asotoff, Peter [mailto:Peter.Popoff-Asotoff@dec.wa.gov.au]
Sent: Thursday, 27 May 2010 6:41 PM
To: Shannon Dolbel
Subject: RE: Gorgon Gas Development - Noise

Hi Shannon

See my suggested changes below.

Note that the assigned levels in the noise regulations are outdoor levels. The EPA Guidance Note No.8 state that where the noise regulations are not the appropriate standard the EPA can nominate another appropriate standard. In your case the acceptable standards should be in term of indoor levels. The EPA Guidance Note No.8 states the EPA policy is that the indoor levels should meet the "satisfactory" criteria in Table 1 of AS 2107-2000.

Regards

Peter Popoff-Asotoff
Acting Manager
Noise Regulation Branch
Department of Environment and Conservation
T 6467 5275
F 6467 5561

From: Shannon Dolbel [mailto:Shannon.Dolbel@kjv.com.au]
Sent: Thursday, 27 May 2010 8:44 AM
To: Popoff-Asotoff, Peter

Subject: Gorgon Gas Development - Noise

Hi Peter,

Thanks for your time yesterday.

In response to my query regarding emergency flaring and venting on Barrow Island and to summarise our telephone conversation can you please confirm the text below is an accurate interpretation and is the DEC's position on the application of the Noise Regulations on Barrow Island for the purposes of the Gorgon Gas Development:

The Noise Regulations do not apply on Barrow Island as the Island is considered to be only one premises for the purposes of the Noise Regulations. The Regulations only apply where noise emissions from one premises affect another premises. There are no other premises affected by noise emitted from Barrow Island.

The situation whereby noise levels may exceed 65 dB (A) during some emergency flaring and venting at one of the environmental receivers on the Island (Admin building) for a time which is greater than allowed by the L_{A10} dB (A) limit (i.e. greater than 10% of a Representative Assessment Period or 24 minutes over the maximum Representative Assessment Period of 4 hours) is not considered to be a non compliance with the Noise Regulations.

Thanks,
Shannon

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13/07/2011

APPENDIX B

OVERALL PLOT PLAN FLARE AREA

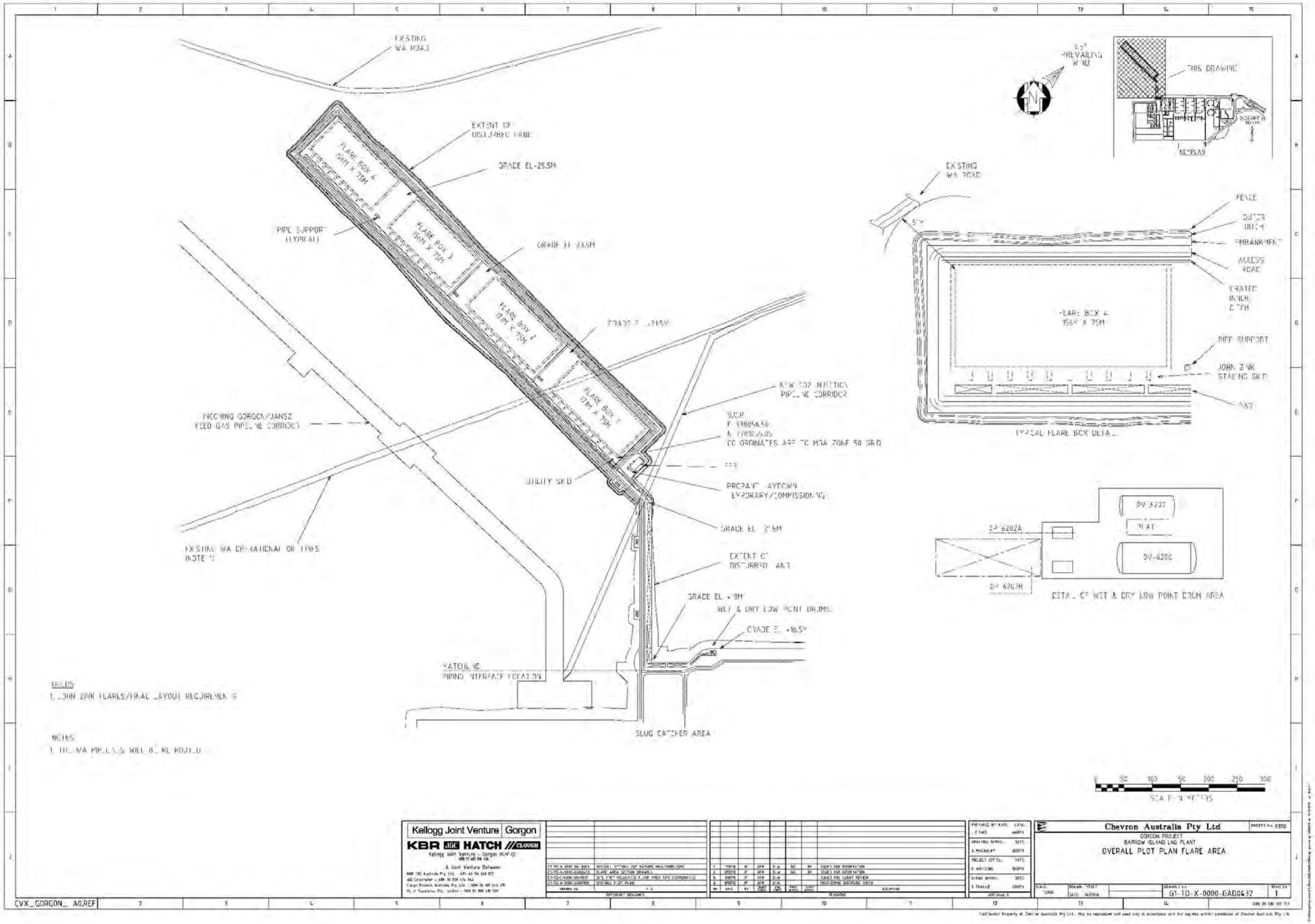

Figure B-1: Overall Plot Plan Flare Area

APPENDIX C

CALCULATED SOUND PRESSURE LEVELS

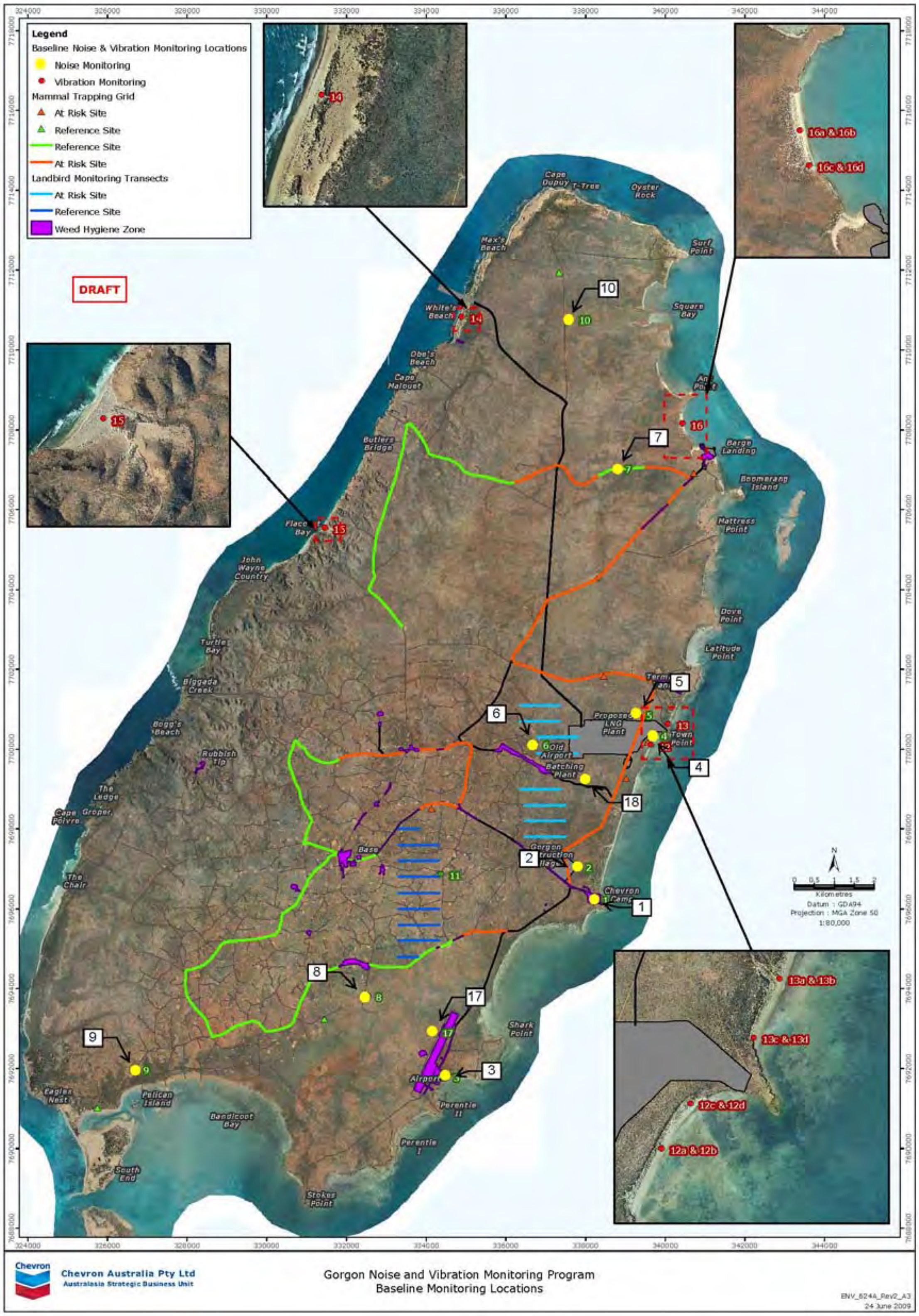

Figure C- 1: Environmental Noise Receptors on Barrow Island

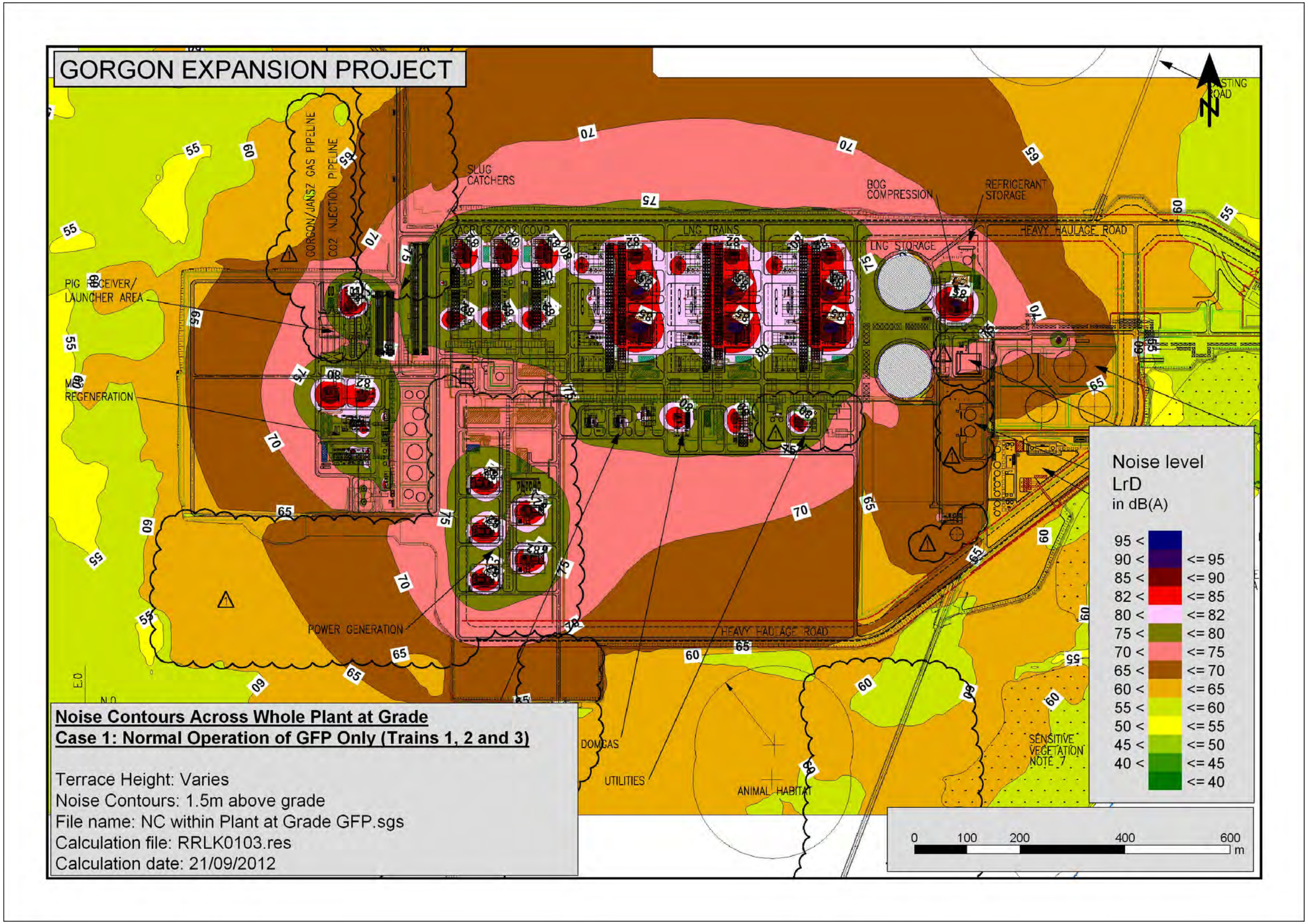

Figure C- 2: Calculated Noise Contours within Plant Areas. Case 1 Normal Operation of Trains 1, 2 and 3

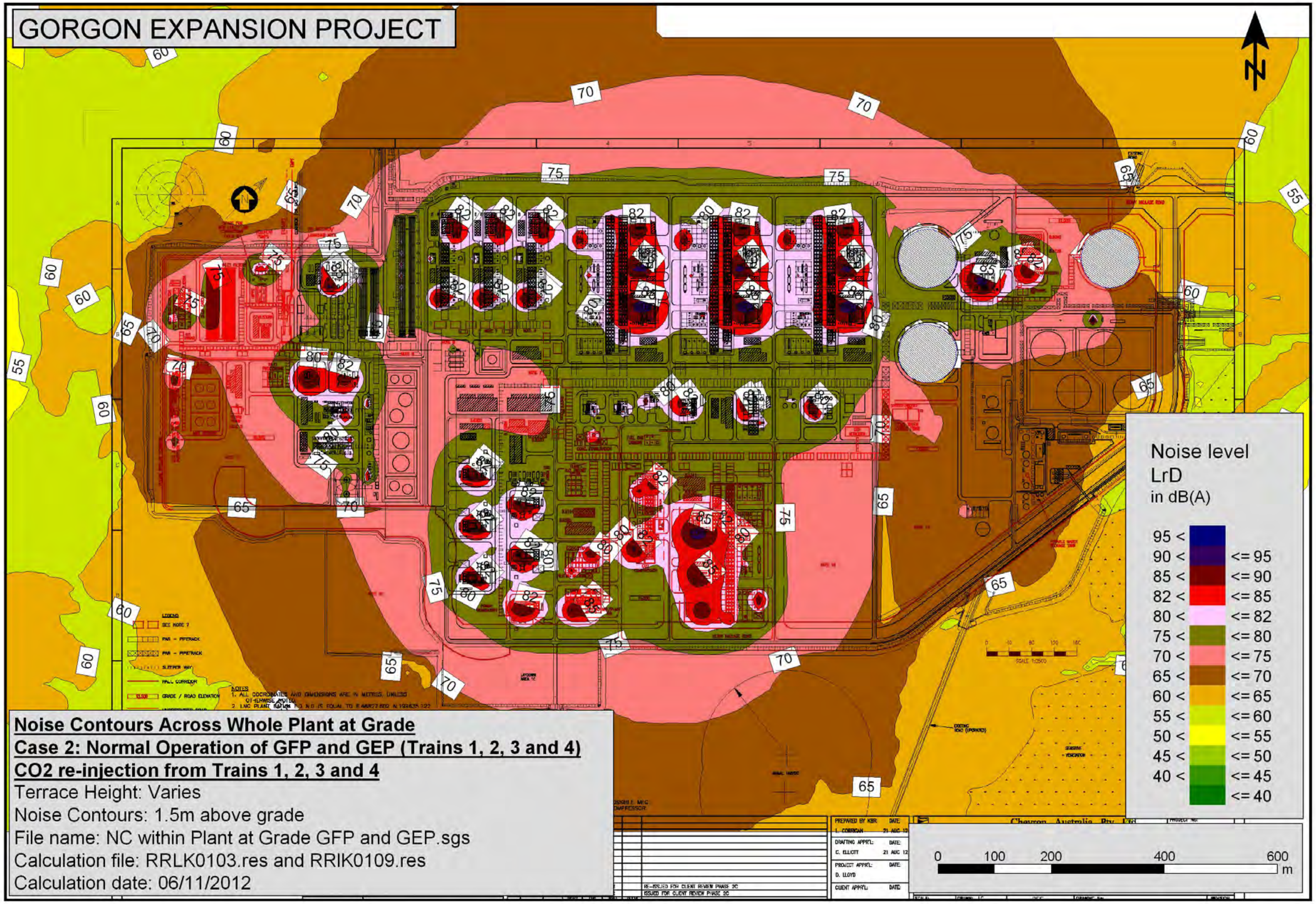

Figure C- 3: Calculated Noise Contours within Plant Areas. Case 2: Normal Operation of Trains 1, 2, 3 and 4. CO2 Re-injection

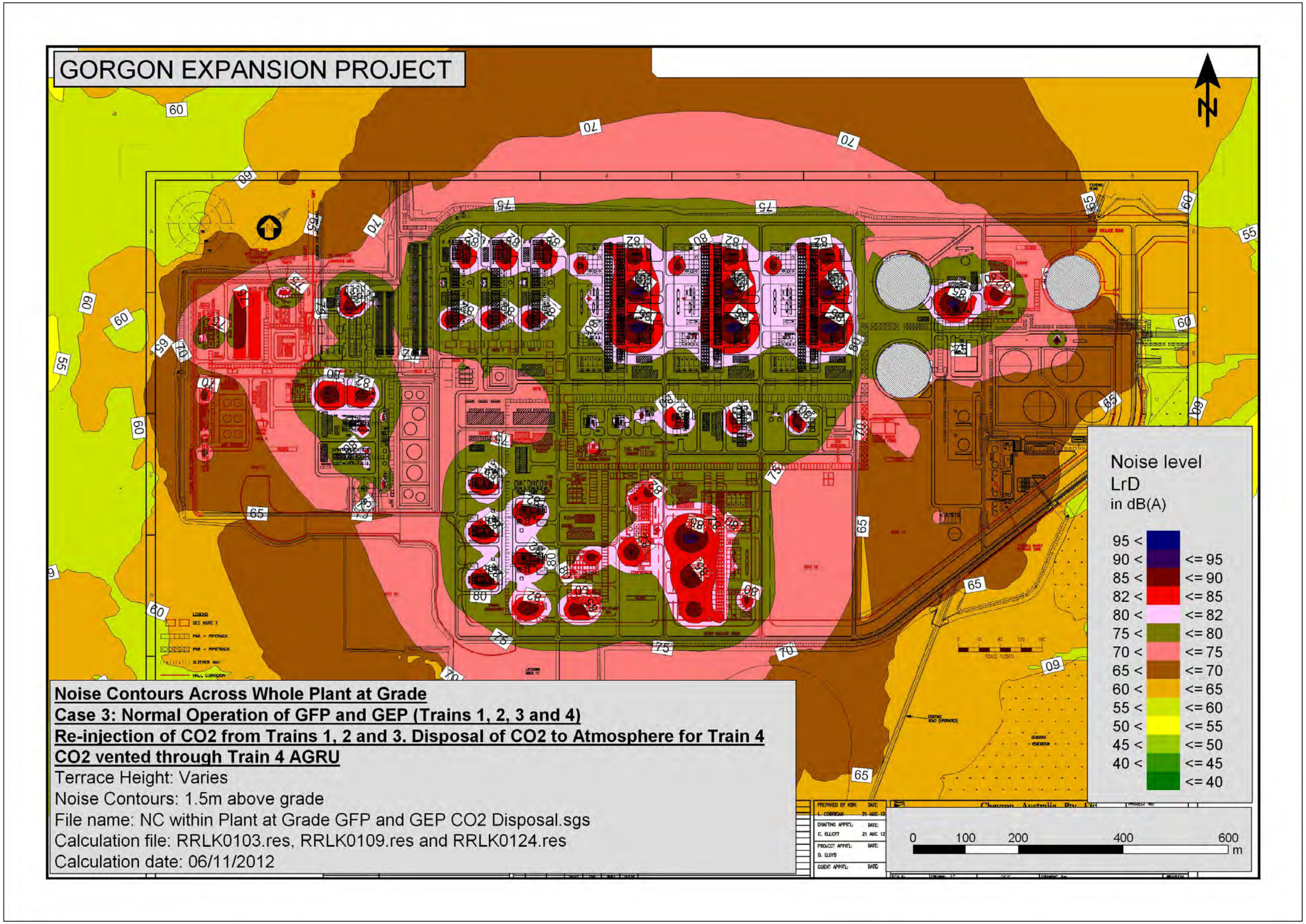

Figure C-4: Calculated Noise Contours within Plant Areas. Case 3: Normal Operation of Trains 1, 2, 3 and 4. Disposal of CO2 to Atmosphere for Train 4

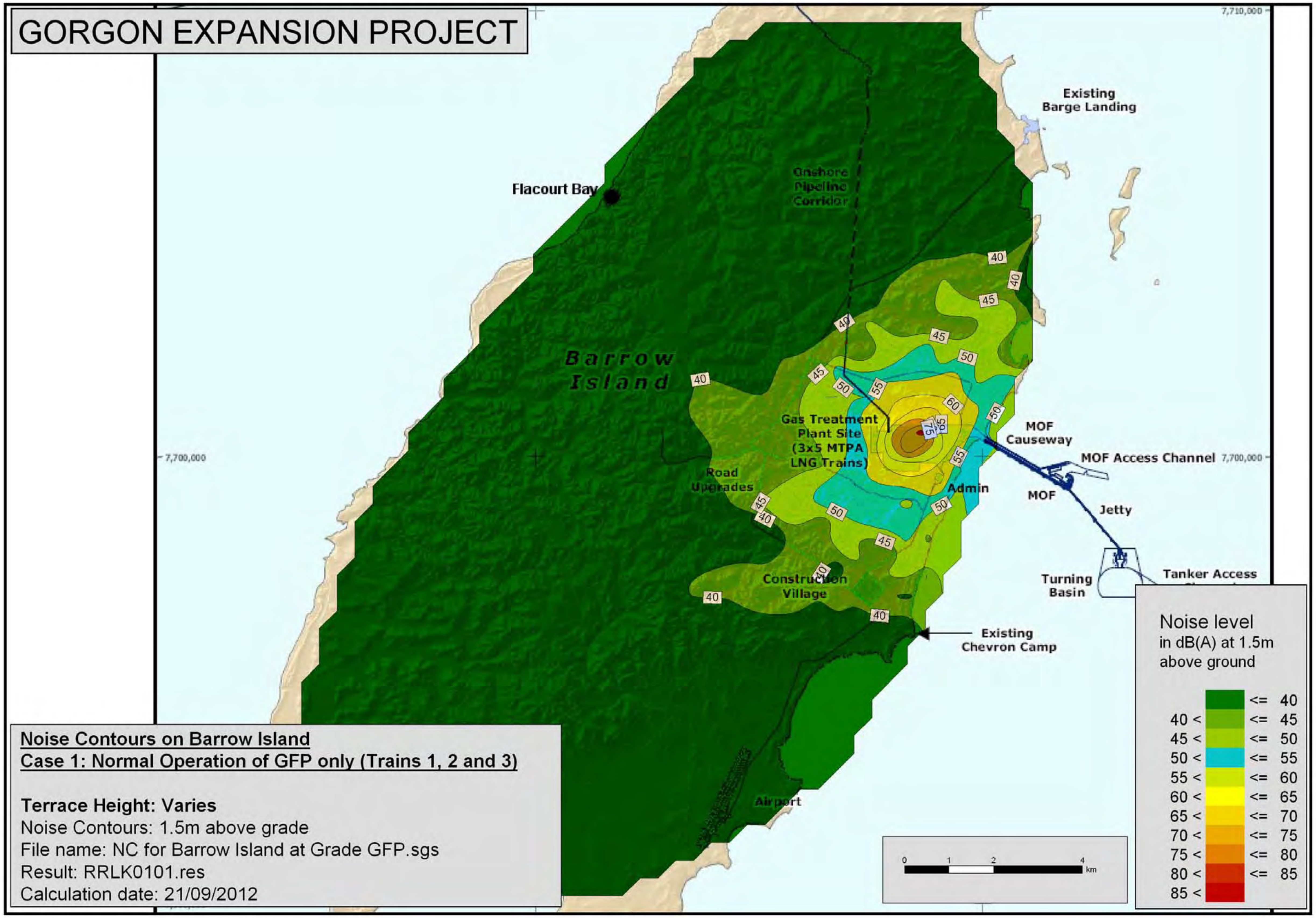

Figure C- 4: Calculated Noise Contours over Barrow Island. Case 1: Normal Operation of Trains 1, 2 and 3

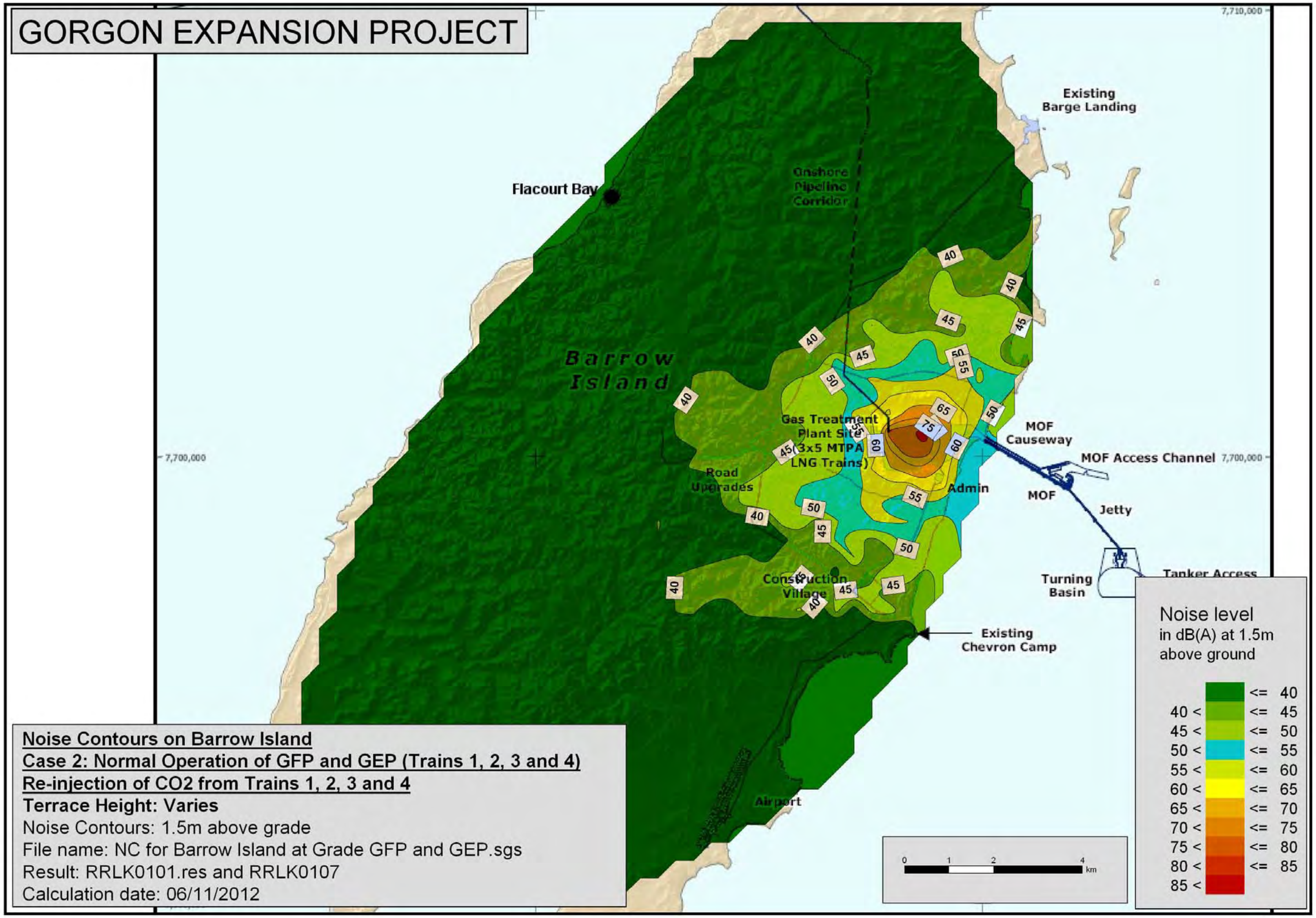

Figure C- 5: Calculated Noise Contours over Barrow Island. Case 2: Normal Operation of Trains 1, 2, 3 and 4. With CO2 Re-injection

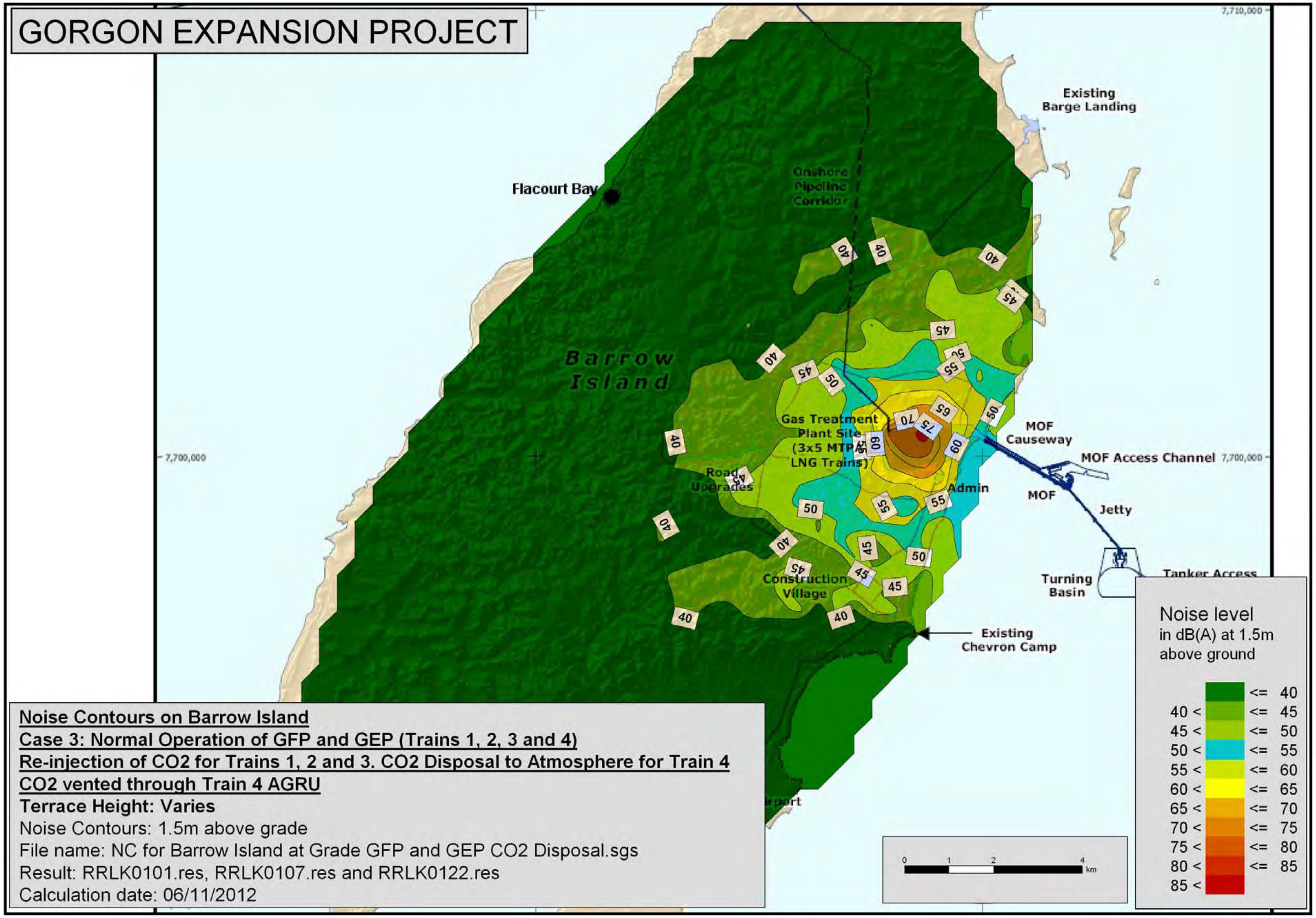

Figure C- 7: Calculated Noise Contours over Barrow Island. Case 3: Normal Operation of Trains 1, 2, 3 and 4. Disposal of CO_2 to Atmosphere for Train 4

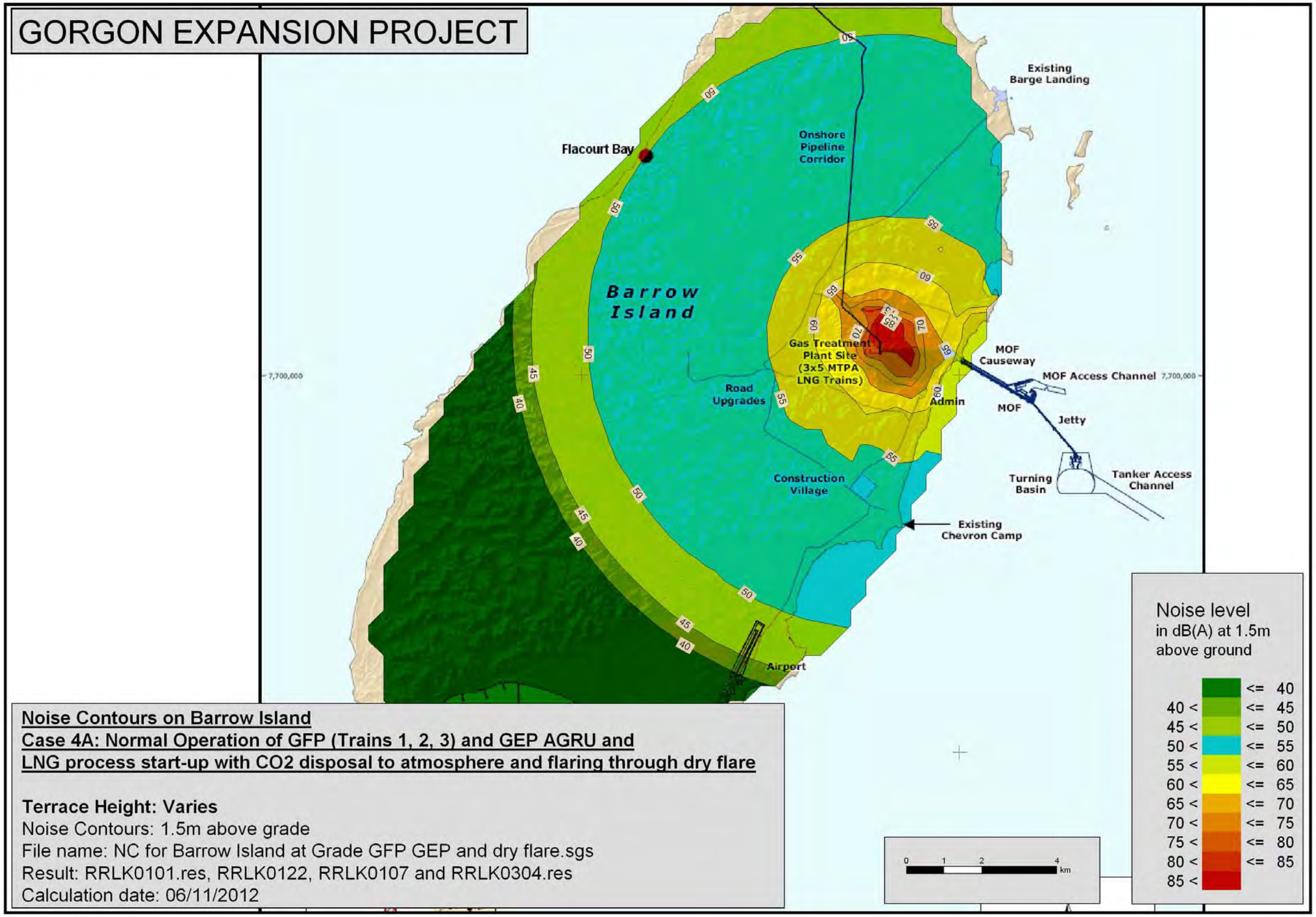

Figure C- 6: Calculated Noise Contours over Barrow Island. Case 4A: Gas Flaring and CO2 Disposal to Atmosphere during Train 4 AGRU and LNG Process Start-up and Normal Operation of Trains 1, 2 and 3. Routed through 114-HCV-0156 into Dry flare stages

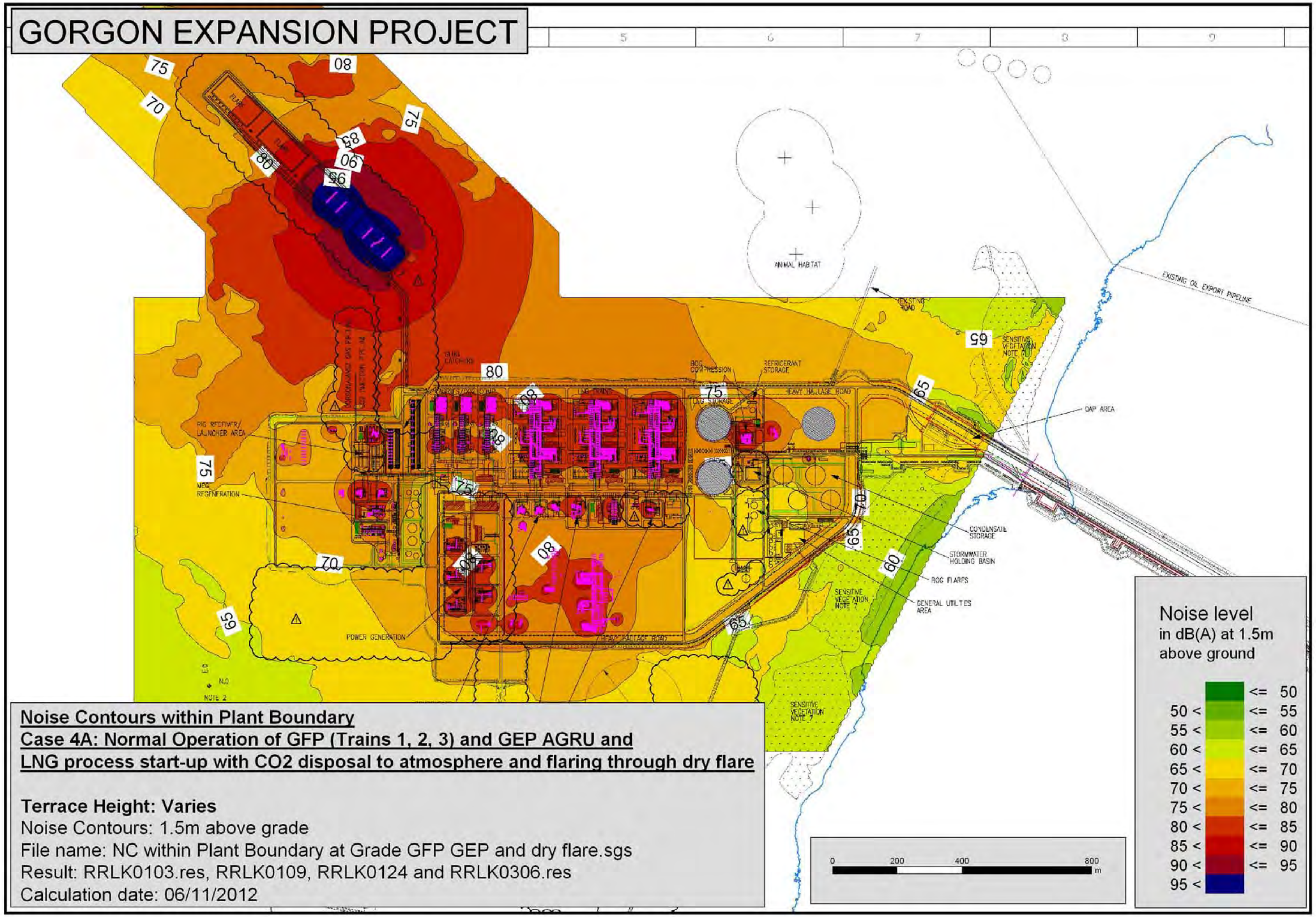

Figure C- 7: Calculated Noise Contours within Plant boundary. Case 4A: Gas Flaring and CO2 Disposal to Atmosphere during Train 4 AGRU and LNG Process Start-up and Normal Operation of Trains 1, 2 and 3. Routed through 114-HCV-0156 into Dry flare stages

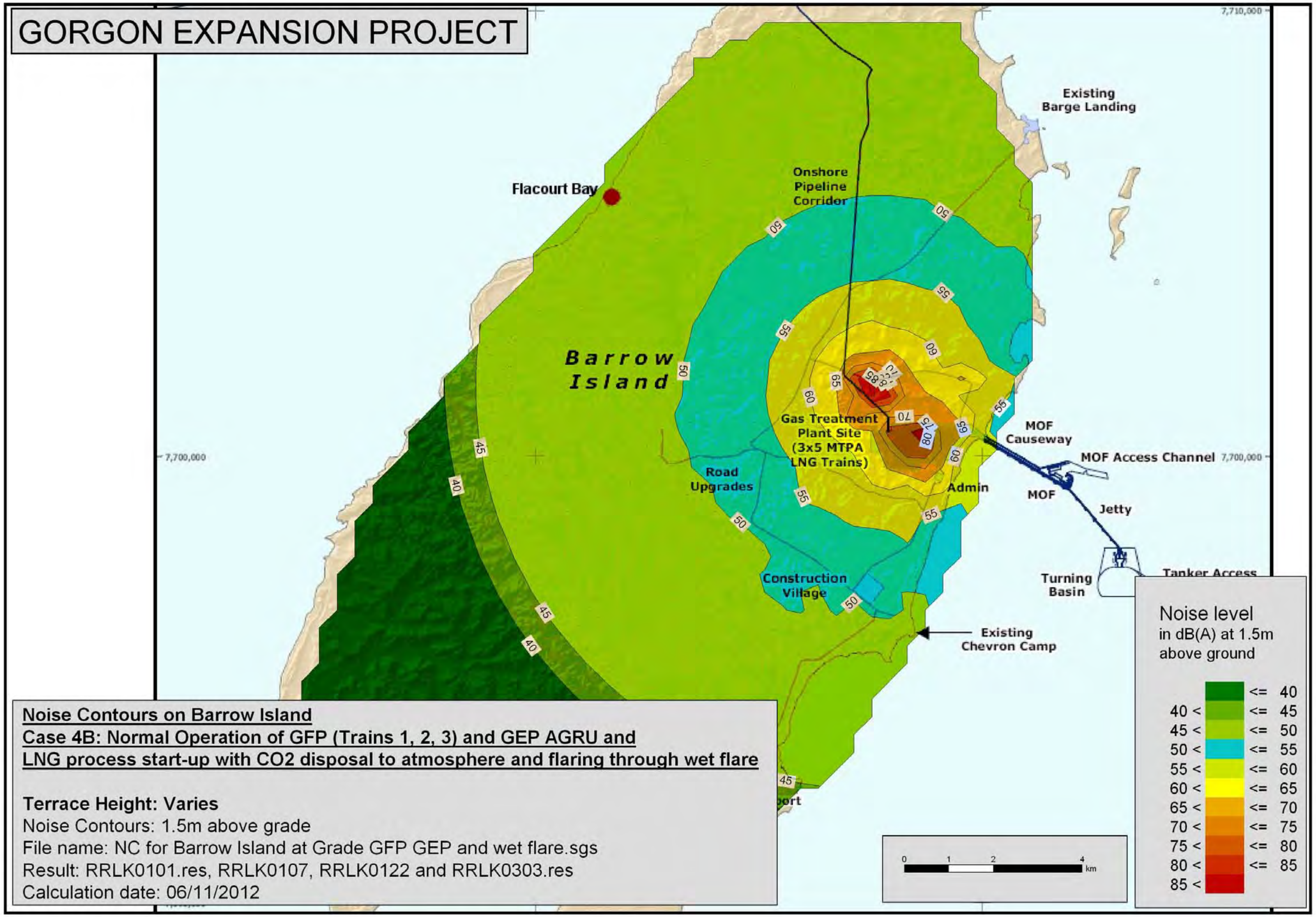

Figure C- 8: Calculated Noise Contours over Barrow Island. Case 4B: Gas Flaring and CO2 Disposal to Atmosphere during Train 4 AGRU and LNG Process Start-up and Normal Operation of Trains 1, 2 and 3. Routed through 114-HCV-0021 into wet flare stages

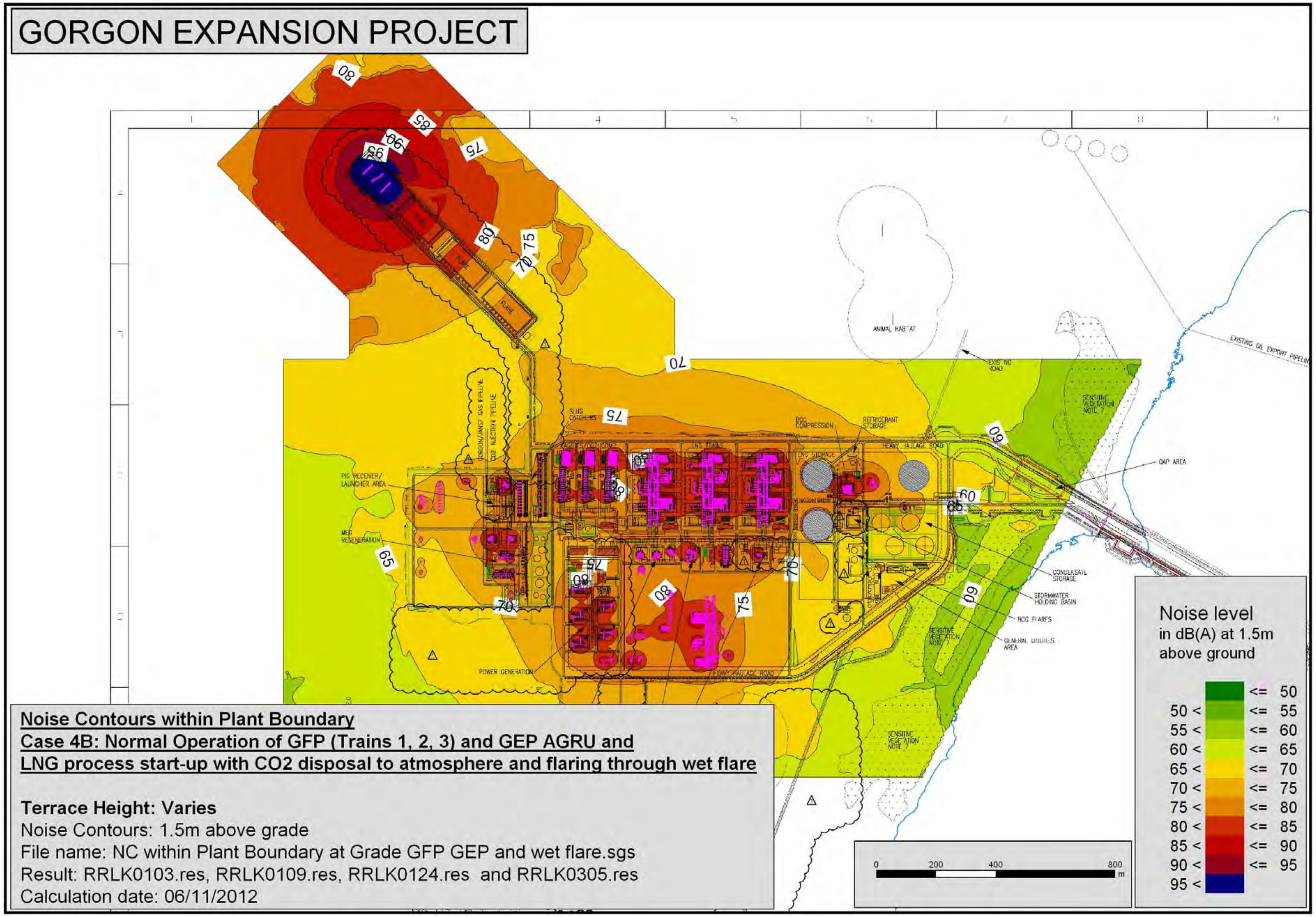

Figure C- 9: Calculated Noise Contours within Plant boundary. Case 4B: Gas Flaring and CO2 Disposal to Atmosphere during Train 4 AGRU and LNG Process Start-up and Normal Operation of Trains 1, 2 and 3. Routed through 114-HCV-0021 into wet flare stages

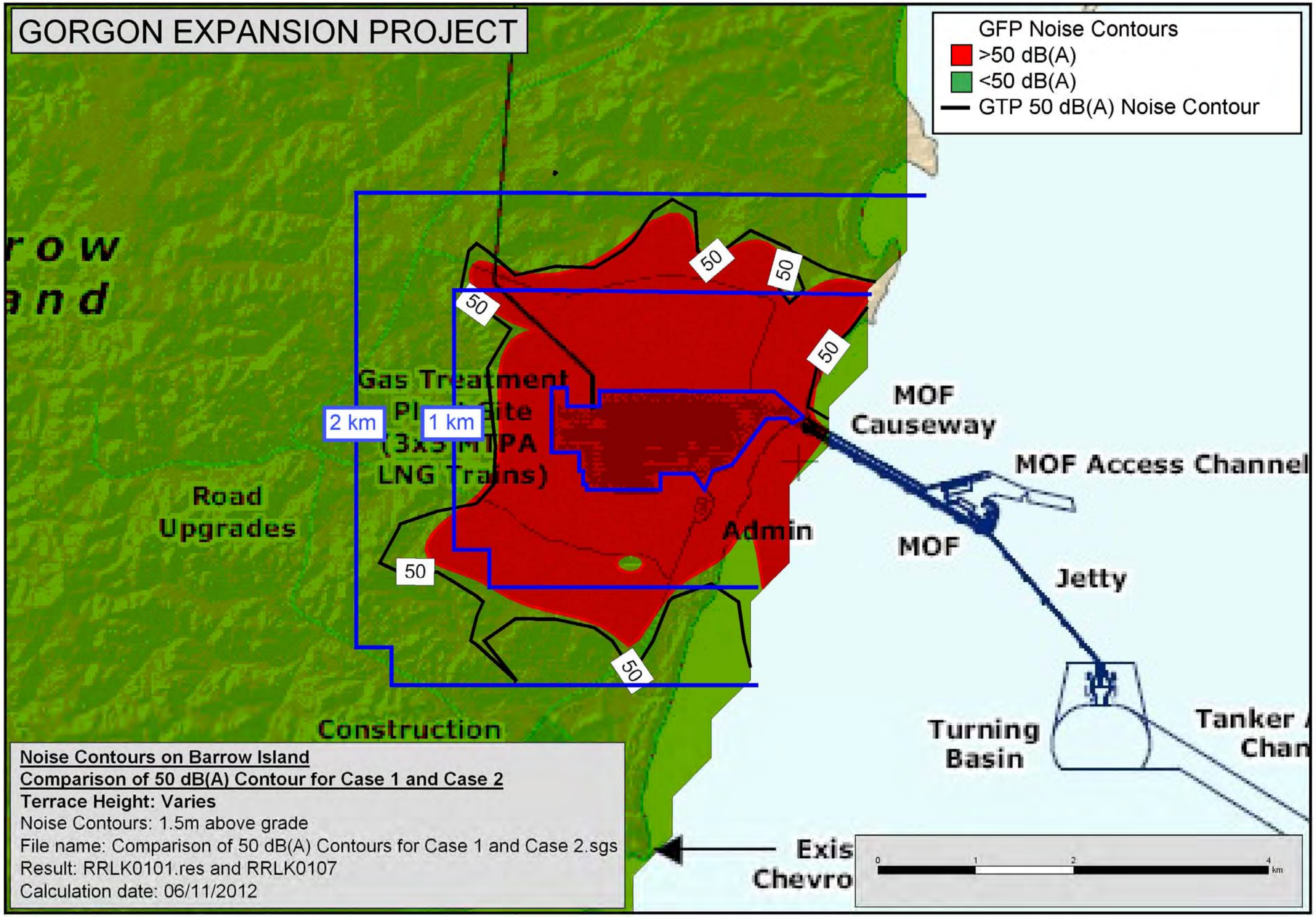

Figure C- 10: Comparison between 50 dB(A) contour for Case 1 and Case 2

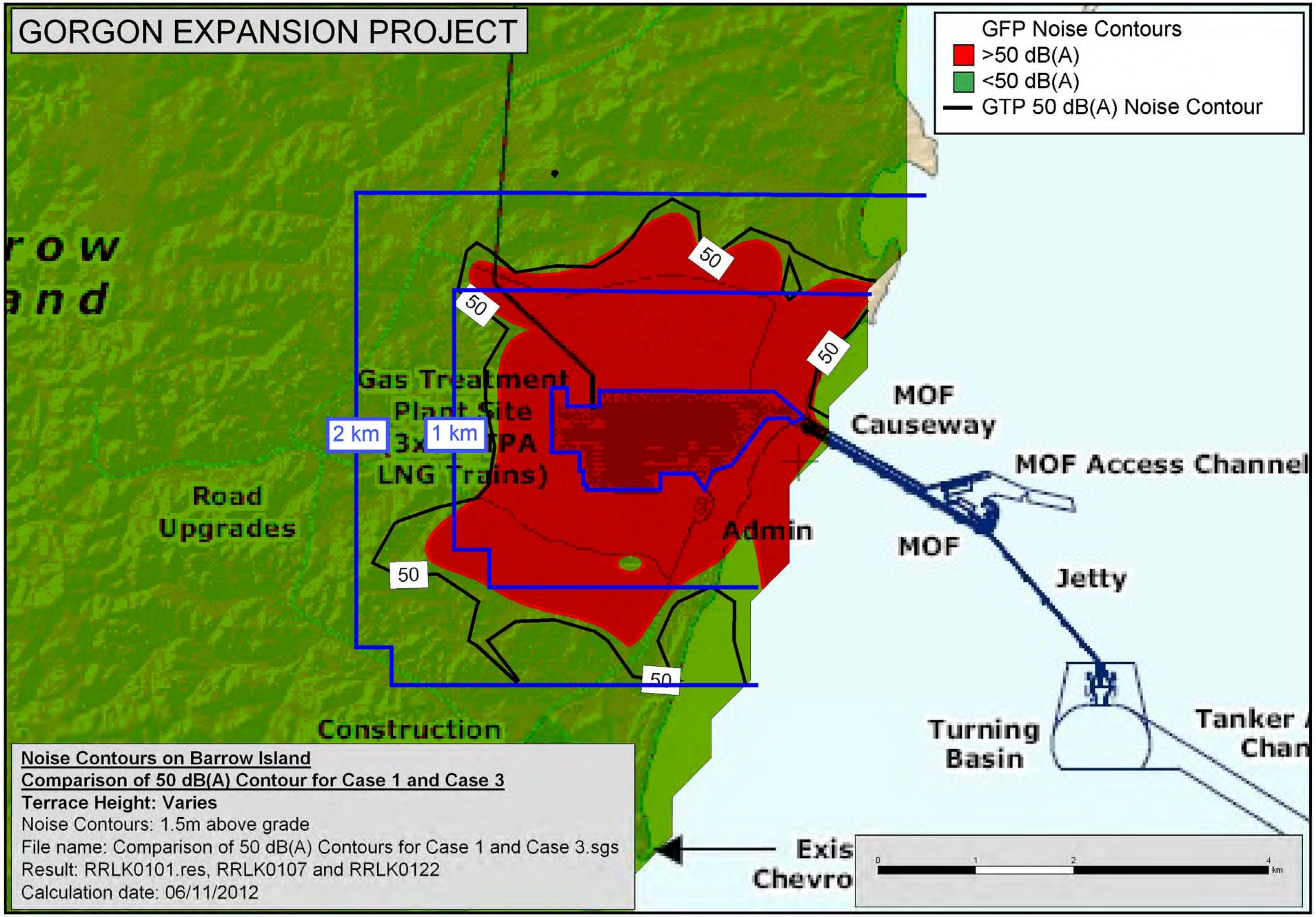

Figure C- 11: Comparison between 50 dB(A) contour for Case 1 and Case 3

Appendix D5: Assessment of Environmental Risk – Hydrocarbon Spill

RPS

ASSESSMENT OF ENVIRONMENTAL RISK: HYDROCARBON SPILL

Gorgon Gas Development, Fourth Train Proposal – Chandon Gas Field

G4-NT-REP00000009

ASSESSMENT OF ENVIRONMENTAL RISK: HYDROCARBON SPILL

Gorgon Gas Development, Fourth Train Proposal – Chandon Gas Field

G4-NT-REP00000009

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Report No: M1301001
Version/Date: Rev 0, March 2013

Document Status

Version	*Purpose of Document*	*Orig*	*Review*	*Review Date*	*Format Review*	*RPS Release Approval*	*Issue Date*
Draft A	*Draft for Internal Review*	*TraEyr/TyrMil/SeaFin*	*SeaFin*	*13.06.12*			
Draft B	*Draft for Client Review*	*TraEyr/TyrMil/SeaFin/ BetLew*	*SeaFin*	*18.06.12*	*SN 19.06.12*		
Draft C	*Draft for Client Review*	*TyrMil/BetLew/SeaFin*	*SeaFin*	*19.07.12*	*DC 19.07.12*		
Draft D	*Draft for Client Review*	*TyrMil/BryMcL/CaiDor/ SamDel*	*JerFit/ Tievan*	*25.02.13*	**DC 25.02.13*		
Rev 0	*Final for Issue*	*BryMcL*	*JerFit/Tievan*	*06.03.13*	*DC 06.03.13*	*J. Fitzpatrick*	*06.03.13*

Disclaimer

EXECUTIVE SUMMARY

Chevron Australia Pty Ltd (Chevron Australia) proposes to expand the production capacity of the previously approved Gorgon Gas Development via the incorporation of additional gas fields (the Fourth Train Proposal). The proposal includes drilling of a number of development wells in the Greater Gorgon Area and the installation of infrastructure to transport well fluids to processing facilities on Barrow Island.

The proposal is subject to assessment by the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) at Environment Impact Statement (EIS) level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). DSEWPaC developed Tailored Guidelines for the proposal requiring the EIS to specifically address potential impacts to four matters of National Environmental Significance (NES) from a range of possible hydrocarbon spill scenarios, including an uncontrolled well blowout. The controlling provisions (matters of NES) for the assessment of this project under the EPBC Act are:

- Sections 15B and 15C (National Heritage Places)
- Sections 18 and 18A (Listed Threatened species and communities)
- Sections 20 and 20A (Listed Migratory species)
- Sections 23 and 23A (Commonwealth Marine Environment).

RPS was engaged by Chevron Australia to assess the potential for environmental impacts to matters of NES as a result of a spill of hydrocarbons from the Fourth Train Proposal using an Environmental Risk Assessment. The risk assessment looked at the probability that matters of NES would be exposed to spilled hydrocarbons, the potential for impacts on these receptors and the expected consequences of exposure, given the management (preventative and response) measures to be put in place. The probability of exposure to spilled hydrocarbons was derived from the probabilities of the spills occurring and the chance that the spilled matter would be transported to an identified sensitive area. The transport and degradation of spilled hydrocarbons was modelled using a sophisticated fate and trajectory model accounting for forcing factors such as winds, currents, dissolution, degradation, evaporation and air and sea temperatures.

The spill modelling was based on a range of credible, but “worst case” scenarios encompassing a range of spill locations, spill volumes, oil types and seasons. Separate spill scenarios were modelled for the summer, autumn transition, winter, and spring transition periods, to cover the range of oceanographic and meteorological conditions under which a spill may occur. Conservatism was applied to the modelling by assuming that there would be no intervention after the accidental release, whereas realistically, spill response procedures would significantly reduce the volumes lost or their dispersion from the spill site. Conservatism was also added in choosing spill locations to model and in setting the thresholds for environmental harm.

Spill locations were selected to represent the most likely or "worst case" scenarios associated with the offshore Fourth Train Proposal. These were:

- an uncontrolled well blowout at the Chandon field where the well fluids are the 'wettest'; having the highest ratio of condensate to gas, a spill here will release more of the volatile liquid hydrocarbons which will form a slick and less gas which will rapidly disperse to atmosphere
- intrafield flowline ruptures at the Chandon and Jansz fields
- spills from vessel refuelling accidents at the Chandon field and along the Feed Gas Pipeline
- Feed Gas Pipeline ruptures at a range of distances from Barrow Island
- a spill at the Materials Offloading Facility (MOF)
- a spill from a tanker grounding adjacent to the LNG Jetty.

Thresholds for environmental harm from spilled hydrocarbons were used to determine which areas required consideration of potential impacts, for each spill scenario. The thresholds were based on the potential for toxicity (concentration of entrained or dissolved hydrocarbons) and for smothering/oiling (thickness of surface slicks). Conservative hydrocarbon concentration thresholds were applied, ranging from recognised no-effects concentrations (to delineate the geographical scope beyond which no further assessment was required), to concentrations at which some ecotoxicological effects may occur. Conservative surface slick thickness thresholds, similarly representing the lower end of the range of thicknesses at which physical effects would be expected, were also applied.

Preventative and spill response measures were taken into account after probabilities were calculated for "worst case" scenarios, to qualitatively determine the overall likelihood of environmental consequence for each scenario.

The main outcomes of the Environmental Risk Assessment are:

- The liquid hydrocarbons potentially involved in spill scenarios generally comprise light oils that are characterised by very high evaporation rates and, given that toxicity is primarily due to volatile aromatic components, will exhibit rapidly attenuating toxicity. The potential for environmental impacts due to toxicity would therefore be limited to a relatively short period following release of a light oil (condensate, diesel or light crude). However, in the event of a tanker grounding, bunker fuel oil (which is a heavier, more persistent oil) may be released, which may have more widespread and longer lasting physical impacts.
- Chandon condensate is a very light oil containing a low proportion of hydrocarbons that would be categorised as 'persistent'. Consequently, the primary source of potential environmental effects would be toxicity associated with the aromatic components in the

fresh condensate. The aromatics in Chandon condensate are largely in the BTEX group that is characterised by high volatility and solubility, especially in the warm air and sea surface temperatures prevailing in the region. Aromatic components would rapidly dissipate through natural processes.

- With the preventative measures proposed, the probability of a major spill affecting sensitive inshore areas during development (including development drilling) or operation of upstream Fourth Train Proposal facilities is considered to be Remote to Rare: less than 9.63×10^{-6} (1 in 103,842 chance) for a blowout, 1.00×10^{-5} (1 in 100,000 chance) for a pipeline rupture, and 1.08×10^{-7} (1 in 9,259,259 chance) for a major fuel spill (vessel fuel tank rupture, 80 m^3).

- An extended (11 weeks) sub-sea blowout at the Chandon field was modelled to represent a "worst case" scenario for a well-head release. If there was no intervention, the spilled condensate could be transported considerable distances, with a moderate to high probability of entrained oil eventually reaching inshore areas in all seasons. The Ningaloo Coast National Heritage Place (NHP) and many of the offshore islands of the Pilbara would likely be exposed to hydrocarbons under certain metocean conditions, but generally at levels unlikely to impact Migratory or Threatened fauna or habitats, given that weathering that would take place during the extended period of travel required to reach shorelines would reduce the toxicity. Intervention would significantly reduce this risk.

- Weathering of the surface slick during transport from a blowout at the Chandon field would make it unlikely (≤3% probability) that even a sheen (>1 μm thick) of condensate would reach any inshore areas during any season. There is a very low (1%) probability that a slick (>10 μm thick) could reach inshore areas of the Ningaloo Coast NHP during winter, but only after an extended period (29 days) at sea. The very low volumes of condensate that would persist for this time, and the weathering that would have occurred *en route*, suggest the hydrocarbon residues reaching the inshore areas would have very limited potential for acute toxicity or oiling effects. The environmental consequences of exposure to entrained and dissolved aromatic hydrocarbons would vary depending on the timing of exposure. The sensitivity of the exposed biota would vary in response to key life cycle events, the presence and intensity of other stresses, and the extent and location of exposure. "Worst case" minimum travel time for entrained hydrocarbons to reach the Ningaloo Coast NHP in concentrations that may cause adverse effects was 10 days or greater, by which time the potential for acute toxicity would be reduced. The concentrations of aromatics predicted to reach inshore areas were very low (<50 ppb), suggesting widespread adverse impacts to the area's environmental values are unlikely.

- The environmental consequences of a hydrocarbon release from the Feed Gas Pipeline would be strongly influenced by the location of the release. A pipeline rupture close to Barrow Island (200 m from shore) would have the greatest potential for substantial impacts to sensitive nearshore habitats, but modelling indicates that even a large release (593 m^3) would have substantially reduced potential for impact if it occurred further (>14 km) offshore.

- In the event of a rupture of an Intrafield Flowline, habitats of importance to Migratory and Threatened fauna of the region are unlikely to be exposed to levels of surface oil, entrained or dissolved hydrocarbons that might cause adverse effects, during any season. Low concentrations of dissolved aromatics (5-100 ppb) and elevated concentrations of entrained oil (>500 ppb) are not predicted to extend beyond the immediate vicinity (1.5 km^2) of the spill location.

- In the event of a major fuel spill at the Chandon field, there would be a low probability the spilled oil causing adverse impacts to Migratory or Threatened fauna or habitats of importance to their survival. Oil released during a major fuel spill at the Chandon field would weather rapidly to non-toxic concentrations before reaching any inshore areas (e.g. turtle nesting beaches) or migratory pathways (e.g. the humpback whale migration route).

- Spill modelling indicates that the most likely spill scenario (small fuel oil (diesel) spill, <2.5 m^3) would have little potential for impacts to inshore areas, even if it occurred in close proximity to Barrow Island, due to the low volume and volatile nature of spilled diesel.

- Offshore islands of importance to fauna of conservation significance, including seabirds and turtles, are unlikely to be exposed to high concentrations of surface and/or submerged hydrocarbons from a blowout during any season. Entrained oil was predicted to reach several of the islands in the region, including those of the Southern Island Group, but generally at low levels and after extended transport periods (minimum of 12 days until contact), suggesting the potential for toxicity or physical oiling impacts would be limited. The risk of considerable adverse effects to regional populations of Threatened or Migratory fauna is low based on the type and concentrations of hydrocarbons predicted to reach them.

- Pelagic marine life would potentially be exposed to hydrocarbons released by a major spill over an extended area surrounding the spill site. However, considering the distance of the field from biologically important areas, and the limited area over which fresh diesel or condensate would extend relative to the distributions of fauna involved, the likelihood of substantial adverse impacts at species level for any Threatened or Migratory fauna known from the region is low.

- The Fourth Train Proposal represents an incremental increase over the Foundation Project in the risks associated with downstream spills. For example, there will be an increase in the number and frequency of export tanker movements and refuelling events. Modelling undertaken for the Foundation Project indicates that the potential for adverse impacts is limited by the nature and quantities of hydrocarbons involved. The likelihood of the Fourth Train Proposal resulting in a refuelling or tanker grounding incident off the east coast of Barrow Island that caused considerable adverse environmental impacts was considered to be very low (7.51×10^{-6}).

- A number of commercial fisheries operate within the area of potential exposure to a major spill; however, significant impacts are unlikely. Most of the commercial fisheries operating in the area have extensive fishing zones that would only be partially affected by any spill event.

Further, the commercially exploited (target) species predominantly live at depth and would have limited exposure to surface spills of hydrocarbons. Fouling of fishing gear is unlikely to be a significant risk as most fishers work in the pelagic or demersal zones and they could remove their gear in the event of a spill. The modelling indicates that there is potential for exposure to the pearl farms in the Montebello Islands under the well blowout, Feed Gas Pipeline rupture and tanker grounding scenarios (potentially involving condensate, diesel, light crude or bunker fuel oil). Pearl oysters are sensitive to soluble aromatic hydrocarbons and exposure could result in acute or chronic effects to oysters and/or the fouling of infrastructure. However, the modelling indicates long periods between time of release and contact in these pearling areas, limiting the potential for exposure to aromatic components and associated toxicity effects. The time before potential exposure also allows mitigation measures to be implemented.

- With the very low probability of a major spill occurring, and the response arrangements in place to avoid or reduce environmental effects in the event of a spill, the level of environmental risk for a hydrocarbon spill associated with the Fourth Train Proposal has been assessed as Trivial to Medium under the Fourth Train Proposal Risk Matrix.

Potential impacts to the four controlling provisions of the project (as specified by DSEWPaC) are summarised in Table ES-1.

Table ES-1: Summary of Potential Impacts to Ecologically Sensitive Receptors

Ecologically Sensitive Receptor	Summary of Likely Impacts
Ningaloo Coast NHP	
Benthic habitats	Potential for impacts is low given exposure limited to condensate spill and extended travel times from the spill site would result in significant weathering and corresponding reduction in toxicity. No exposure to elevated (>500 ppb) dissolved aromatic concentrations during any season. Volumes of surface and entrained oil predicted to reach inshore areas generally low, reducing the potential for physical oiling of fauna or habitats. Little potential for widespread impacts to the Ningaloo coral reef or to benthic seagrass habitats that may support EPBC listed marine turtles and dugongs.
Whale sharks	Whale sharks are at greatest risk while aggregating at the Ningaloo NHP. However, widespread adverse impacts to whale sharks aggregating at Ningaloo NHP are considered unlikely. Very low levels of surface hydrocarbons and dissolved aromatics predicted to reach the Ningaloo coast from a spill during the autumn-winter aggregation period. Effect of exposure to "worst case" entrained concentrations uncertain but toxicity effects unlikely due to extended travel time (>10 days) and slicks predicted to remain below levels expected to cause physical oiling impacts (<500 ppb) under 97% of conditions. Risks to whale sharks during other times of the year are negligible, given that whale sharks are absent or present in only very low numbers.
Marine turtles	Marine turtles unlikely to be exposed to inhalation effects from volatised hydrocarbons given the extended travel time of surface slicks from the spill site and low volumes predicted to persist. Exposure to "worst case" entrained concentrations may cause injury or irritation to soft tissues in exposed individuals. Possibility that spills during spring or summer could contact nesting females leading to reduced nesting success, but unlikely to involve large numbers of any species. Widespread impacts to important food sources unlikely given types and concentrations of hydrocarbons.
Migratory seabirds and shorebirds	Potential for widespread impacts is limited as surface oil thicknesses predicted to remain below levels reported to cause harm to seabirds or shorebirds. Only one of the three Migratory seabirds known to breed in the Ningaloo Coast NHP is listed as Threatened and all have widespread regional distributions.
Marine mammals	Extended travel time required for any surface slicks to reach the Ningaloo NHP indicates that adverse effects from inhalation of volatised hydrocarbons are unlikely. Direct contact with entrained hydrocarbons not expected to have substantial deleterious effects given effectiveness of cetacean's skin as a barrier to toxicity, low (<500 ppb) levels predicted from a spill under most conditions, and reduced toxicity following long travel times. Little potential for widespread impacts to important food sources, such as the seagrass meadows preferred by dugongs.
Anchialine communities	The low concentrations of spilled oil predicted (with low probability) to reach the Ningaloo NHP are unlikely to be sufficient for contaminated seawater to diffuse through subterranean connections into anchialine communities. Spill response measures would be expected to further reduce this risk.
Threatened and Migratory Species and their Habitats	
Fish	Whale sharks are only likely to be exposed to low levels of highly weathered condensate if a spill occurs during the aggregation period and the probability of considerable impacts to the species is low. A spill close to Barrow Island may generate elevated levels of hydrocarbons in inshore areas potentially resulting in acute and/or chronic effects on the dwarf sawfish which may be present in low numbers, and sawfish habitat.

Ecologically Sensitive Receptor	Summary of Likely Impacts
Marine mammals	Potential for acute toxicity impacts if marine mammals are present in the vicinity of a release, particularly via inhalation of aromatic compounds if surfacing in areas of freshly released oil. Direct contact may cause irritation in sensitive tissues but there is little empirical evidence on impact of hydrocarbons to marine mammals. Modelling indicates that aggregation areas (such as the Exmouth Gulf for humpback whales and dugongs) are unlikely to be affected, but a major spill or leak occurring close to the humpback whale migration route during migration season could coincide with substantial numbers of whales. Duration and extent of potential impact restricted by rapid dispersion of slicks and high evaporation rates of aromatic components and unlikely to be meaningful at population level. Small numbers of migratory dolphins, whales and dugongs present in the waters of the east coast of Barrow Island may suffer physiological effects from exposure to fresh hydrocarbons in the event of a release from a grounded export vessel or a spill from refuelling activities at the MOF. However, spatial extent and the duration of potential impact are limited, reducing the likelihood for widespread adverse effects. Widespread or long term impacts to important habitat, including seagrass meadows that support foraging dugongs, are unlikely. Modelling predicts low probability (<5%) of entrained hydrocarbons reaching Exmouth Gulf, which is a biologically important area for dugongs and humpback whales; therefore it is highly unlikely that individuals resting or foraging in the gulf would be affected. No exposure was predicted for any other biologically important areas or critical habitat for marine mammals.
Marine turtles	Offshore spill unlikely to result in widespread or long term impact on marine turtles or areas of important habitat, including nesting beaches. Spills occurring close to the coast of Barrow Island would likely have adverse impacts on the health of adult turtles, affect reproductive success and may result in the mortality of hatchlings. A spill during the nesting season may affect biologically important internesting/foraging areas for green, hawksbill and flatback turtles around Barrow, Montebello and Lowendal Islands. Staggered nature of turtle nesting in the species involved indicates only a proportion of local and/or regional populations likely to be affected by exposure to spilled hydrocarbons in their internesting or foraging habitats.
Marine avifauna	Spill at the Chandon gas field unlikely to affect large numbers of any seabirds given remote location and generally low volumes predicted to reach inshore areas. A greater potential of exposure to seabird biologically important areas (waters surrounding nesting islands) was predicted. Spill close to Barrow Island could affect Migratory species via plumage fouling, ingestion and/or reduction in breeding success and potentially physical oiling and toxicity effects. Species that breed at locations predicted to be potentially affected by a spill associated with the Fourth Train Proposal all have widespread regional distributions, suggesting impacts to regional populations or at species level are unlikely.
Commonwealth Marine Environment and Key Ecological Features (KEFs)	
Seabed	Localised areas of seabed at the release site could be directly affected by condensate during pipeline rupture or blowout. Scenarios predicted to have the greatest extent within the Commonwealth Marine Area only involve very light oils (condensate or diesel) and therefore post-spill sedimentation of hydrocarbons not expected.
Benthic habitats and fauna	Water depths in Commonwealth Marine Area and highly buoyant and non-persistent nature of light oils associated with scenarios that could affect extensive area suggests widespread affects to benthos unlikely. Possibility of exposure higher in vicinity of release site for subsea spill scenarios, but impacts are expected to be short-term and re-colonisation rapid following degradation of hydrocarbons. Potential for lasting, adverse impacts limited given the ubiquitous nature of benthic habitats and fauna across the region and localised and temporary nature of likely effects.

Ecologically Sensitive Receptor	**Summary of Likely Impacts**
Water column (including Commonwealth waters adjacent to Ningaloo Reef (KEF)) Values of KEF: High productivity and marine life aggregations.	Above threshold concentrations of hydrocarbons predicted to travel up to 1,350 km from release site in "worst case" scenario but significant reduction in water quality following a spill is likely to be temporary at any location and limited in extent due to the rapid weathering, dispersion and degradation of the types of oil involved (condensate or diesel). Even in the event of a "worst case" blowout, highest predicted "worst case" aromatic concentrations in the water column outside the immediate release site are an order of magnitude lower than the relevant ANZECC/ARMCANZ guidelines for protection of 99% of marine species.
Pelagic marine fauna and habitats	Elevated hydrocarbon concentrations in vicinity of release site likely to cause acute toxicity and/or physical oiling in individual pelagic fauna. Absence of aggregation habitats in Commonwealth Marine Area of Fourth Train Proposal Area suggests impacts at population level unlikely in any species, although spill in/near humpback migration routes during migration season could expose substantial numbers. Extent and duration of potential impacts from larger spills limited by light nature of oils involved (condensate and diesel) with very high evaporation and dissolution rates for toxic components and low proportion of persistent hydrocarbons.
Other users of the marine environment	Likely impacts limited to short-term displacement of commercial activities, including commercial fishing, with most of the commercial fisheries operating in the area having wide ranging fishing zones and targeting species that occur predominately at depth with reduced potential to suffer adverse effects.
Exmouth Plateau (KEF) Values of KEF: Unique seafloor feature with regionally significant ecological properties.	The release sites for a well blowout and major and minor spills from a vessel have been modelled within the waters associated with the Exmouth Plateau. Pelagic habitats and associated fauna valued within this KEF are most likely to be exposed to oil released from a well blowout or vessel spills which would impact the water quality of a small portion of the waters of the Exmouth Plateau. Given condensate associated with a well blowout will evaporate on exposure to the atmosphere, and the aromatic components of a diesel spill will similarly evaporate, the only likely impacts to the pelagic habitat are from entrained oil. This may include physical oiling, ingestion and damage to internal organs causing acute / chronic toxicity effects. Only a portion of the KEF is likely to be affected, and only low numbers of pelagic fauna are likely to be present at the time of a spill, therefore the function and integrity of the Exmouth Plateau is unlikely to be permanently affected by a spill.
Ancient Coastline at 125 m Depth Contour (KEF) Values of KEF: Unique seafloor feature with regionally significant ecological properties.	No adverse impacts are expected to the Ancient Coastline as it lies 125 m under the water surface and the spilled hydrocarbons would be on or in the surface waters. The waters overlying portions of the KEF may be contacted by a rainbow sheen during a well blowout and releases of light crude oil or bunker fuel oil from a grounded tanker adjacent to the LNG Jetty. Entrained oil may affect surface waters over of the KEF in autumn in the event of a well blowout. However concentrations will be low (<100 ppb) with toxicity reduced due to travel time and weathering. Low levels of dissolved hydrocarbons, likely to be devoid of aromatic components, have a 10% probability of contact during summer and autumn. It is therefore unlikely adverse effects on function or integrity of the KEF will occur.
Canyons Linking the Argo Abyssal Plain and Scott Plateau (KEF) Values of KEF: High productivity and marine life aggregations.	No permanent adverse impacts are expected to this KEF. Exposure is limited to <100 ppb of entrained hydrocarbons reaching the canyons during a well blowout scenario in all seasons. Given the distance (785 km north-east) travel times and distance of the entrained hydrocarbons, reduction of toxicity and low concentrations of entrained hydrocarbons are unlikely to affect the functioning and integrity of the ecosystem.
Glomar Shoals (KEF) Values of KEF: High productivity and marine life aggregations.	No permanent adverse impacts are expected to this KEF which lies approximately 33 - 77 m under the sea surface. Low concentrations of entrained oil (<100 ppb) may reach the Glomar Shoals as a result of a well blowout, during summer, winter and spring. The loss of volatile components of oil due to the weathering as the oil travels approximately 245 km east from the release site to the Glomar Shoals, means it is unlikely to have adverse effects on the fish and pelagic fauna associated with the Glomar Shoals. Therefore it is unlikely to adversely affect the ecosystem function or integrity of the KEF.

Ecologically Sensitive Receptor	Summary of Likely Impacts
Wallaby Saddle (KEF) Values of KEF: High productivity and marine life aggregations.	No permanent adverse impacts are expected to this KEF. Likely impacts may occur in autumn from a well blowout scenario only, but are limited to entrained oil concentrations of <100 ppb (100% probability) to <500 ppb (5% probability). Surface slicks are highly unlikely (1% probability). Deep water depths (>2000 m) are likely to preclude impacts to the benthos, and concentrations of entrained hydrocarbons are unlikely to cause lethal and sub-lethal effects to pelagic species. Therefore ecosystem functioning and integrity is not likely to be compromised by a well blowout.
Canyons Linking the Cuvier Abyssal Plain and Cape Range Peninsula (KEF) Values of KEF: Unique seafloor feature with regionally significant ecological properties.	No adverse impacts are expected to this KEF. Effects would be limited to a silver sheen in autumn (10% probability) from a well blowout. Entrained oil may reach the canyons however concentration are predicted to be <100 ppb, at which pelagic species are unlikely to be adversely impacted.
Continental Slope Demersal Fish Communities (KEF) Values of KEF: High species endemism.	Fish, fish eggs and larvae associated with the continental slope demersal fish communities may be exposed to entrained oil resulting from a well blowout. Concentrations are likely to be <500 ppb, and impacts would be restricted to a small portion of the continental slope and hence a small portion of demersal fish communities. Toxicity levels of the entrained oil are likely to reduce over time, therefore reducing the risk of acute toxicity of fish. Based on the depths involved (and the buoyancy of the majority of oil types considered), sedimentation of oil is unlikely, therefore long-lasting effects on the habitat of demersal species are unlikely.
Mermaid Reef and Commonwealth Waters Surrounding Rowley Shoals (KEF) Values of KEF: High productivity and marine life aggregations.	Very low probabilities of low concentrations of entrained oil reaching this KEF only under certain conditions. These concentrations are highly unlikely to adversely impact the functioning of this KEF.
Seringapatam Reef and Commonwealth Waters in the Scott Reef Complex (KEF) Values of KEF: High productivity and marine life aggregations.	Exposure limited to very low probabilities of low concentrations of entrained oil reaching this KEF only under certain conditions. These concentrations are highly unlikely to adversely impact the functioning of this KEF.
Ashmore Reef and Cartier Island and Surrounding Commonwealth Waters (KEF) Values of KEF: High productivity and marine life aggregations.	No contact of any oil type predicted, under any conditions.

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LIST OF ACRONYMS

Term	Definition
ALARP	As Low As Reasonably Practicable
AMOSC	Australian Marine Oil Spill Centre
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment Conservation Council
APASA	Asia Pacific Applied Science Associates
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BOP	Blow Out Preventer
BTEX	Benzene, toluene, ethylbenzene and xylenes
COLREGS	International Regulations for the Prevention of Collision at Sea 1972
DP	Dynamic Positioning
DSEWPaC	Department of Sustainability, Environment, Water, Populations and Communities
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EIS	Environmental Impact Statement
HB	Hand Book
HPHT	High Pressure or High Temperature
IMR Plan	Inspection, Maintenance and Repair Plan
KEF	Key Ecological Feature
LNG	Liquefied Natural Gas
MEG	Monoethylene glycol
MOF	Materials Offloading Facility
MOPP	Marine Oil Pollution Plan
MTPA	Million Tons Per Annum
NA	Not Applicable
NC	No Contact
NES	National Environmental Significance
NHP	National Heritage Place
NOEC	No Observed Effect Concentration
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
OSORP	Oil Spill Operational Response Plan
PAH	Polyaromatic Hydrocarbons
PER	Public Environmental Review
PTS	Pipeline Terminating Structure
ROV	Remotely Operated underwater Vehicle
TPH	Total Petroleum Hydrocarbon
WA	Western Australia
WestPlan-HAZMAT	Western Australia Hazardous Materials Emergency Management Plan
WestPlan-MOP	Western Australian Marine Oil Pollution Plan

GLOSSARY

Term	Definition
Acute toxicity	Rapid adverse effect (e.g. death) on a living organism caused by exposure to a substance.
Aromatic hydrocarbon	Hydrocarbon which contains one or more benzene rings with alternating double and single bonds between carbon atoms. Aromatic hydrocarbons (aromatics) can be monocyclic (MAH) or polycyclic (PAH).
Autumn transition	April
Blowout	An incident where formation fluid flows out of the well or between formation layers after all the predefined technical well barriers or activation of the same have failed.
BOP	A Blow Out Preventer (BOP) is a large valve at the top of a well that may be closed if the control of formation fluids is lost. Closing this valve usually regains control of the reservoir.
BTEX	Benzene, toluene, ethylbenzene and xylenes. Some of the volatile organic compounds present in petroleum derivatives.
Chronic toxicity	Ecotoxicological effects exhibited after continuous or repeated exposure.
Condensate	Very light hydrocarbons that are gaseous in a reservoir but condense to form a liquid as they rise to the surface where the pressure is much less (retrograde condensation).
Consequence	The implication of the potential impact.
Degradation of hydrocarbons	The bacterial or photochemical breakdown of oil compounds from their long carbon chain form into simpler and biologically inert forms.
Degradation of habitat	The process in which the quality of natural habitat that supports an organism or biological population is reduced.
Dissolution	The process whereby soluble components of an oil mixture dissolve into the water column to form a hydrocarbon solution. Because dissolution requires migration of the soluble oil compounds across an oil-water interface, the rate of dissolution will be greater where there is a greater surface area to volume ratio. Thus, the rate of dissolution will be faster from entrained droplets than from surface-bound slicks.
Downstream	The oil and gas operations that take place after the production phase.
EC50	Median Effective Concentration or Half Maximal Effective Concentration. EC50 refers to the concentration of a toxicant which induces a response halfway between the baseline and maximum after a specified exposure time.
Entrained oil	Droplets or globules of oil that physically mix (but are not dissolved) into the water column. Physical entrainment can occur either during pressurised release from a sub-surface location, or through action of breaking waves.
Evaporation	The process whereby volatile components of an oil mixture are released from a liquid state on the sea surface to gas in the atmosphere.
Fresh hydrocarbons	Hydrocarbons newly released to the receiving environment, before the weathering process begins.
Full bore	Unrestricted leak resulting in maximum volume of spill.
Hydrocarbons	A class of liquid, solids or gas organic compounds containing only carbon and hydrogen, the basis of almost all petroleum products.
Impact	Direct interaction of a stressor with an environmental or social factor.
Inshore	The near coastal waters extending from the coastline out to three nautical miles.
Intertidal	The portion of coastline between the high tide mark and low tide mark.

Term	Definition
KEF	Key Ecological Features (KEFs) are regionally important elements of the Commonwealth marine environment that contribute to ecosystem functioning and integrity or biodiversity of the region.
LC50	Lethal Concentration 50%. LC50 refers to the toxicity that will kill half of the sample organism test population after a specified duration.
Light oil	Oil that has a low density (lighter than water) and flows freely at room temperature.
Likelihood	The probability of a stressor impacting on an environmental factor.
Likely impact	An impact that has a real or not remote chance (or possibility) of occurring as defined in DSEWPaC’s Tailored Guidelines (DSEWPaC 2011). Likely impacts have been incorporated into the term ‘potential impacts’ in this assessment.
Local/Localised	Impacts restricted to discrete spatial areas, rather than widespread through a habitat or range of habitats.
Long-term	More than five years.
NOEC	No Observed Effect Concentration. NOEC refers to the highest concentration of a toxicant to which organisms are exposed in a full lifecycle or partial life cycle test that causes no observable effect in the organism.
Non-HPHT wells	A well that is not considered to be High Pressure or High Temperature.
Offshore islands	Barrow, Lowendal and Montebello Islands.
Persistent	Existing or continuing for a long period of time.
Reservoir	A formation which holds hydrocarbons within the pore spaces between individual grains.
Sedimentation	The process whereby oil droplets sink and adhere to the seabed. The specific gravity of most oil types is lower than marine water. Sedimentation for these oils requires the loss of light fractions and adhesion to suspended sediment particles.
Short-term	Less than five years.
Spring transition	October
Stranding	The process whereby oil slicks or films adhere to coastlines. Stranding is a dynamic process that is influenced and limited by the viscosity of the oil and the absorbance of the coastline (e.g. sand versus rock). A proportion of the oil may subsequently detach/resurface and be transported away by currents.
Summer	November to March.
Surface oil	Oil that remains bound to the sea surface as a slick or film due to buoyancy and surface tension.
Tailored Guidelines	Guidelines issued by DSEWPaC to Chevron Australia for the preparation of a Draft Environmental Impact Statement of the Fourth Train Proposal in September 2011.
Temporary	Impacts that are short-term and end on removal of the stressor (e.g. noise impacts during construction will cease as soon as the noise source is removed).
TPH	Total Petroleum Hydrocarbon. TPH is used to refer to any mixture of hydrocarbons measured in crude oil.
Trajectory	The path or pattern of movement of hydrocarbon plumes over time.
Upstream	Oil and gas operations that involve the exploration for, recovery of, and the production of oil and gas.
Volatile	Evaporating readily at normal temperatures and pressures.
Weathering	Physical, chemical and biological processes which act to degrade or break up a substance. Weathering of spilled hydrocarbons results in attenuating toxicity and a reduction in physical presence.

Term	Definition
Widespread impacts	Impacts affecting large portions of habitat, habitat ranges or biological communities, rather than isolated or localised impacts.
Winter	May to September.

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APPENDICES

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1.0 INTRODUCTION

1.1 Background

Chevron Australia Pty Ltd (Chevron Australia), on behalf of the Gorgon Joint Venturers, proposes to expand the production capacity of the Gorgon Gas Development from the 15 million tons per annum (MTPA) currently approved (Foundation Project) to 20 MTPA, via the Gorgon Gas Development Fourth Train Proposal (hereafter referred to as the 'Fourth Train Proposal').

The Fourth Train Proposal involves the development of gas fields in the Greater Gorgon Area, within the Carnarvon Basin on the North West Shelf, more than 130 km off the north-west coast of Western Australia. It includes the development of an additional four gas fields in the Greater Gorgon Area (Figure A), namely:

- Orthrus (approximately 95 km from Barrow Island)
- Geryon (approximately 95 km from Barrow Island)
- Maenad (approximately 100 km from Barrow Island)
- Chandon (approximately 175 km from Barrow Island).

The Fourth Train Proposal involves the drilling of approximately 16 production wells and the installation and operation of a Feed Gas Pipeline System (FGPS) to transport gas, condensate and produced water from the gas fields to the gas processing facilities on Barrow Island. The FGPS is expected to include the construction of an additional Feed Gas Pipeline to Barrow Island with Intrafield Flowlines linking the field wells to the Feed Gas Pipeline. The Intrafield Flowlines will be located in Commonwealth waters in depths of up to 1,500 m, whilst the Feed Gas Pipeline will traverse both Commonwealth and State waters.

Chevron Australia referred the Fourth Train Proposal to the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 27 April 2011. DSEWPaC subsequently deemed the proposal would require assessment at Environmental Impact Statement (EIS) level and issued Chevron Australia with Tailored Guidelines for the preparation of a draft EIS on 19 September 2011.

The Tailored Guidelines identified four matters of National Environmental Significance (NES) as relevant to the Fourth Train Proposal (EPBC Ref: 2011/5942) and required their assessment in the EIS. The controlling provisions (matters of NES) for the assessment of this project under the EPBC Act are:

- Sections 15B and 15C (National Heritage Places)
- Sections 18 and 18A (Listed Threatened species and communities)
- Sections 20 and 20A (Listed Migratory species)
- Sections 23 and 23A (Commonwealth Marine Environment).

Section 7.2 of the Tailored Guidelines required the EIS to include an analysis of the likelihood of a range of hydrocarbon spill scenarios, considering:

> 7.2 a) the complexity of the drilling proposal, including water depth, duration and number of wells;
>
> 7.2 b) the level of understanding of the geophysical and geochemical properties over the drilled depth;
>
> 7.2 c) prevention measures; and
>
> 7.2 d) the historical context (i.e. the frequencies of blowouts and well control incidents for operations in similar offshore environments).

Section 7.3 of the Tailored Guidelines included a requirement to undertake hydrocarbon spill trajectory modelling for a range of spill scenarios, including a "worst case" loss of well control scenario, as follows:

> 7.3 a) model a sub-sea and sea level blowout, if appropriate, of at least 11 weeks duration
>
> 7.3 b) address all times of the year for which approval is sought
>
> 7.3 c) provide a description of, and justify the modelling of, the hydrocarbon type, including toxicity, weathering characteristics and release volumes
>
> 7.3 d) model any other more likely scenarios such as spills or leaks from infrastructure or equipment.

In addition, Section 7.4 of the guidelines required a description of the relevant impacts and consequences for all matters of NES likely to be impacted, should a spill occur, taking into account:

> 7.4 a) the characteristics of the hydrocarbons released, including toxicity and weathering characteristics and be specific to the modelling results
>
> 7.4 b) physical and toxicity impacts
>
> 7.4 c) impacts on habitats for listed species
>
> 7.4 d) impacts on heritage places and the Commonwealth Marine Area.

RPS was engaged by Chevron Australia to assess the environmental risks associated with a range of credible spill scenarios associated with its offshore Fourth Train Proposal, to support the EIS in addressing the requirements of Sections 7.2 – 7.4 of the Tailored Guidelines.

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Scale: Main Map - 1:2,500,000
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Source: RPS 2012

Figure A

Project and Shoreline Locations

1.2 Scope and Purpose

To meet the requirements of the Tailored Guidelines and following consultation with DSEWPaC, Chevron Australia identified a number of potential spill scenarios specifically associated with the Fourth Train Proposal which represent the range of potential spill events. These comprised:

- a "worst case" well blowout at a Fourth Train Proposal field during development drilling, involving a "full bore" sub-sea release of condensate, continuing for 11 weeks, simulating the Montara spill event in the Timor Sea in 2009
- a release of condensate from an Intrafield Flowline
- a major refuelling accident (vessel collision) resulting in the loss of light fuel oil (diesel) during Chandon gas field development
- a minor refuelling accident resulting in the loss of diesel during Chandon gas field development.

Chevron Australia also identified a number of potential spill scenarios which had been modelled for the oil spill risk assessment for the Foundation Project and which were relevant to the Fourth Train Proposal. The outcomes from the modelling of these spill scenarios was used in the current risk assessment. They were:

- a release of condensate from a Feed Gas Pipeline (at 200 m and 14 km from Barrow Island)
- a minor refuelling accident releasing diesel during Feed Gas Pipeline construction (at 2.5, 5 and 10 km from Barrow Island)
- an accidental release of diesel during refuelling at the Materials Offloading Facility (MOF) on the east coast of Barrow Island
- a spill of condensate, light crude oil or bunker fuel oil from a tanker grounding adjacent to the LNG Jetty at Barrow Island.

Independent modelling specialists Asia Pacific Applied Science Associates (APASA) were engaged to review the hydrocarbon spill modelling undertaken for the Foundation Project and to undertake further numerical three dimensional modelling of the additional spill scenarios associated with the Fourth Train Proposal (Appendices 1 and 2).

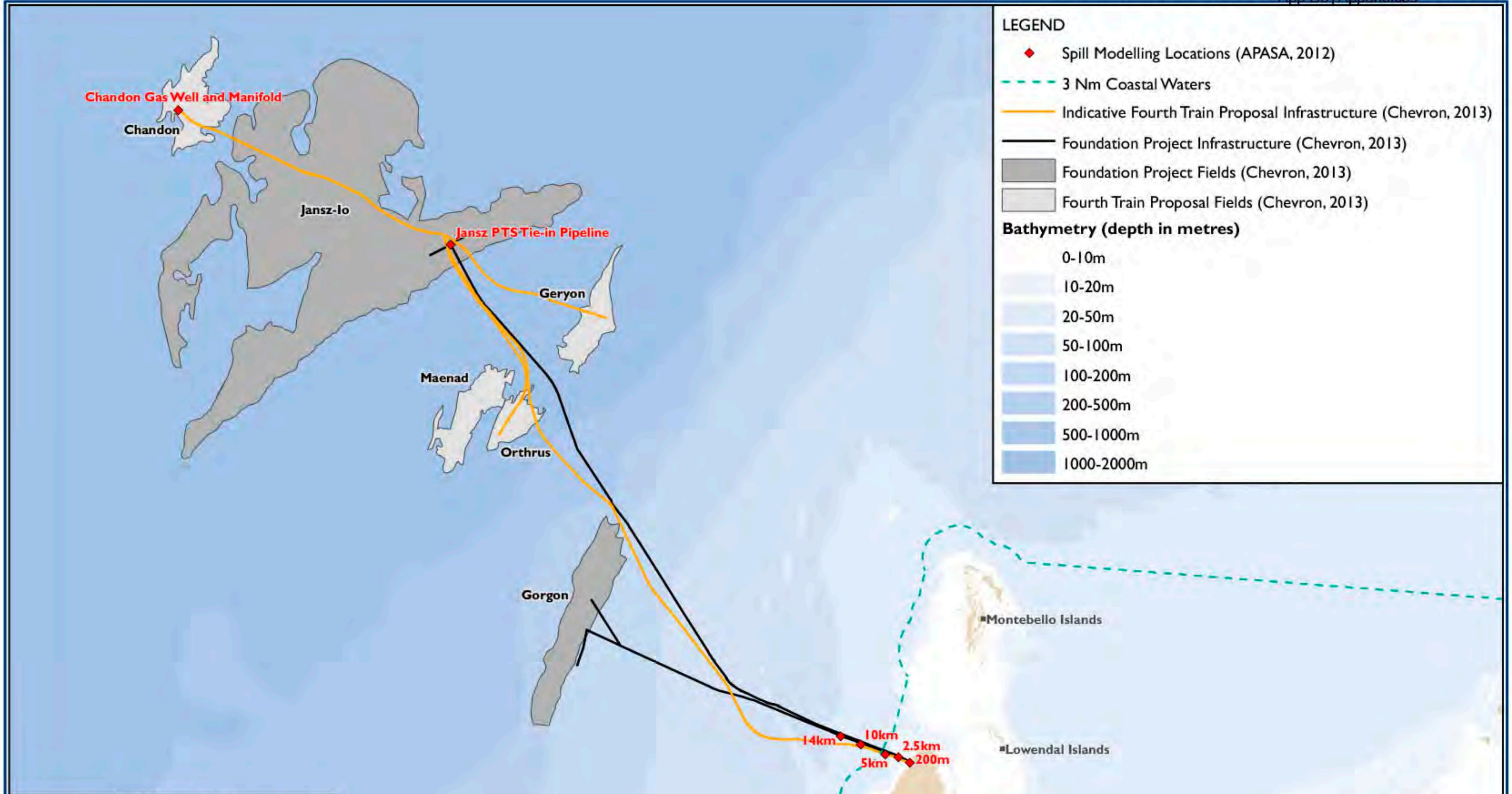
The modelling considered the spreading, evaporation, entrainment, dissolution, transport and stranding of both surface and entrained hydrocarbons over time, taking account of prevailing temperatures, wind conditions, surface water currents and sea conditions in each season of the year.

Condensate assay data and reservoir information gained from appraisal drilling in the Chandon field (Figure A) was incorporated into the modelling, including relative proportions of volatile and persistent components (Section 2.2). An uncontrolled release at the Chandon field was selected to represent a “worst case” scenario as Chandon is the “wettest” (highest condensate to gas ratio) of the Fourth Train Proposal fields. The “wettest” field will release the greatest volume of condensate under a blowout or pipeline rupture scenario and thus represents the greatest potential for environmental impacts. This conservative approach to the modelling tends to over-estimate the likely impacts from spills.

For similar reasons, the Chandon to Jansz Pipeline Terminating Structure (PTS) Pipeline (Figure B) was considered to represent a “worst case” flowline release scenario. Releases were modelled at the tie-in points at each end (Chandon PTS and Jansz PTS), which were identified as the most likely locations for a flowline rupture.

Modelling for the blowout and flowline rupture scenarios incorporated a sub-sea release of condensate to provide further conservatism to the assessment of environmental consequences. Sub-sea releases result in considerably higher levels of hydrocarbons becoming entrained in the water column, where the condensate degrades much more slowly, and hence the extent of potential impact is typically far greater than for a surface release.

Modelling of fuel spills included a major (80,000 L) “worst case” spill associated with a vessel collision causing a complete fuel tank rupture during drilling rig refuelling and a smaller (2,500 L) spill that might result from equipment failure or human error during refuelling for drilling or construction operations. Vessels spills were simulated at the Chandon field and along the Feed Gas Pipeline route closer to Barrow Island.



Spill Modelling Scenarios	
Chandon Gas Well and Manifold	Refuelling accident (2.5 m3 and 80 m3 spill)
	Chandon manifold flowline rupture
	Well Blowout
Jansz PTS Tie-in	Pipeline rupture
Feed Gas Pipeline	Refuelling accident 2.5km from Barrow Island
	Refuelling accident 5km from Barrow Island
	Refuelling accident 10km from Barrow Island
	Pipeline rupture 200m from Barrow Island
	Pipeline rupture 14km from Barrow Island
MOF Jetty	Refuelling accident
LNG Jetty	Vessel grounding

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Figure B

Fourth Train Proposal Infrastructure and Modelled Release Locations

1.3 Approach

The approach to assessing the environmental risks associated with possible spills from the Fourth Train Proposal comprised:

- Assessment of the likely scale and intensity of exposure of the identified matters of NES to spilled hydrocarbons under the range of spill scenarios using numerical modelling of the fate and trajectory of spilled hydrocarbons (see Table 3 and Figure B for modelling scenarios).

- Assessment of the environmental implications of the extent and nature of exposure indicated by the modelling outcomes, based on a review of existing literature regarding the effects of oil spills and available information describing the matters of NES within the area likely to be affected (see Figures C to G for protected areas and important habitats).

- Consideration of the probability of a release occurring (primary risk) and the likelihood of any release then contacting (secondary risk) sensitive matters of NES or habitats of particular importance to matters of NES.

- Qualitative evaluation of the level of residual risk by applying the Fourth Train Proposal Risk Matrix (Table 1) to characterise the potential consequences of exposure to hydrocarbons and the likelihoods of the defined consequences, given the management expected to be implemented.

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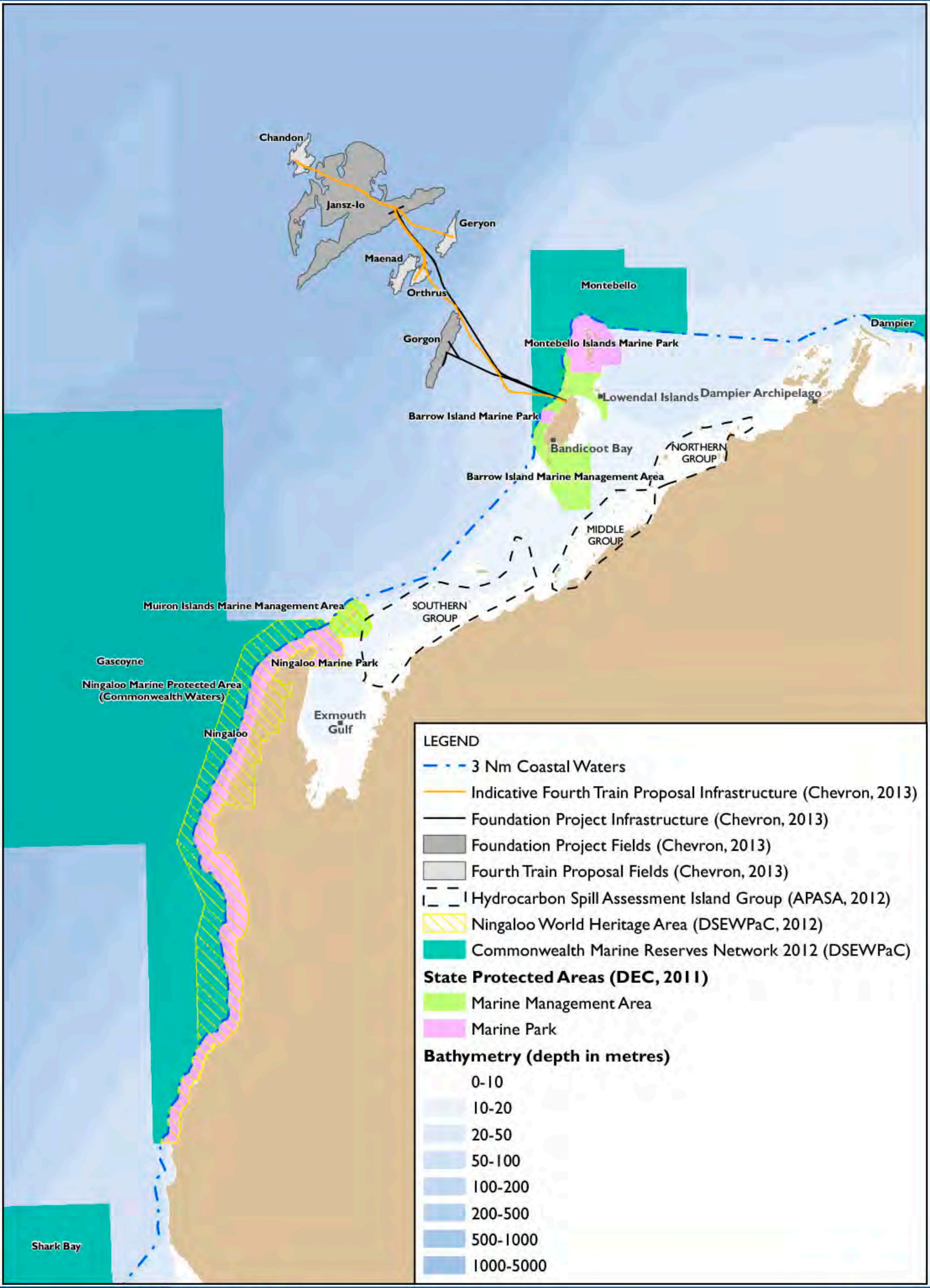

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Figure C

Project Location and Protected Areas

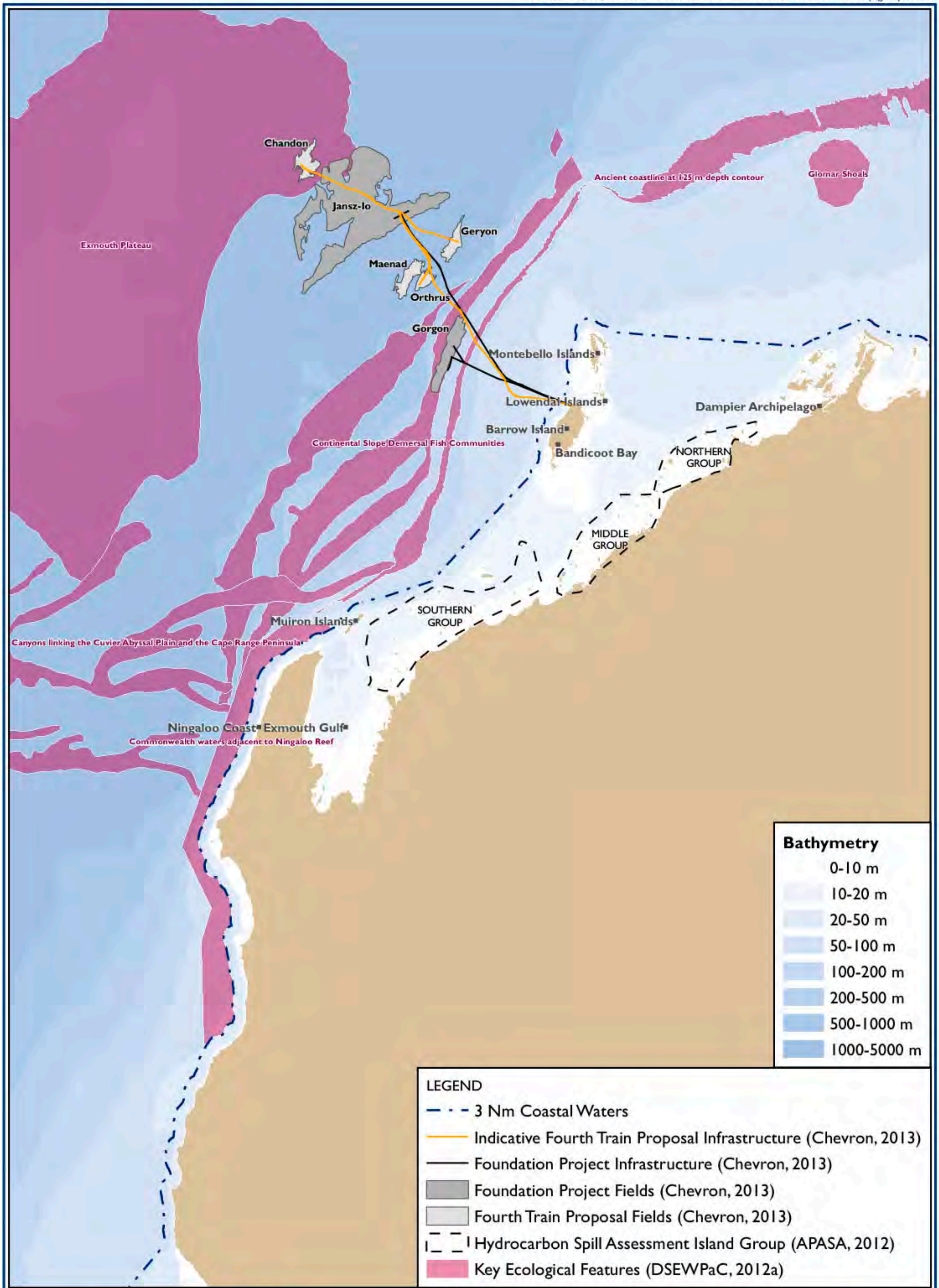

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Figure D

Project Area and Key Ecological Features

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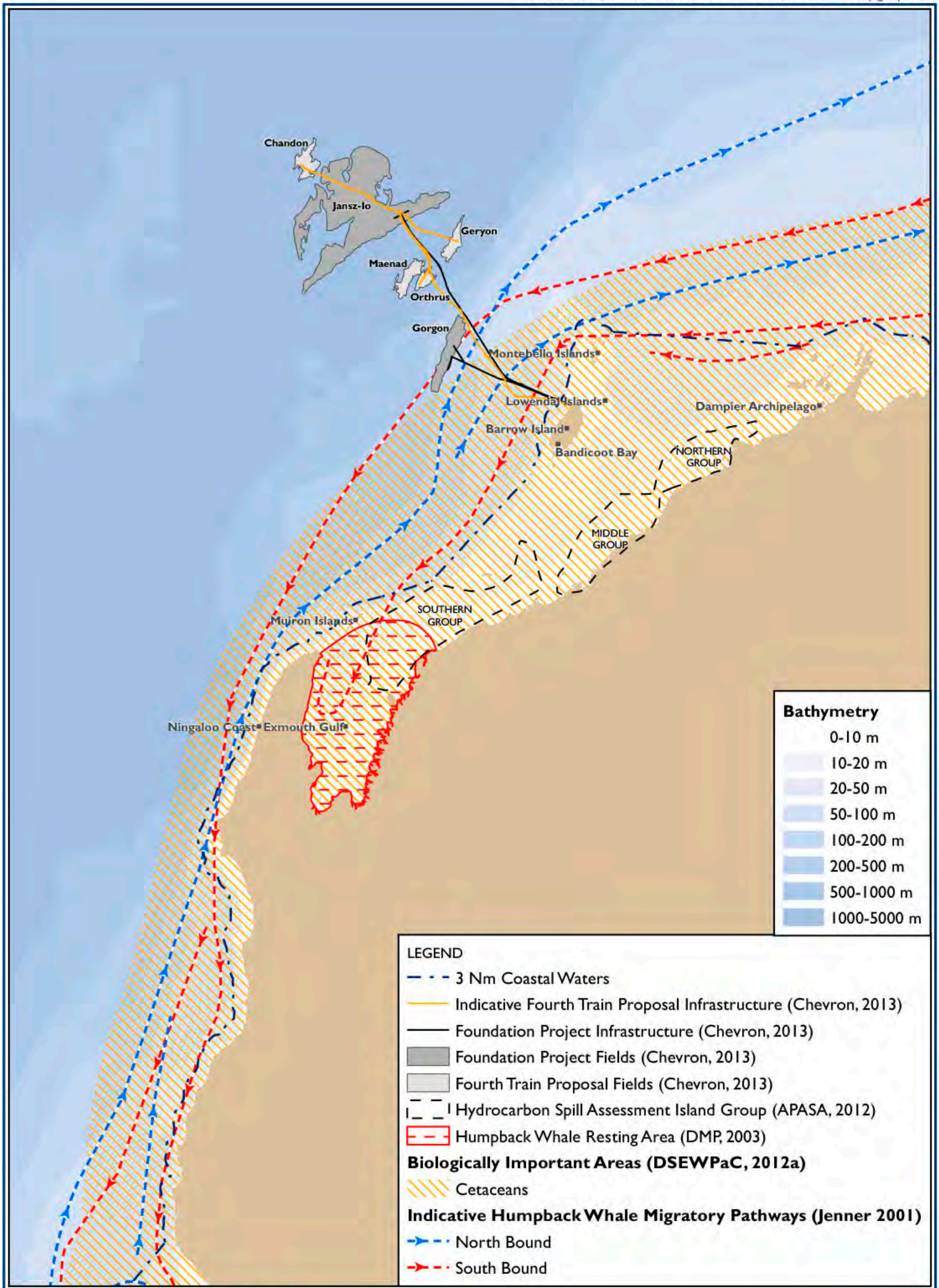

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Figure E

Project Area and Important Marine Mammal Habitats

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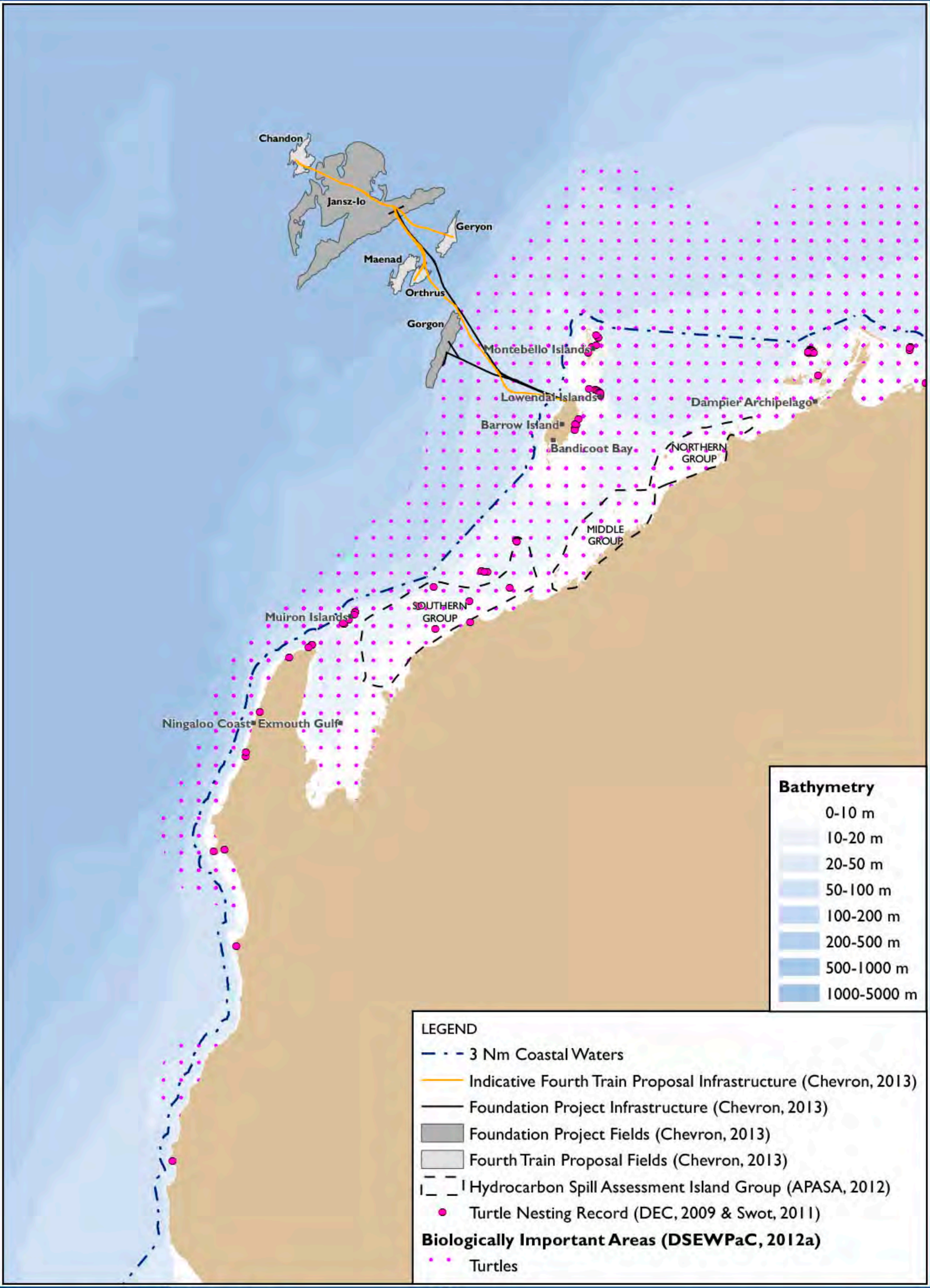

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Figure F

Project Area and Important Turtle Habitats

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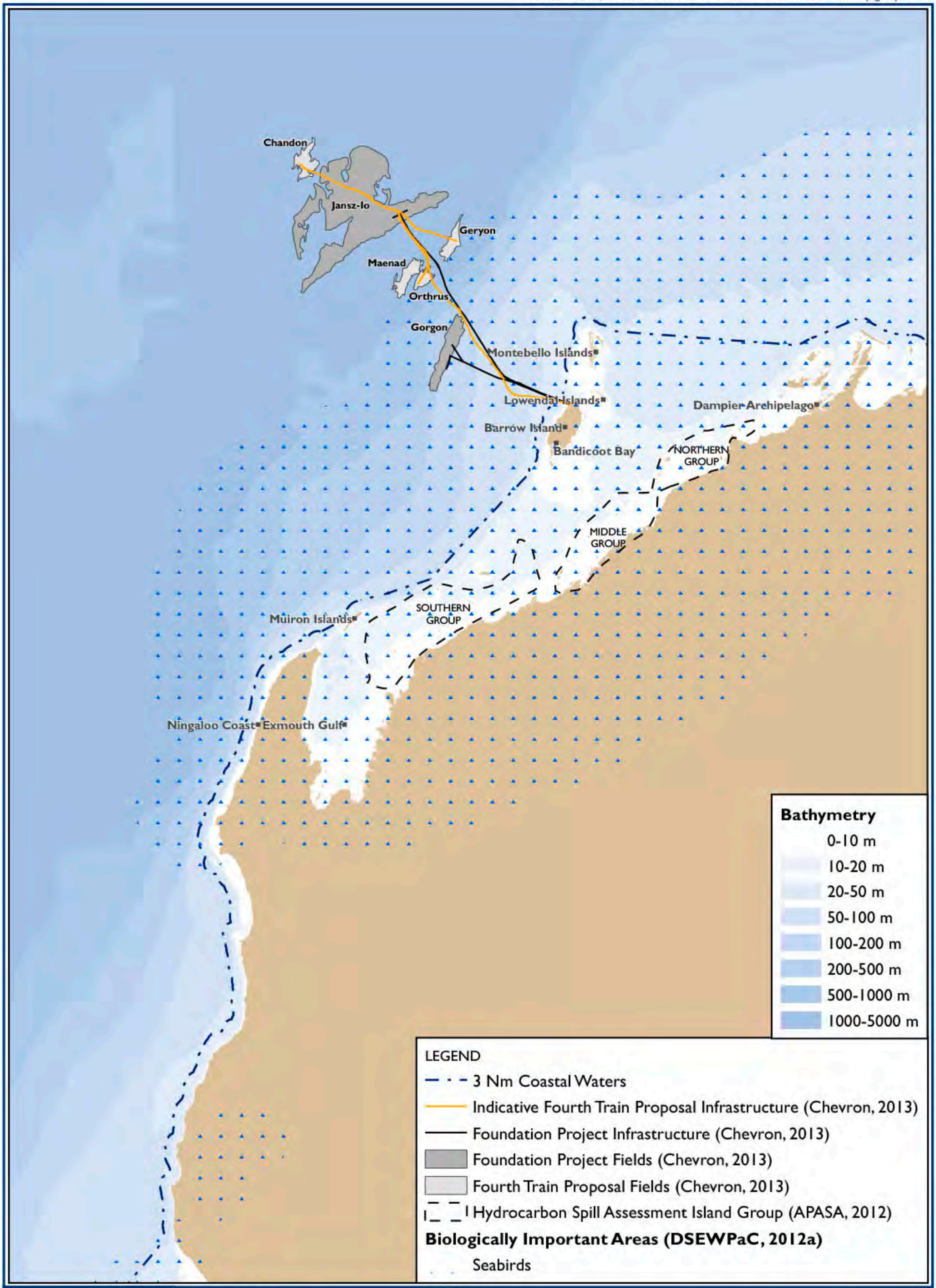

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Figure G

Project Area and Important Seabird Habitats

1.3.1 Fates and Trajectory Modelling

Wherever practicable, data representative of the specific characteristics of the Fourth Train Proposal (e.g. condensate characteristics) was incorporated into the assessment, but combined with a conservative approach to uncertainties in the magnitude and location of the spills and to the evaluation of likely effects on environmental resources. The conservative elements of the spill modelling are described in Section 3.0.

The modelling was used to derive stochastic probabilities for (and potential concentrations of) hydrocarbon contact with sensitive nearshore locations of the mainland coast and Pilbara islands.

1.3.2 Consequence Determination

The likely environmental impacts (consequences) associated with hydrocarbon spills depend on the type and concentration of oil, the thickness of surface slicks and the minimum times (and hence periods of weathering) until contact with the receptor. The potential for adverse impacts on the receptors is also affected by the mechanisms of exposure in the receptors of concern, the biology of the organisms exposed and the pre-existing stress and energy levels of the individual organisms affected.

Since empirical data on the effects of oil spills on biological resources on the North West Shelf environment is scant or non-existent, prediction of impacts and the potential for subsequent recovery was inferred from literature reviews, including ecotoxicological studies of the effects of hydrocarbon exposure on marine biota (Section 2.0). Wherever possible, the assessment relied on information directly relevant to environments and oil types of the Fourth Train Proposal.

In assessing potential impacts to matters of NES, the sensitivity, value, and quality of the receiving environment and the intensity, duration, magnitude, and geographic extent of the impact being assessed were considered.

1.3.3 Likelihood Determination

The statistical probability of each of the spill scenarios occurring (primary risk) was investigated through review of existing literature and published statistics. Where more than one relevant database was identified, the more conservative values were selected. Secondary risk is the probability of spilled oil contacting receptors (the outcomes of the stochastic modelling of each scenario, in each prevailing season). Probabilities of a spill occurring and resulting in exposure to a selected location were calculated as a function of the primary risk values and secondary risk values. The most conservative (i.e. "worst case") stochastic indication of exposure at any sensitive shoreline location from any of the three modelled plumes of hydrocarbons (surface, entrained and aromatic) was applied in the calculations for each season, and the seasonal outputs then annualised to provide an overall "worst case" probability.

1.3.4 Risk Assessment

A qualitative environmental risk assessment was undertaken for each of the spill scenarios. The assessment involved categorisation of the severity of environmental consequences and the likelihood of those consequences eventuating. The residual risk allowed for the reduction in potential risk brought about by implementing standard management measures (Section 4.0). A residual risk ranking was derived from the Fourth Train Proposal Risk Matrix (Table 1) in accordance with relevant Australian standards and guidelines (Section 5).

Table 1: Fourth Train Proposal Risk Matrix

Likelihood Description (Likelihood of the Consequence, not the event occurring)	Likelihood Indices		6 Incidental	5 Minor	4 Moderate	3 Major	2 Severe	1 Catastrophic
			Consequence Indices ← Decreasing Consequence					
Consequence can reasonably be expected to occur in the life of the Fourth Train Proposal	1	Likely	Medium	Medium	High	High	High	High
Conditions may allow the consequence to occur in the life of the Fourth Train Proposal, or the event has occurred within the Foundation Project	2	Occasional	Low	Medium	Medium	High	High	High
Exceptional conditions may allow consequences to occur within the life of the Fourth Train Proposal or it has occurred within Chevron Australia	3	Seldom	Low	Low	Medium	Medium	High	High
Reasonable to expect that the consequence will not occur for the Fourth Train Proposal; it has occurred several times in the industry but not in Chevron Australia	4	Unlikely	Low	Low	Low	Medium	Medium	High
Has occurred once or twice within the industry	5	Remote	Trivial	Low	Low	Low	Medium	Medium
Rare or unheard of	6	Rare	Trivial	Trivial	Low	Low	Low	Medium

1.4 Limitations and Assumptions

The following limitations and assumptions apply to the assessment of environmental risk:

- Modelling for a release from the Foundation Project Feed Gas Pipeline that was undertaken during the environmental assessment (EIS/ERMP) for the Foundation Project (Chevron Australia 2005) was confirmed by APASA to remain valid for the Fourth Train Proposal Feed Gas Pipeline, assuming it follows a similar alignment to Barrow Island.

- APASA also confirmed that while the Foundation Project modelling used simpler methods, the results remain valid given the shallow depth of the areas modelled (Appendix 2).

- A spill of monoethylene glycol (MEG) has not been considered in this assessment as it had previously been shown (Chevron Australia 2005) to have negligible risk of significant environmental consequences. The offshore use and discharge of MEG is considered under the Oslo and Paris Conventions for the Protection of the Marine Environment of the North-East Atlantic (OSPAR 2008) as posing little or no risk to the environment. It has very low aquatic toxicity, is readily biodegradable in the marine environment and will dilute rapidly to below levels that could affect marine biota (Dobson 2000). Acute toxicity testing (48 hr and 96 hr LC50 tests) for ethylene glycol on aquatic organisms (including invertebrates, fish and amphibians) indicated an LC50 of 17,000 mg/L or greater (Dobson 2000). Assessment of the potential impacts of a MEG spill for the Foundation Project identified a maximum credible "worst case" (pipeline rupture) release volume of 11 m^3 (Chevron Australia 2005). The modelling showed that the release would result in maximum concentrations of 6 mg/L, dispersing to <0.05 mg/L within three hours and dilute to <0.05 mg/L within 3 km of the discharge (APASA 2005). The probability of a rupture occurring (ERS 2005) was very low (4.32×10^{-5} per pipeline km per year) and no contact to shorelines was predicted from the modelling.

- The risk assessment, including fates and trajectory modelling, has been based on information regarding the relevant characteristics of the Fourth Train Proposal's reservoirs, condensate and infrastructure provided by Chevron Australia and no attempt to independently verify that information has been attempted.

- Review of the potential environmental effects from scenarios modelled for the Foundation Project were based on the information published in the EIS/ERMP documentation, including technical appendices, and no additional modelling or further interrogation of the previous modelling was undertaken.

- Due to the wide range of reported toxicity levels in the literature and lack of North West Shelf specific data, the thresholds used to determine exposure to oil are conservative (i.e. are not absolute thresholds) (Section 3.1; APASA 2012).

- The risk assessment focussed on "worst case" scenarios, in terms of the release scenario and the exposure to hydrocarbons. Other scenarios may have generated different outcomes.

2.0 ENVIRONMENTAL EFFECTS OF HYDROCARBON SPILLS

The environmental effects of a hydrocarbon spill largely depend on the chemical and physical characteristics of the hydrocarbons involved and the nature of the receiving environment.

2.1 Toxicity

The toxicities of different oils, including North West Shelf condensates, have been investigated in several studies (e.g. French 2000; INPEX 2010; Tsvetnenko et al. 1998; Woodside 1997). These studies provide an indication of the concentrations required to impact environmental resources. However, the different methodologies employed in different toxicity assays often make comparative analysis of results difficult. In particular, the toxicity values for any given oil that are derived via testing of water-soluble hydrocarbon solutions (i.e. the fraction of oil that dissolves into the water) will generally differ from those derived from testing oil-in-water solutions (i.e. comprising both dissolved and entrained hydrocarbons). Furthermore, extrapolation of experimental results to field situations is complicated by the diversity of factors affecting both the characteristics of any oil following release and the sensitivity of the environmental resources that may be exposed to the different states of the oil. Aromatic hydrocarbons are generally highly volatile and, in the warm sea and air temperatures of the region, will rapidly evaporate. Consequently, spilled condensate will “weather” rapidly at the surface and leave minimal volumes of heavier, less toxic residues.

The toxicity of a given concentration of hydrocarbons dissolved in water will typically be greater than the toxicity of a similar concentration of oil entrained in water as a water–oil emulsion (Tsvetnenko et al. 1998). Aromatic hydrocarbons are lipophilic and therefore the most bioavailable (absorbable into the tissue of organisms) fractions. Dissolved aromatic hydrocarbons are therefore the most likely to have deleterious biological effects. However, the toxicity of spilled light oils decreases rapidly over time, as the aromatic components are lost through evaporation, biodegradation, photooxidation and other processes (French-McCay & Payne 2001).

French (2000) predicted that the acute toxicity (LC50) of aromatic hydrocarbons in spilled oil would depend on the prevailing weather conditions and would range from 0.2-0.6 mg/L (200-600 ppb) under calm conditions to 0.05-0.09 mg/L (50-90 ppb) under turbulent conditions. French (2000) suggested that small droplets of oil would become entrained in the water under highly turbulent conditions which would allow more of the aromatics to dissolve and potentially have a greater effect on the exposed biota.

Impacts to marine organisms from aromatic components are related to the dose of exposure, which depends on both the concentrations to which the organism is exposed and the time over which that exposure continues. Generally, effects from long-term chronic exposure are apparent at lower concentrations than for short-term exposure because many organisms are resilient to relatively high concentrations for short periods.

Some of the aromatic components of a hydrocarbon spill will dissolve into the surrounding sea water following sub-sea release, as it rises through the water column and when the oil is floating on the surface. The evaporation of aromatic components from surface slicks in tropical environments will typically be several-fold more rapid than dissolution into the ocean, limiting the potential for toxicity effects.

The point of release (i.e. surface or subsurface) also has implications to the rate of weathering and thus the potential spatial and temporal extent of impact. A vessel collision or refuelling incident would generally result in the release of oil to the surface, where evaporation would immediately start to reduce the aromatic content. Conversely, dispersion of the condensate into small droplets within the water column by pressurised release at depth, as would be the case for a sub-sea blowout or pipeline rupture scenario, would accentuate the loss by dissolution of aromatic components.

2.1.1 Condensate

French (2000) reviewed experimental data from a range of studies to develop a generalised model for estimating hydrocarbon toxicity to marine biota. An estimated oil-in-water toxicity that will kill half of a biological population (LC50) of 1 mg/L (1000 parts per billion (ppb)) was reported for condensate.

INPEX (2010) investigated the toxicity of the Ichthys condensate solution on marine biota, with tests indicating a concentration of 0.27 mg/L (270 ppb) produced no observable acute toxicity effects in fish larvae (no observed effect concentration, NOEC) which were the most sensitive of the marine biota included in the study.

Tsvetnenko et al. (1998) compiled and reviewed toxicity data from studies of several hydrocarbon types, including two condensates from the North West Shelf. They derived a normalised toxicity (LC50) of 0.5–0.6 mg/L (500–600 ppb) for North West Shelf condensate to the most sensitive species tested, *Penaeus monodon* (giant tiger prawn) and an overall NOEC for Total Petroleum Hydrocarbons (TPH) of 7 µg/L (7 ppb), for a range of species. The review deliberately excluded any results from assays that were not based on the water soluble component with the note that "it was known that water–oil emulsions were always less toxic than petroleum hydrocarbons dissolved in water".

Woodside (1997) reported the results of ecotoxicity testing of whole North West Shelf condensate and its water soluble fraction by the Centre for Environmental Toxicology. The 96 hr LC50 for *Penaeus monodon* ranged from 1.5 mg/L (1,500 ppb) for the water soluble fraction to 109 mg/L (109,000 ppb) for whole condensate in seawater.

Assay data for condensate from an exploration well previously drilled by Chevron Australia in the Chandon Field (Chandon-2) indicate that the light Chandon condensate has an aromatic content of approximately 5%, with a large proportion (approximately 50–60%) of the aromatics falling within the BTEX group of highly volatile and relatively soluble hydrocarbons (benzene, toluene, ethylbenzene, and xylenes). The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000) indicate that at benzene concentrations of less than 0.5 mg/L (500 ppb) in marine water, over 99% of species would not be affected. Benzene is the only BTEX for which there is a guideline threshold.

2.1.2 Diesel

Diesel is a refined petroleum product. Similar to condensate, its potential for environmental impact relates primarily to the acute toxicity of the aromatic compounds (NOAA 2006), although it has been reported that the entrained component of a diesel spill may also contribute to toxicity (APASA 2005), possibly because of refining additives (Neff et al. 2000).

Schein et al. (2009) reported that the polyaromatic hydrocarbons (PAH) in diesel remained toxic after 18 hours of weathering, with a median lethal concentration (LC50) of 8 mg/L (8,000 ppb) to rainbow trout, and a sub-lethal median effective concentration (EC50) of approximately 1-6 mg/L (1,000-6,000 ppb). Swan et al. (1994) reported experimental LC50 values for the effects of diesel on a variety of marine species as ranging between 0.2 and >6 mg/L (200 – >6,000 ppb).

2.1.3 Light Crude Oil

Crude oils from different reservoirs show considerable variation in chemical composition and physical properties. Light crude oil is a naturally occurring oil with a lower wax content than heavier crude oils. Similar to diesel and condensate, light crude oil evaporates rapidly and the potential for environmental impacts from light crude oil largely relates to its aromatic compounds (Neff et al. 2000).

Experimental 96 hr LC50 values for various shrimp species range from 0.2 to 22 mg/L (200–22,000 ppb) for the water soluble fractions of crude oil (Swan et al. 1994). Tsvetnenko et al. (1998) reported LC50 values of 0.07–2.30 mg/L (70–2300 ppb) for *Penaeus* spp. exposed to four crude oils commonly found on the North West Shelf.

2.1.4 Bunker Fuel Oil

Bunker fuel oil, also known as fuel oil number 6 or bunker fuel oil C (Irwin et al. 1997), is a refined, heavy oil used to power large vessels. It is considered to be highly persistent because it weathers slowly with little to no evaporation or dissolution in the marine environment (NOAA 1996). Although bunker fuel oil contains high concentrations of aromatic hydrocarbons (Mohr et al. 2007), it is considered to have low acute toxicity relative to other fuel types, due to the larger proportion of high molecular weight hydrocarbons that are less soluble (Irwin et al. 1997).

Ara et al. (2002) reported a toxicity (LC50) range of 0.95–12.84 ppm (950–12,840 ppb) for marine copepods exposed to bunker fuel oil C. The 96 hr LC50 values for *Penaeus* spp., when exposed to the water soluble component of bunker fuel oil, were reported by Tsvetnenko et al. (1998) as 0.66–0.68 mg/L (660–680 ppb).

2.2 Physical Impacts

The potential for physical impacts from an oil spill are largely related to the spill size, the thickness of the layer of floating oil, the oil type and its persistence within the marine environment. The sensitivity of different organisms to the physical effects of oil spills depends on the species' life history traits, habitats, behaviour and physiology. Generally the physical impacts of oil include:

- Smothering of plants and animals; preventing photosynthesis and respiration and reducing the insulating efficiency of fur and feathers.

- Ingestion by organisms may be lethal, but the most common cause of death is from drowning, starvation.

In offshore, deep water spill locations, hydrocarbon slicks at the surface present a risk to the biota that come into direct contact with the slicks. Marine biota that reside in or transit the surface water layer, including seabirds, cetaceans, turtles and plankton may be directly affected, but mid-water or benthic (bottom-dwelling) organisms are unlikely to be affected, unless those organisms become entrained in a spill plume. Surface slicks will be subject to a number of weathering processes that act simultaneously, their relative importance varying with the oil properties and prevailing environmental conditions. The weathering agents are: spreading, evaporation, dissolution, dispersion, emulsification, sedimentation, photo-oxidation and bio-degradation. For a condensate such as from Chandon, which has a low asphaltene content, a low emulsive capacity, and contains a low proportion of residual volatiles (Table 2), the most important of these weathering agents are spreading on the sea surface, evaporation and dispersion (APASA 2012).

From the point that oil is spilled at sea, its composition and location will change with time. The volume of the diesel or condensate slick will tend to decrease rapidly due to weathering as volatile fractions are lost through evaporation.

Hydrocarbons dissolved or entrained into the water column, either upon release or through subsequent wind/wave action, may also affect pelagic (inhabiting the water column) species. If a spill persists long enough to reach shallow areas, the entrained oil or the surface slick may affect benthic organisms, especially if the spill contacts intertidal habitats. The potential for entrained and surficial oil to reach inshore habitats is reduced by the natural weathering processes, such as dissolution, dispersion, emulsification, sedimentation and bio-degradation.

2.2.1 Condensate

Condensates typically contain relatively low proportions of residual hydrocarbons and their potential for wide scale physical impact is limited.

Assay data from the Chandon gas field indicated the light nature of its condensate (API gravity of 60.7°), with relatively low proportions of residual hydrocarbons and persistent components (APASA 2012; Table 2; Appendix 1). Review of the assay data and weathering predictions for an 11 week, deep-water seabed release of condensate suggests that less than 10% of the oil is likely to be present on the water surface at any one time. Due to the high proportion of volatile components (boiling point <180°C), condensate has a strong tendency to evaporate once it reaches the surface (APASA 2012; Appendix 1), and only approximately 9% would remain as persistent residues (likely long-chain wax compounds) following weathering. Approximately 20–30% of the condensate may remain in the water column after the cessation of the blowout (APASA 2012).

Table 2: Chandon-2 Condensate Properties

Initial density (kg/m^3) at 15 °C	Viscosity (cP) (20 °C)	Component	Volatiles	Semi Volatiles	Low Volatiles	Residual
		BP (°C)	<180	180 - 265	265 - 380	>380
736.1	0.566	% of total	73.25	10.18	7.47	9.09

Source: APASA (2012)

2.2.2 Diesel

Diesel is a mixture of volatile and persistent hydrocarbons that are lighter than water. In the event of a spill, diesel will initially remain at the surface, and as small droplets form, it may gradually become entrained in the surface waters. The heavier and more persistent, components of diesel have a strong tendency to become entrained into the upper water column due to wind-generated wave mixing. Secondary slicks can form when the weather calms and suspended droplets of diesel resurface where they are again subject to high evaporation rates (APASA 2012; Appendix 1).

In the marine environment, diesel spills will be short-lived due to dispersion, dissolution, emulsification, evaporation and photo oxidation (Neff et al. 2000). Among these processes, evaporation removes the greatest amount of diesel from the ocean surface (approximately 60-80% loss) and evaporation rates are positively correlated with air and sea temperatures (Woodside 2011) and wind speeds.

Approximately 40-50% of the original mass of a diesel spill is predicted to evaporate over the first two days, depending upon prevailing conditions, with further evaporation slowing over time (APASA 2012; Appendix 1).

2.2.3 Light Crude Oil

Light crude oil has a tendency to form surface slicks when spilled in the marine environment, which facilitates the loss of volatile components to the atmosphere (APASA 2005). However, small droplets may form under the influence of surface mixing and become entrained in the water column.

Weathering processes that have the most effect on the chemical and physical properties of light crude oil are spreading and evaporation. Approximately 50–70% of light crude oil lost to evaporation occurs within the first 10–12 hours after a spill (Neff et al. 2000). A surface slick of light crude oil is likely to evaporate completely within a week of the spill, leaving only traces of hydrocarbons, mostly as PAHs in the water column (Neff et al. 2000). Total concentrations remaining entrained in the water column are likely to be well below 1 mg/L (1000 ppb) (Neff et al. 2000).

2.2.4 Bunker Fuel Oil

Bunker fuel oil is comprised of mixtures of petroleum distillate hydrocarbons and is commonly known as “residual oil”, as it partly comprises heavy distillation residues from refinery processing. Bunker fuel oil typically has higher concentrations of aromatic hydrocarbons compared to other petroleum oils, due to its refining and manufacturing process (Volkman et al. 1994). When spilled to the marine environment, bunker fuel oil tends to form thick slicks, weathering very slowly and undergoing little or no evaporation or dissolution (Irwin et al. 1997).

A surface slick of bunker fuel oil is likely to be highly persistent, with a portion of the slick persisting indefinitely (APASA 2005). Only 10–20% of a spill of bunker fuel oil is expected to be lost through evaporation in the first 48 hours after a spill (APASA 2005). Heavy, thick slicks may sink and persist on the seabed or they can smother intertidal areas (Irwin et al. 1997).

3.0 FATES AND TRAJECTORY MODELLING

3.1 Oil Spill Modelling Method and Scenarios

The likely trajectory and fate of hydrocarbons released under the spill scenarios identified as relevant to the Fourth Train Proposal were predicted by modelling of spill trajectories and weathering rates under ambient meteorological and oceanographic conditions (APASA 2005, 2012; Appendix 1). The model generated probability contours based on conservative dose-response predictions.

Hydrodynamic circulation was simulated for the area using a high resolution, three-dimensional, hydrodynamic model (HYDROMAP), together with data archives for tidal, wind and drift current components. The three dimensional spill transport and fates model Spill Impact Mapping and Assessment Program (SIMAP) was applied to predict the movements and concentrations of surface slicks, entrained oil and dissolved aromatic hydrocarbons from the spill scenarios outlined in Table 2 and indicated in Figure B. For each scenario, modelling was undertaken for summer (November to March), winter (May to September) and transitional (April and October. The 2012 modelling (APASA 2012; Appendix 1) further broke down the transitional period into autumn transitional and spring transitional seasons.

Condensate assay data from exploration well Chandon-2 and representative diesel fuel oil (fuel type: Southern USA 1997) were incorporated into the modelling so that the modelled outputs reflect the specific characteristics of hydrocarbons associated with a Fourth Train Proposal spill.

A series of conservative hydrocarbon concentration thresholds were applied to the modelling, ranging from recognised no-effects levels (to delineate the geographical scope beyond which no further assessment was required), to upper levels that approximated where impacts to sensitive species may occur. Conservatism was built into a number of other aspects of the modelling, including:

- volumes of hydrocarbons released (modelled largest credible volume)
- position of the blowout and pipeline release (modelled Chandon field with the highest condensate to gas ratio and greatest dispersion potential)
- three dimensional vs. surface only modelling (3D model accounts for entrained hydrocarbons)
- assumption of no intervention, regardless of time to reach shorelines (maximum concentrations arriving at shore).

The modelling was used to derive stochastic probabilities for exposure and was interrogated to obtain indications of the intensity of exposure (loadings or concentrations of hydrocarbons) at identified environmentally sensitive areas within the region. The key locations selected for the Fourth Train Proposal specific scenarios represent the areas of higher conservation significance in the local region and comprised (Figure A):

- Ningaloo Coast
- Muiron Islands
- Barrow Island
- Lowendal Islands
- Montebello Islands
- Dampier Archipelago
- Southern Island Group (of the Pilbara nearshore islands)
- Middle Island Group (of the Pilbara nearshore islands)
- Northern Island Group (of the Pilbara nearshore islands)
- Bernier and Dorre Islands
- Abrolhos Islands.

The key locations included in the trajectory and fates reporting for the Foundation Project (APASA 2005) were (Figure A):

- Barrow Island
- Lowendal Islands
- Montebello Islands.

At each location, the “worst case” (highest) concentration recorded in any grid cell during any simulation were reported for each season, along with the minimum period required during any simulation for any exposure to occur in any grid cell at each location. These measures provide a further level of conservatism relative to average levels of exposure or transport periods that would likely be experienced at any location.

In real spill events, slicks break up into multiple patches separated by areas of open water, such that the concentration of oil within the spatial extent of the slick will vary. The modelling reported the local concentration of oil within the oil patches, and the highest concentrations of each hydrocarbon state (surface, entrained and dissolved aromatic hydrocarbons) within patches that reached the selected inshore locations, adding further conservatism to the predictions.

An overview of key aspects of the 2012 modelling is provided in the following Table 3, with outcomes for each scenario summarised in Sections 3.2 and 3.3, together with an overall synopsis in Section 3.4. A fuller description of methodology and results is provided in APASA (2012; Appendix 1) and APASA (2005).

Table 3: Hydrocarbon Spill Modelling Summary

Spill Source	Release Location	Season	Hydrocarbons Modelled	Volume	Duration	Plumes Modelled
Well blowout	Chandon Well (1,200 m depth at seabed)	All	Chandon condensate	28,756,500 L	11 weeks	Surface, entrained, aromatics
Flowline rupture	Chandon Manifold Intrafield Flowline Tie-in (1,200 m depth at seabed)	All	Chandon condensate	200,000 L	3 hours	Surface, entrained, aromatics
Flowline rupture	Jansz PTS Intrafield Flowline Tie-in (1,345 m depth at seabed)	All	Chandon condensate	200,000 L	3 hours	Surface, entrained, aromatics
Feed Gas Pipeline rupture*	14 km west of Barrow Island (seabed)	All	Gorgon condensate	593,000 L	4.5 hours	Surface, aromatics
Feed Gas Pipeline rupture*	200 m west of Barrow Island (seabed)	All	Gorgon condensate	593,000 L	4.5 hours	Surface, aromatics
Refuelling accident*	Feed Gas Pipeline route – 10 km west of Barrow Island (surface)	All	Diesel	2,500 L	<1 hour	Surface, entrained and aromatics (total)
Refuelling accident*	Feed Gas Pipeline route – 5 km west of Barrow Island (surface)	All	Diesel	2,500 L	<1 hour	Surface, entrained and aromatics (total)
Refuelling accident*	Feed Gas Pipeline route – 2.5 km west of Barrow Island (surface)	All	Diesel	2,500 L	<1 hour	Surface, entrained and aromatics (total)
Refuelling accident*	Adjacent MOF	All	Diesel	100 L to 10,000 L	<1 hour	Surface, entrained and aromatics (total)
Refuelling accident	Chandon field (surface)	All	Diesel	80,000 L	6 hours	Surface, entrained, aromatics
Refuelling accident	Chandon field (surface)	All	Diesel	2,500 L	<1 hour	Surface, entrained, aromatics
Spill from grounded tanker*	Adjacent to LNG Jetty†	All	Gorgon condensate	10,000 L to 100,000 L	1 to 24 hrs	Surface, aromatics
Spill from grounded tanker*	Adjacent to LNG Jetty†	All	Light crude oil	10,000 L to 100,000 L	1 to 24 hrs	Surface, aromatics
Spill from grounded tanker*	Adjacent to LNG Jetty†	All	Bunker fuel oil	10,000 L to 100,000 L	1 to 24 hrs	Surface, aromatics

*Scenario taken from Foundation Project EIS/ERMP Technical Appendix B3: Modelling of spills and discharges (APASA 2005).

†Note that APASA (2005) refers to the LNG Jetty as the 'tanker terminal'.

3.1.1 Surface Slicks

To identify areas potentially exposed to surface slicks of diesel from a refuelling accident, or condensate from a pipeline rupture or well blowout, the modelling calculated the probability of exposure to surface hydrocarbons in key locations under each scenario. Probability contours were developed to show the potential extent of thick surface slicks (10.0 g/m^2) and very thin films (1.0 g/m^2). These slicks represent a 10 µm thick surface layer which would appear to have a dull metallic colour and a 1 µm thick rainbow sheen on the sea surface, respectively (Table 4; APASA 2012; Appendix 1). The Foundation Project modelling generated contours based on oil concentrations greater than 0.3 g/m^2, which describes the minimum thickness which is visible as a rainbow sheen (Table 4; APASA 2005).

These thresholds are very conservative and are considered to be below the concentrations at which adverse effects would be expected from direct contact with the slick, for most marine life. The minimum thickness of surface slicks that will result in harm to seabirds on the water surface has been estimated to be 10–25 g/m^2 (Volkman et al. 1994; French 1998; APASA 2012; Appendix 1). The surface slick trajectories and spatial extent provide an indication of the likely trajectories of the visible surface slick and allow for a conservative prediction of potential impacts.

Table 4: The Bonn Agreement Oil Appearance Code

Appearance	g/m^2	µm	L/km^2
Discontinuous true oil colours	50 – 200	50 – 200	50,000 – 200,000
Dull metallic colours	5 – 50	5 – 50	5,000 – 50,000
Rainbow sheen	0.3 – 5	0.3 – 5	300 – 5,000
Silver sheen	0.04 – 0.3	0.04 – 0.3	40 – 300

The modelling of surface slicks for each season developed relative probabilities of any given area being affected by a surface slick under the metocean conditions prevailing during the relevant period. While stochastic modelling does not provide an absolute measure of the likely extent of any one slick, it does provide an indication of likely patterns of slick movement, areas most likely to be affected, and areas unlikely to be exposed to condensate or diesel following a spill.

The modelling was also interrogated to determine the minimum time for a spill to reach inshore areas, as well as the maximum volumes of oil that would arrive.

3.1.2 Entrained Oil

Modelling of entrained hydrocarbons applied a conservative threshold of 10 ppb, based on the methodology suggested by French (2000). This represents a no effects concentration for fresh entrained condensate (i.e. inclusive of aromatic content) and essentially delineates the boundaries beyond which no further consideration of potential effect is required. This concentration represents the lowest trigger level for chronic (i.e. ongoing) exposure in the ANZECC/ARMCANZ (2000) guidelines.

Stochastic modelling was also undertaken applying thresholds of 100 ppb, which represents the lower level for triggering acute exposure, and 500 ppb. These levels are more indicative of acute toxicity over different exposure times for freshly released condensate that retains its aromatic content and are therefore highly conservative for predicting impacts from spilled oil more than a couple of days old.

To gain insight into the intensity of exposure at selected locations, the model outputs were interrogated to determine the "worst case" (i.e. highest) maximum instantaneous concentrations from any of the simulations, and the mean maximum concentrations across all simulations. Both these measures relate to highest instantaneous concentrations predicted by the modelling. "Worst case" maximums were the highest concentration predicted for any grid cell at a given location in any simulation. The mean maximum concentration is the mean of the "worst case" maximum concentrations over all simulations. Average concentrations experienced at any given location over the duration of any one simulation are expected to be considerably lower than either of these measures.

3.1.3 Dissolved Aromatics

The trajectory and fates modelling of dissolved hydrocarbons incorporated the assay data for Chandon condensate. The aromatic components of this condensate are largely (approximately 50-60%) within the BTEX group.

The ANZECC/ARMCANZ guidelines (2000) indicated that concentrations of benzene, one of the more soluble toxic aromatic hydrocarbons (and the only BTEX for which there is a guideline criteria), of less than 500 ppb in marine waters would be expected to impact less than 1% of species.

The stochastic modelling applied a 5 ppb threshold concentration for dissolved aromatics, using a conservative no effects concentration based on the methodology of French (2000), to identify areas where no further consideration was required. Probabilities of exposure to higher concentrations (50 ppb and 500 ppb) were also modelled to gain additional insight into the likely extent of exposure and to assist the assessment of potential impacts, which represent acute lethal thresholds to 5% and 50% of biota, respectively (French et al. 1999; French-McCay 2002, 2003).

The model outputs were further interrogated to determine maximum concentrations of dissolved aromatic hydrocarbons that would reach the key areas of interest which, as noted above, provide a conservative measure of the concentrations that most areas at any location would be exposed to over longer periods.

3.2 Oil Spill Modelling Results – Upstream Scenarios

3.2.1 Well Blowout

APASA (2012; Appendix 1) quantified the likely trajectory and fate of condensate released from the Chandon gas field in the event of a long duration (11 weeks) release at the seabed (1,200 m water depth) during drilling operations.

The modelling incorporated hydrocarbon assay data from the Chandon-2 exploration well fluid samples that yielded a condensate to gas ratio of approximately 5.4 bbls/mmscf. A discharge rate of 373.6 m^3/day was assumed, resulting in a total discharge volume of 28,756.5 m^3 (28,756,500 L) over an 11 week period (APASA 2012; Appendix 1).

3.2.1.1 Surface Slick

The modelling for a blowout at the Chandon manifold tie-in location indicated that subsea release at a water depth of 1,200 m would result in low (≤ 20%) probabilities of condensate surfacing at any one location in concentrations above a sheen (>1 μm thick) during any season. The resulting surface condensate could potentially be transported over an extended area due to the large variability and high complexity of currents in the region (APASA 2012; Appendix 1).

Surface slicks were predicted to be predominantly transported away from the Western Australian (WA) coastline, and the modelling indicated that no inshore areas were likely to be exposed to surface condensate above 10 g/m^2 during any season. Similarly, a sheen of condensate (>1 μm thick) was unlikely to reach any shoreline under most conditions. There was a low (3%) probability that a sheen would reach inshore areas of the Ningaloo Coast during winter only, after 29 days at sea, but no inshore exposure to a condensate sheen (>1 μm thick) was predicted for any other season or any other location.

If a blowout was to occur during summer or winter, the surface slick was predicted to most likely expose areas to the south-south-west, west, and north-west. In the event of a blowout during autumn, the surface slick tended to extend towards the south-west and north-east, and during spring, towards the north-west with some transport of surface slicks to the south-west of the release location.

For a blowout that commenced in autumn, a surface sheen would mostly remain within the vicinity of the release site, and was relatively unlikely (<20% probability) to extend more than 250 km to the south-west, although there was a very low potential (1% probability) of a patch of surface condensate (>1 g/m^2) travelling as far south as offshore of the Abrolhos Islands. The distance of surface condensate transport was reduced for oil at a threshold of 10 g/m^2, with a very low potential of surface condensate patches reaching approximately 450 km from the release location. Surface condensate from a blowout during other seasons would extend over shorter distances, with extremely low potential of patches more than a sheen (>1 μm thick) located up to 450 km to the north-west during spring, >300 km north-west and south-west in summer, and >1000 km to the south-west of the release location during winter.

The modelling predicted that there was a low potential for surface slick concentrations of 10 g/m^2 to occur following a well blowout at the Chandon manifold location. The area of potential exposure to surface condensate above 10 g/m^2 was significantly reduced, with a very low probability (1%) of small patches extending approximately 400 km south-west in summer and spring, and approximately 300 km south-west in winter.

Generally, very low concentrations were predicted to strand on shorelines of the Muiron Islands, Ningaloo Coast and the Southern Island Group, usually as a result of gradual accumulation of residues following contact by trace (below threshold) films of condensate. The "worst case" maximum shoreline concentrations were predicted to occur during summer at the Muiron Islands (60 g/m^2) and Ningaloo Coast (43 g/m^2). Maximum shoreline concentrations at the Southern Island Group were predicted to be 13 g/m^2 in spring and 2 g/m^2 in summer. During all other seasons, and at all other locations, no contact was predicted.

3.2.1.2 Entrained Oil

Entrained oil was predicted to be transported the furthest from the release location during the autumn transition, with a 90% probability of oil at concentrations >10 ppb predicted in up to 700 km south-west from the release location. The 90% probability contour extended predominantly to the south-west during all seasons, approximately 600 km in spring, 500 km during summer, and up to 350 km during winter. At concentrations >100 ppb, the south-westerly extent of the 90% probability contour was further reduced to a maximum of approximately 120 km from the release site during spring, and to less than 50 km during all remaining seasons. Entrained concentrations >500 ppb had a lower probability (50%) of occurring in the water column. The 50% probability contour was predicted to extend a maximum of approximately 120 km from the release site during spring.

The modelling predicted that entrained oil would be transported predominantly in a south-west direction during all seasons. As a result, shorelines of the Ningaloo Coast and Muiron Islands had the highest probabilities of exposure to entrained oil. Entrained oil concentrations >10 ppb had a 70% probability of reaching the Ningaloo Coast during autumn, with reduced probabilities of exposure during spring (50%), summer (40%) and winter (36%). The probability of exposure was reduced for concentrations of entrained oil >100 ppb, with a maximum of 36% in spring, and 20% in autumn.

Exposure of inshore areas to concentrations >500 ppb was predicted for the Ningaloo Coast and Muiron Islands only, with a maximum probability of 23% for both locations during spring. For remaining seasons, the probability of exposure at these locations was very low (3–6%).

The greatest instantaneous maximum entrained concentrations predicted to occur at the Ningaloo Coast National Heritage Place (NHP) were during spring (2.9 ppm and 2.2 ppm for the Ningaloo Coast and Muiron Islands respectively). Predicted maximum concentrations were reduced during other seasons, with a maximum of 1.9 ppm in summer and 1.2 ppm in winter.

The minimum time taken for entrained oil (>10 ppb) to reach the shorelines of the Ningaloo Coast NHP was 10-11 days for all seasons. The minimum time taken for entrained concentrations >500 ppb was longer, from 16 days in winter to up to three weeks in autumn.

Entrained oil concentrations were not predicted to exceed 500 ppb at any of the offshore islands during any season. Low probabilities (up to 16%) of exposure to entrained oil concentrations >10 ppb were predicted for some offshore islands during summer, winter and spring, but no contact was predicted at any island during autumn.

The greatest instantaneous maximum concentration predicted to occur at the offshore islands was 350 ppb (Barrow Island) during spring. During all other seasons, concentrations were low (≤ 55 ppb).

The minimum time for entrained oil >10 ppb to reach the offshore islands was during spring, taking 12 days to reach shorelines of the Montebello Islands.

3.2.1.3 Dissolved Aromatic Hydrocarbons

The modelling indicated that dissolved aromatic concentrations were not predicted (<1% probability) to exceed 50 ppb in the waters surrounding the release location during any season. Dissolved aromatic hydrocarbons >5 ppb are predicted to predominantly occur in a limited area immediately to the east of the release location, with low to moderate probabilities (<30%) of extending to more distant areas.

There was a low to moderate (maximum 23%) probability of dissolved aromatic hydrocarbons >5 ppb reaching inshore areas at the Ningaloo Coast, Muiron Islands and the Southern Island Group during spring, but “worst case” maximum concentrations were very low (30 ppb). Probabilities of dissolved aromatic hydrocarbons reaching any inshore area during any other season were very low (≤ 6%). Dissolved aromatic concentrations >5 ppb were not predicted to reach any inshore area during autumn.

3.2.2 Pipeline Release

3.2.2.1 Intrafield Flowline Rupture – Chandon Manifold Tie-in

APASA (2012; Appendix 1) predicted the likely trajectory and fate of a sub-sea release of condensate from an intrafield flowline rupture at the seabed (1,200 m water depth) at the Chandon Manifold Tie-in location. The modelling incorporated a release over three hours, yielding a total discharge volume of 200 m³ (200,000 L) of Chandon condensate.

Surface Slick

The modelling for an intrafield flowline rupture at the Chandon Manifold Tie-in location indicated that a subsea release at a water depth of 1,200 m would result in low to moderate (<30%) probabilities of condensate surfacing in concentrations above a sheen (>1 µm) during any season. The resulting surface slicks were generally limited in spatial extent, with the 1% probability contour predicted to remain within 300 km of the release site during any season, and the 10% probability contour within 100 km of the release site. Surface slicks were predicted to be predominantly transported away from the WA coastline during all seasons and were most likely to expose areas to the north-west to south-west during all seasons.

A surface sheen was not predicted to enter state waters (within 3 nautical miles of land) or approach closer than 5 km to any inshore locations. Consequently, a surface sheen (>1 µm) was not predicted (<1% probability) to contact any shoreline during any season.

Entrained Oil

Entrained oil in the water column was predicted to be transported primarily to the south-west and north-west during all seasons, away from the WA coastline. Similarly to the behaviour of surface slicks, the modelling indicated low to moderate probabilities (<30%) of entrained oil in the water column extending beyond the immediate release site.

Entrained oil was most likely to expose areas to the south-west during all seasons, with the longest trajectories predicted during autumn. Entrained oil concentrations >10 ppb may reach up to 450 km from the spill site (1% probability), however was predicted to remain within 300 km of the spill site under 90% of conditions.

There was a very low probability (1%) of exposure of inshore waters of the Ningaloo Coast to entrained oil (>10 ppb) during spring, and as well as a very low (1%) probability of shoreline contact at the Ningaloo Coast. The maximum concentration at this location was predicted to be very low (60 ppb), and take 13 days to reach the shoreline. Concentrations above 100 ppb were not predicted to reach the inshore waters of Ningaloo Coast during spring. Entrained oil was not predicted to reach any other shoreline during any other season.

Dissolved Aromatic Hydrocarbons

Dissolved aromatic hydrocarbons (>5 ppb) were not predicted to be present in the water column in the vicinity of the release site (approximately 1.5 km^2), and consequently were not predicted to occur at any shoreline location during any season.

3.2.2.2 Intrafield Flowline Rupture – Jansz PTS Tie-in

APASA (2012; Appendix 1) predicted the likely trajectory and fate of a sub-sea release of condensate from an intrafield flowline rupture at the seabed (1,345 m water depth) at the Jansz PTS tie-in location. The modelling incorporated a release over three hours, yielding a total discharge volume of 200 m³ (200,000 L) of Chandon condensate.

Surface Slick

The modelling for an intrafield flowline rupture at the Jansz PTS manifold tie-in location indicated low to moderate (<30%) probabilities of condensate surfacing in concentrations above a sheen (>1 µm thick) during any season.

During summer and autumn, slicks were transported to the west and south-west, whilst during winter and spring, slicks were transported primarily to the south-west. The resulting surface slicks were generally limited in spatial extent, with a sheen predicted to remain within 300 km of the release site under 99% of conditions, and within 150 km under 80% of conditions.

It was highly unlikely (≤1% probability) that a surface sheen would enter state waters (within 3 nautical miles of land), and was not predicted to approach closer than approximately 5 km of any shoreline. Consequently, a surface sheen (>1 µm thick) was not predicted (<1% probability) to contact any inshore locations during any season.

Entrained Oil

The modelling indicated low to moderate probabilities (<30%) of entrained oil in the water column extending beyond the immediate release site. Entrained oil was most likely to expose areas to the south-west during all seasons, with some transport to the north-west during winter. Entrained oil trajectories to the south-west were longest during autumn and summer, and entrained concentrations greater than 10 ppb were predicted to remain within approximately 300 km of the release site under 99% of conditions.

The modelling indicated a very low (1%) probability of entrained oil (>10 ppb) reaching inshore waters at the Ningaloo Coast during summer only. The maximum concentration at this location was predicted to be very low (25 ppb), and take 12 days to reach the shoreline. Concentrations above 100 ppb were not predicted to reach the inshore waters of the Ningaloo Coast during summer. Entrained oil was not predicted to reach any other shoreline during any other season.

Dissolved Aromatic Hydrocarbons

Dissolved aromatic hydrocarbons (>5 ppb) were not predicted to be present in the water column in the vicinity of the release site (1.5 km²), and consequently were not predicted to occur at any shoreline location during any season.

3.2.2.3 Feed Gas Pipeline Rupture

APASA (2005) modelled the likely trajectory and fate of a 1,612 m³ condensate release due to a Feed Gas Pipeline rupture near the shore crossing at Barrow Island (200 m west of Barrow Island), as well as 14 km west of Barrow Island. Predictions of the length of shoreline exposed (km), the volume on shore (m³), and concentration in the water column were generated, along with probabilities of shoreline exposure. The model assumed a release depth of 50 m and spill duration of 4.5 hours for the spill scenario 14 km west of Barrow Island, and a release depth of 12 m and spill duration of 4.5 hours for the spill scenario 200 m west of Barrow Island.

Surface Slick

Release 200 m from Barrow Island

Oil from a pipeline rupture near the shore crossing at Barrow Island would almost certainly reach the shorelines of Barrow Island during all seasons (100% in transitional months; 99% in summer; 96% in winter). The "worst case" volume of condensate on shore (159 m^3) was predicted during summer, resulting in a total of 43 km of west and north coast shorelines that could be affected. However, there was a significantly lower probability of oil beaching on the north coast (0.5-2%) compared to the west coast (90-100%) under this spill scenario.

Release 14 km from Barrow Island

The probability of exposure to any shoreline (63%) and the potential volume of condensate on shore (up to 27 m^3) were predicted to be highest during the summer months due to the higher frequency of south-westerly winds in the season. Shoreline locations that were predicted to have >10% risk of exposure from a sheen of condensate (>0.3 g/m^2) during summer included the west coast of Barrow Island, most islands in the Lowendal group and islands along the south western side of the Montebello islands.

Dissolved Aromatic Hydrocarbons

Release 200 m from Barrow Island

The modelling predicted that elevated concentrations of aromatic hydrocarbons (up to 4.5 ppm) could reach the shorelines of Barrow Island, the Montebello Islands and Lowendal Islands.

Release 14 km from Barrow Island

This scenario was predicted to potentially generate concentrations of aromatic hydrocarbons exceeding 10 ppb at the shorelines of Barrow Island and the Montebello Islands. Maximum concentrations up to 0.866 ppm (mean of 0.027 ppm) were predicted at the Montebello Islands during the summer months, reducing to no contact in the transitional months (April and September) and in the winter months.

3.2.3 Fuel Spill

3.2.3.1 Major Diesel Spill

APASA (2012; Appendix 1) predicted the likely trajectory and fate of an 80 m^3 (80,000 L) surface spill of diesel over six hours at the Chandon field location. An 80 m^3 diesel spill would result from the entire fuel load of a typical support vessel tank spilling into the marine environment, which is considered to be the "worst case" credible scenario.

Surface Slick

The modelling indicated that for a major diesel spill at the Chandon field location, the probability of surface concentrations of diesel >1 g/m^2 extending beyond the immediate release site was ≤50%. The modelling also indicated that surface slick trajectories were transported predominantly to the north-west during summer. In autumn and winter, surface diesel would be transported primarily in a west to south-west direction, with some transport to the north and south. A major surface spill of diesel in spring would result in a surface slick transported largely to the north of the release site.

Diesel in concentrations >10 g/m^2 were unlikely (≤1%) to extend beyond 100 km from the release site. Consequently, not even a sheen (>1 μm thick) was predicted (<1% probability) to contact any shoreline during any season.

Entrained Oil

Entrained oil in the water column was predicted to be transported further than surface slick trajectories. During all seasons, entrained oil was most likely to expose areas primarily to the south-west, with some potential to expose waters to the north during spring and winter, and to the north-west during summer.

The modelling indicated a very low (1%) probability of entrained oil (>10 ppb) reaching the inshore waters of the Ningaloo Coast during spring. The maximum concentration at this location was predicted to be low (120 ppb), and take 12 days to reach the shoreline. During spring, entrained oil >100 ppb was not predicted to enter state waters or approach the inshore waters of the Ningaloo Coast. Entrained oil was not predicted to reach any other shoreline during any other season.

Dissolved Aromatic Hydrocarbons

The modelling indicated that dissolved aromatic hydrocarbons (>5 ppb) were not predicted to occur more than 100 km from the spill site, and consequently were not predicted to occur at any shoreline location during any season. Dissolved aromatic hydrocarbons were not predicted to exceed 50 ppb outside of the immediate spill location (approximately 1.5 km^2).

3.2.3.2 Minor Diesel Spill

2.5 m^3 Diesel Spill at the Chandon Field

APASA (2012; Appendix 1) predicted the likely trajectory and fate of an instantaneous 2.5 m^3 (2,500 L) surface diesel spill at the Chandon location. This volume was considered to represent a conservative (i.e. over) estimate of the likely volumes of diesel that might be released in the event of a refuelling hose rupture, or other equipment malfunction or procedural error during refuelling.

The modelling indicated that surface diesel was most likely to expose areas to the north-west and north-east during summer, to the west to south-west during autumn, to the south during winter, and to the north during spring. Surface diesel >10 g/m^2 was unlikely (1%) to extend beyond approximately 50 km from the release site.

Consequently, surface diesel resulting from a minor spill at the Chandon field was not predicted to reach any inshore location.

The probability that diesel on the surface would entrain into the water column at concentrations >10 ppb during all seasons was low (≤5%), and entrained diesel was unlikely (1% probability) to extend beyond approximately 50 km from the release site during any season. There was no probability that entrained oil concentrations >10 ppb would enter state waters or reach any inshore location during any season.

Dissolved aromatic concentrations exceeding 5 ppb were unlikely (<1%) to occur beyond the immediate vicinity of the spill site in any season (averaged over one grid cell, or 26 km^3) and consequently were not predicted to occur at any shoreline location during any season.

2.5 m^3 Diesel Spill along the Feed Gas Pipeline

APASA (2005) modelled the likely trajectory and fate of a 2.5 m^3 diesel refuelling accident occurring at 2.5 km, 5 km and 10 km west of Barrow Island, providing an indication of the exposure risks from a refuelling spill occurring along the Feed Gas Pipeline. The probabilities of exposure, length of shoreline exposed (km), volume on shore (m^3) and concentration in the water column were predicted.

Surface Slick

The trajectory modelling indicated that the likelihood of inshore areas being affected was highest in summer but reduced significantly with increasing distance offshore. The fate and transport modelling indicated that the probability of a diesel spill of up to 2.5 m^3 close to shore (2.5 km) reaching the west coast of Barrow Island was 84%, reducing significantly with increasing distance offshore, with a 16% probability of contact from a spill occurring 10 km offshore.

The model predicted a maximum shoreline exposure at Barrow Island (6.8 km and mean + st dev 2.1 ± 2.4) as well as maximum volumes to reach the Barrow Island shoreline (0.1 m^3 and mean + st dev 0.08 ± 0.06) to occur during the summer months.

Dissolved Aromatic Hydrocarbons

Aromatic hydrocarbons were not predicted to reach any shoreline during winter, and maximum aromatic concentrations were predicted for the Montebello Islands during summer (440 ppb) and transitional months (59 ppb). Mean concentrations were significantly reduced with a mean of 11 ppb and 3 ppb respectively.

3.3 Oil Spill Modelling Results – Downstream Scenarios

3.3.1 Spill alongside MOF

APASA (2005) modelled the likely trajectory and fate of a minor (0.1–1.0 m^3) diesel refuelling accident that was quickly (<1 hour) shut-off, occurring adjacent to the MOF. The probabilities of exposure, length of shoreline exposed (km), volume on shore (m^3) and concentration in the water column were predicted.

3.3.1.1 Surface Slick

A refuelling accident adjacent to the MOF had a high probability (84%) of reaching the eastern shorelines of Barrow Island and the shorelines of the Lowendal Islands during summer. The "worst case" volume of diesel on shore was 0.5 m^3 during any season, with a maximum 22 km of shoreline exposed during the transitional months.

3.3.1.2 Aromatic Hydrocarbons

The highest instantaneous maximum concentration of aromatic hydrocarbons contacting the inshore waters of the east coast of Barrow Island was predicted to be 2,372 ppb during winter, with a mean maximum concentration of 160 ppb. The maximum concentration during summer was predicted to be 1,888 ppb, whilst the maximum predicted for the transitional months was 2,356 ppb.

3.3.2 Spill from Grounded Tanker adjacent to LNG Jetty

APASA (2005) modelled the likely trajectory and fate of a condensate release, light crude oil release and bunker fuel oil release resulting from a tanker grounding incident adjacent to the LNG Jetty, along the 20 m depth contour, approximately 10 km off the east coast of Barrow Island. Predictions of the length of shoreline exposed (km), the volume onshore (m^3) and concentration in the water column were generated, along with probabilities of shoreline exposure. The model assumed a surface release from a cracked tank that was brought under control within one day.

3.3.2.1 Surface Slick

During the summer and transitional months, the most likely grounding site predicted for a tanker was on the north-east side of the LNG Jetty. Slicks resulting from a spill during these seasons were most likely to drift to the north-east, passing to the south of the Lowendal Islands. The eastern shorelines of Barrow Island were predicted to have the greatest risk of exposure, with the shorelines of the Lowendal group predicted to have lower probabilities of exposure.

During the winter months the shallow waters west of the LNG Jetty was predicted to be the most likely grounding site. Slicks during this period were predicted to most likely drift north–south with the strong current operating within the Barrow Island channel, before traversing around the north and south ends of Barrow Island. The eastern shorelines of Barrow Island were predicted to have the greatest risk of exposure; however, other shorelines on adjacent islands (Lowendal and Montebello Islands) were also predicted to be at some risk.

Bunker fuel oil slicks were predicted to persist for longer and at heavier concentrations than for condensate and light crude oil slicks, as bunker fuel oil is a heavy oil that tends to form thick surface slicks that are not rapidly broken down in the marine environment.

Condensate Release

A spill of condensate from a grounded tanker adjacent to the LNG Jetty would have a high probability (95%) of reaching the shorelines of Barrow and Lowendal Islands in winter. A condensate spill during this season was predicted to result in 60 km of shoreline that would potentially be affected, with a maximum onshore volume of 12 m^3. Probabilities for shoreline contact were much lower for summer (25% probability) and the transitional season (57% probability). The maximum length of shoreline at risk of exposure during summer was predicted to be 37 km, with a maximum onshore volume of 6 m^3. During the transitional period, the maximum length of shoreline exposure was predicted to be 41 km, with a maximum onshore volume of 9 m^3.

Light Crude Oil

A spill of light crude oil from a grounded tanker adjacent to the LNG Jetty would almost certainly (99% probability) contact the shorelines of Barrow Island and the Lowendal Islands in winter, with a maximum onshore volume of 20 m^3, potentially exposing up to 70 km of shoreline. The transitional period was predicted to have a similar risk of exposure (91%), with a maximum onshore volume of 18 m^3 exposing a maximum of 70 km of shoreline. Probability of exposure during summer was lower (51%), with a maximum predicted onshore volume of 18 m^3 potentially exposing 56 km of shoreline.

Bunker Fuel Oil

A spill of bunker fuel oil from a grounded tanker adjacent to the LNG Jetty had a very high probability (95%) of contacting the shorelines of Barrow Island and the Lowendal Islands during winter. Maximum on shore volumes for winter were predicted to reach 47 m^3, potentially exposing up to 51 km of shoreline. Predicted risk of exposure for shorelines during the transitional period was 68%, with maximum volume onshore predicted at 35 m^3 potentially exposing up to 47 km of shoreline. Probability of shoreline contact during summer was much lower (32%), with predicted maximum onshore volumes of 40 m^3, potentially exposing a maximum of 32 km of shoreline.

3.3.2.2 Aromatic Hydrocarbons

During the summer and transitional periods, aromatic hydrocarbons from the slicks were predicted to most likely expose the shallow pavement areas and bommie fields to the south and south-east of the Lowendal Islands, at concentrations of up to 500 ppb depending on oil type.

Under winter conditions, subsurface plumes of aromatic hydrocarbons were expected to most likely affect the east coast of Barrow Island at concentrations up to 260 ppb, and potentially reaching Barrow Shoals at concentrations <100 ppb.

Condensate

The modelling indicated that aromatic components of condensate would be rapidly lost through evaporation and/or dissolution with only low probabilities (<5%) of low concentrations (>10 ppb) contacting inshore areas. The highest predicted concentration of aromatic hydrocarbons contacting any shoreline was predicted to be 117 ppb on the eastern shorelines of Barrow Island during winter, with a mean concentration of only 4 ppb. Maximum concentrations were low during other seasons. During summer, a maximum concentration of 26 ppb was predicted for the Lowendal Islands, and a maximum of 43 ppb predicted for Double Island during the transitional months.

Light Crude Oil

The modelling suggested that aromatic components of light crude oil persist longer and at higher concentrations than for condensate. Probabilities of inshore contact were low (5-10%), but maximum potential concentrations were greater for light crude oil (100-300 ppb). The highest predicted concentration of aromatic hydrocarbons was predicted to be 264 ppb on the eastern shorelines of Barrow Island during winter, with a mean maximum concentration of 8 ppb. The maximum aromatic hydrocarbon concentration during summer was predicted to be 222 ppb (Lowendal Islands), while the maximum predicted level for the transitional months was 79 ppb on the eastern shorelines of Barrow Island.

Bunker Fuel Oil

The modelling indicated low probabilities (<5%) of aromatic hydrocarbons (>10 ppb) reaching inshore areas, as bunker fuel oil tends to form thick slicks rather than entrain into the water column. The highest concentration of aromatic hydrocarbons was predicted to be 150 ppb (Lowendal Islands) during the transitional months, with a very low mean inshore concentration of 2 ppb. Maximum winter concentration was predicted to be 110 ppb (eastern shoreline of Barrow Island) and maximum summer concentration was predicted to be low, at 14 ppb (eastern shoreline of Barrow Island).

3.4 Summary of Modelling Results

Table 5 provides a summary of the upstream and downstream hydrocarbon spill modelling results, as generated by APASA (2005, 2012). Where the modelling predicted no contact (NC) for a certain threshold, no higher thresholds are given for that scenario (as they would similarly have no contact predicted).

Table 5: Spill Modelling Results Summary

Scenario	First Contact Point – Sensitive Area	Oil State and Threshold Concentration	Seasonal Contact	Minimum Travel Time to Sensitive Shoreline Location (days)	Highest Probability of Threshold Breach (%)	Max Concentration During any Season	Worst case Seasonal Likelihood	Worst Case Annualised Probability	Furthest Contact at 1% Probability	General Direction of Travel Across Seasons
APASA 2012										
Well Blowout at Chandon Gas Field	Ningaloo Coast NHP	Surface (1 g/m^2)	Winter	29	3	60 g/m^2 (Summer)	1.35 × 10^{-6} (Summer)	9.63 × 10^{-6} (1 in 103,842 chance of a spill resulting from a well blowout reaching the shoreline of the Ningaloo Coast NHP per year)	>1,350 km (Entrained)	Surface SW or NW in summer and winter. NE or WSW in autumn. NNW (some SSW) in spring. Entrained SSW in summer. SSW and SW in autumn and spring. SW, W and N in winter. Dissolved Aromatics E for each season.
		Surface (10 g/m^2)	NC	-	-					
		Entrained (10 ppb)	All seasons	10	70 (Autumn)	2,940 ppb (Spring)				
		Entrained (100 ppb)	All seasons	10	36 (Spring)					
		Entrained (500 ppb)	All seasons	16	23 (Spring)					
		Dissolved Aromatics (5 ppb)	Summer, Winter, Spring	NA	23 (Spring)	30 ppb (Spring)				
		Dissolved Aromatics (50 ppb)	NC	-	-					
Intrafield Pipeline Rupture – Chandon Manifold Tie-in	Ningaloo Coast NHP	Surface (1 g/m^2)	NC	-	-	-	2.00 × 10^{-6} (Spring)	2.00 × 10^{-6} (1 in 500,000 chance of a spill resulting from a pipeline rupture reaching the shoreline of the Ningaloo Coast NHP per year)	480 km (Entrained)	Surface SSW and NNW in summer and spring. SSW in autumn. SW in winter. Entrained SSW to SW during each season. NNW in summer, winter and spring. Dissolved Aromatics NA.
		Entrained (10 ppb)	Spring	13	1	60 ppb (Spring)				
		Entrained (100 ppb)	NC	-	-					
		Dissolved Aromatics (5 ppb)	NC	-	-	-				
Intrafield Pipeline Rupture – Jansz PTS Tie-in	Ningaloo Coast NHP	Surface (1 g/m^2)	NC	-	-	-	1.00 × 10^{-5} (Summer)	1.00 × 10^{-5} (1 in 100,000 chance of a spill resulting from a pipeline rupture reaching the Ningaloo Coast NHP per year)	600 km (Entrained)	Surface W and SW in summer and autumn. SW in winter and spring. Entrained SSW to SW during each season. NNW also for winter. Dissolved Aromatics NA.
		Entrained (10 ppb)	Summer	12	1	25 ppb (Summer)				
		Entrained (100 ppb)	NC	-	-					
		Dissolved Aromatics (5 ppb)	NC	-	-	-				
Major Diesel Spill (80 m^3)	Ningaloo Coast NHP	Surface (1 g/m^2)	NC	-	-	-	1.08 × 10^{-7} (Spring)	1.08 × 10^{-7} (1 in 9,259,259 chance of a spill resulting from a major diesel spill reaching the shoreline of the Ningaloo Coast NHP per year)	460 km (Surface/ Entrained)	Surface WNW in summer. W and SW in autumn. W and NW in winter. NNE in spring. Entrained SSW to SW during each season. WNW in summer. N to NNE in autumn, winter and spring. Dissolved Aromatics NA.
		Entrained (10 ppb)	Spring	12	1	120 ppb (Spring)				
		Entrained (100 ppb)	NC	-	-					
		Dissolved Aromatics (5 ppb)	NC	-	-	-				

Scenario	First Contact Point – Sensitive Area	Oil State and Threshold Concentration	Seasonal Contact	Minimum Travel Time to Sensitive Shoreline Location (days)	Highest Probability of Threshold Breach (%)	Max Concentration During any Season	Worst case Seasonal Likelihood	Worst Case Annualised Probability	Furthest Contact at 1% Probability	General Direction of Travel Across Seasons
Minor Diesel Spill (2.5 m^3)	NC	-	NC	-	-	-	-	-	260 km (Surface)	Surface NW and NE in summer. SW in autumn. SW in winter. N in spring. Entrained NW and SE in summer. W and SW in autumn and winter. NE, SE and SW in spring. Dissolved Aromatics NA.
APASA 2005										
Rupture of Feed Gas Pipeline 14 km west of Barrow Island	NA*	Surface (0.3 g/m^2)	All seasons	NA[†]	63 (Summer)	NA[§]	8.8×10^{-6} (Summer)	9.79×10^{-6} (1 in 102,145 chance of a spill resulting from a rupture of the Feed Gas Pipeline 14 km west of Barrow Island reaching any shoreline per year)	60 km[‖] (Dissolved Aromatics)	Surface ENE Dissolved Aromatics NE
		Dissolved Aromatics (10 ppb)	All seasons	NA[†]	10-20[‡] (Annual)	1754 ppb[§] (Summer) at Montebello Islands				
Rupture of Feed Gas Pipeline 200 m west of Barrow Island	NA*	Surface (0.3 g/m^2)	All seasons	NA[†]	99 (Summer)	NA[§]	1.39×10^{-5} (Summer)	2.76×10^{-5} (1 in 36,232 chance of a spill resulting from a rupture of the Feed Gas Pipeline reaching any shoreline per year)	75 km[‖] (Dissolved Aromatics)	Surface N Dissolved Aromatics NNE
		Dissolved Aromatics (10 ppb)	All seasons	NA[†]	90-100[‡] (Annual)	4524 ppb[§] (Summer) at Barrow (west)				
Diesel spill Feed Gas Pipeline – 10 km west of Barrow Island	NA*	Total Hydrocarbons (0.1 g/m^2)	All seasons	NA[†]	16 (Summer and Winter)	103 ppb[§] (Transitional) at Barrow (west)	3.28×10^{-3} (Summer)	6.29×10^{-3} (1 in 159 chance of a spill resulting from a diesel spill reaching any shoreline per year.)	25 km[‖] (Surface)	Surface NNE
Diesel spill Feed Gas Pipeline – 5 km west of Barrow Island	NA*	Total Hydrocarbons (0.1 g/m^2)	All seasons	NA[†]	60 (Summer)	56 ppb[§] (Summer) at Barrow (west)	1.23×10^{-2} (Summer)	1.45×10^{-2} (1 in 69 chance of a spill resulting from a diesel spill reaching any shoreline per year)	30 km[‖] (Surface)	Surface NNE
Diesel spill Feed Gas Pipeline – 2.5 km west of Barrow Island	NA*	Total Hydrocarbons (0.1 g/m^2)	All seasons	NA[†]	84 (Summer)	440 ppb[§] (Summer) at Montebello Islands	1.72×10^{-2} (Summer)	2.43×10^{-2} (1 in 41 chance of a spill resulting from a diesel spill reaching any shoreline per year)	30 km[‖] (Surface)	Surface NE
Diesel spill during refuelling adjacent to the MOF	NA*	Total Hydrocarbons (0.1 g/m^2)	All seasons	NA[†]	84 (Summer)	2,372 ppb[§] (Winter) at Barrow (east)	2.86×10^{-3} (Summer)	4.03×10^{-3} (1 in 248 chance of a spill as a result of a diesel spill reaching any shoreline per year)	85 km[‖] (Surface)	Surface ENE
Condensate release from a grounded tanker adjacent to the LNG Jetty	NA*	Surface (0.3 g/m^2)	All seasons	NA[†]	95 (winter)	NA[§]	4.43×10^{-6} (Winter)	7.51×10^{-6} (1 in 133,156 chance of a condensate spill resulting from a tanker grounding reaching any shoreline per year)	90 km[‖] (Surface)	Surface NE Dissolved Aromatics NW
		Dissolved Aromatics (10 ppb)	All seasons	NA[†]	<5[‡] (annual)	117 ppb[§] (Winter) at Barrow (east)				
Light crude oil release from a grounded tanker adjacent to the LNG Jetty	NA*	Surface (0.3 g/m^2)	All seasons	NA[†]	95 (Winter)	NA[§]	4.43×10^{-6} (Winter)	1.01×10^{-6} (1 in 990,099 chance of a light crude oil spill resulting from a tanker grounding reaching any shoreline per year)	>110 km[‖] (Surface)	Surface NE Dissolved Aromatics NE and SW
		Dissolved Aromatics (10 ppb)	All seasons	NA[†]	10-20[‡] (Annual)	264 ppb[§] (Winter) at Barrow (east)				

Scenario	First Contact Point – Sensitive Area	Oil State and Threshold Concentration	Seasonal Contact	Minimum Travel Time to Sensitive Shoreline Location (days)	Highest Probability of Threshold Breach (%)	Max Concentration During any Season	Worst case Seasonal Likelihood	Worst Case Annualised Probability	Furthest Contact at 1% Probability	General Direction of Travel Across Seasons
Bunker fuel oil release from a grounded tanker adjacent to the LNG Jetty	NA*	Surface (0.3 g/m^2)	All seasons	NA†	95 (Winter)	NA§	4.43×10^{-6} (Winter)	8.26×10^{-6} (1 in 121,065 chance of a bunker fuel oil spill resulting from a tanker grounding reaching any shoreline per year)	100 km‖ (Surface)	Surface: Variable; Dissolved Aromatics: WSW
		Dissolved Aromatics	All Seasons	NA†	5-10‡ (Annual)	150 ppb§ (Transitional) at Lowendal Islands				

*APASA 2005 did not specify first point of contact locations.

†APASA 2005 did not specify minimum travel time to sensitive shoreline locations.

‡Highest probability of threshold breach ranges for dissolved aromatics were taken from APASA 2005 figures and are for all seasons. Seasonal threshold breaches were not provided in APASA 2005 for dissolved aromatics.

§APASA 2005 maximum concentrations were for aromatic hydrocarbons in inshore waters, except for diesel spill scenarios which are total hydrocarbons.

‖Maximum travel distances from the spill site have been estimated from APASA 2005 figures.

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4.0 OIL SPILL MANAGEMENT MEASURES

Chevron Corporation operates internationally, conducting business in approximately 180 countries. In many of these countries, Chevron Corporation is actively engaged in oil and gas exploration and production, and at any time has approximately 200 drilling rigs on contract, of which approximately 30 are offshore rigs.

Management of hydrocarbon spill risk for the Fourth Train Proposal is expected to comprise both preventative and reactive measures, the former to reduce the likelihood of an hydrocarbon spill occurring and the latter to reduce the probability of adverse impacts should a spill occur. Both aspects of spill management are subject to direct government oversight and regulation via a suite of agencies (e.g. Australian Maritime Safety Authority (AMSA), National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) and WA Department of Transport).

Chevron Corporation systematically develops and refines measures for the management of hydrocarbon spill risk associated with well and pipeline construction and operation in accordance with its management systems. The sort of measures expected to be adopted in the management for the Fourth Train Proposal, and assumed for the purposes of this risk assessment, are outlined in the following sections.

4.1 Control Measures

4.1.1 Well Control

The wells proposed as part of the Fourth Train Proposal will be planned and engineered to minimise the likelihood of loss of well control, in accordance with safety considerations, NOPSEMA regulations and other legislative requirements. Well design and operations will be detailed in a project-specific Well Operations Management Plan, for assessment by NOPSEMA.

A number of barriers (safeguards or controls) will be put in place with the aim of reducing the likelihood of a loss of well control. These barriers include preventative measures and mitigation, or recovery, measures. The preventative barriers can be further defined as engineering or administrative controls while the assumed mitigation/recovery measures ensure that, if a loss of well control occurs, the severity of the event can be limited by controlling and recovering the situation.

The drilling rig will be fitted with Blow Out Preventers (BOPs) capable of withstanding pressures that might be encountered during the drilling program. The BOPs, in conjunction with the casing design, are intended to prevent any releases of drilling or formation material to the marine environment in the event of loss of hydrostatic pressure control.

The following well control equipment may be used to provide assurance of BOP functionality and reliability to prevent a loss of well control incident if control from the rig was compromised or completely lost (Chevron Australia 2011):

- dual rigid hydraulic lines from the surface to the stack (one a hot line) to provide redundancy in hydraulic control to function the BOP stack
- a flying lead off the sub-sea BOP mounted accumulator bottles for remote operated vehicle (ROV) assisted BOP function
- an ROV fitted with a hot stab and a bladder with control fluid to function the BOP rams
- "Deadman" which will activate the blind shears to severe the drill pipe and seal the well, if all electrical and hydraulic control is lost from the rig to both controls pods.

It is assumed that testing of the BOPs will include:

- stump test of the complete stack and valves to an agreed maximum working pressure prior to running the stack
- additional testing during operations as per the agreed well control procedures.

During drilling, the fluid flow rates, bit penetration rate and pressure parameters will be continuously monitored to provide for early warning and correction of potential well control problems.

4.2 Refuelling Procedures

It is expected that the drilling rig will be periodically refuelled from the support vessels (generally every 10–14 days). Construction vessels during pipe-lay operations may also be refuelled at sea by support vessels.

All refuelling operations will be conducted in strict accordance with relevant procedures, including the support vessel refuelling procedures for bunkering in port and the construction vessel / rig specific procedures for refuelling offshore. This assessment assumes that measures to reduce the risk of fuel leaks or spill during refuelling at sea may include:

- refuelling only undertaken when weather/sea/visibility conditions are appropriate, as determined by the Vessel Master

- using reinforced hoses with flotation collars, dry break couplings and breakaway couplings, which are fit for purpose, used within their design life limits, and regularly checked for damage to prevent leaks
- continuous visual monitoring of hoses, couplings and flow gauges as well as maintaining open communication channels between vessels during refuelling
- installing scupper plugs to mitigate against overboard loss during a refuelling spill
- secondary containment under all onboard coupling points.

4.3 Collision Prevention

The drilling rig will be restricted in its ability to manoeuvre during well construction and under tow when relocating between well sites, and will therefore have right-of-way over other vessels. A 500 m safety zone will be established around the drilling rig and a Notice to Mariners warning of the presence of the rig and construction vessels will be broadcast. The rig is also likely to be fitted with Automated Radar Plotting Aid radar or similar.

It is assumed that the location of the wells and schedule for the drilling and construction activities, including pipelay activities, will be communicated to the commercial fishers (via Australian Fisheries Management Authority and Western Australian Fishing Industry Council) and other commercial mariners (via AMSA and all relevant port authorities) who may operate in the area.

All vessels associated with the Fourth Train Proposal will be required to comply with the International Regulations for the Prevention of Collision at Sea 1972 (COLREGS) as adopted by the *Western Australian Marine Act 1982*.

The drilling rig, construction and support vessels, including pipelay vessels, will display all required navigation lighting to minimise any navigation hazard to passing vessels. It is assumed that all marine operations will cease and vessels will seek safe harbour (or deep water) where extreme conditions make it unsafe to continue their activities.

During operation of the Fourth Train Proposal, trained and qualified pilots are expected to be used on all export vessels bound for the Product Loading Facility and either pilots or masters with exemption certificates on vessels calling at the MOF.

4.4 Flowline and Pipeline Monitoring

The FGPS and intrafield flowlines will be designed in accordance with industry standards including AS2885 and DNV OS-F101 to meet the oceanic, climatic and seismic conditions of the area. This may include appropriate design to reduce the potential for impact to flowline and the FGPS from anchoring or shipping, possibly through the use of weighted concrete coating or external stabilisation, acting as protection, depending on the depths and hydrodynamic properties of the area. A precautionary zone will also be implemented around the FGPS and flowlines so that other vessels in the area are discouraged from anchoring in proximity of the flowlines and FGPS.

A corrosion management plan will be implemented over the operating life of the FGPS and intrafield flowlines, and this assessment assumes that such a plan will detail potential intervention methods to be initiated to define and resolve any corrosion problems. Externally, a combination of anodes, cathodic protection, corrosion coatings and monitoring could be employed to minimise the risk of external corrosion.

Installed FGPS and flowlines will be routinely inspected and monitored to identify any buckles, coating damage and free-spans greater than design specifications. It is assumed that all damage will be assessed and remedial work performed as required to assure long-term pipeline integrity.

Pipeline integrity inspections and routine maintenance activities as well as a schedule of activities will be detailed in an Inspection, Maintenance and Repair Plan (IMR Plan) or equivalent. It is expected that as part of this Plan, regular, ongoing inspections of the flowlines and the FGPS will be undertaken to ensure continued integrity. These may include, where applicable:

- hydrostatic testing of each pipeline prior to commissioning
- intelligent “pigging” to monitor the condition of the pipelines
- pressure/flow monitoring sensors on the pipelines to indicate/detect (large) spills
- regular hydrostatic, a scanning or ultrasonic testing of the flowlines and pipelines
- regular ROV surveys of sub-sea infrastructure.

4.5 Mitigation Measures

4.5.1 Oil Spill Response

In the unlikely event of an accidental spill to the ocean, it is assumed that Chevron Australia and its contractors will respond in accordance with a project-specific Emergency Response Bridging Document and the Oil Spill Operational Response Plan (OSORP), in conjunction with Chevron Australia’s Marine Oil Pollution Plan (MOPP) and the rig’s/construction vessels’ Shipboard Oil Pollution Emergency Plan and Emergency Response Plan. These documents assign responsibilities, specify response procedures and identify resources available in the event of an oil spill or other incident.

The OSORP provides direction for immediate onsite response for the most likely spills and details the notification and response procedures to coordinate control of a larger spill. Containment and cleanup resources, including spill containment kits, bunding and drain plugs, and competent personnel, are expected to be maintained offshore during any activity that has an increased potential for hydrocarbon loss to the marine environment, such as flaring and refuelling, to reduce the likelihood of onboard spills reaching the marine environment. It is assumed that support vessels will be capable of deploying dispersant booms (with the consent of NOPSEMA as per the MOPP) if required.

The MOPP details the overall coordination of response to an oil spill associated with Chevron Australia's activities on the North West Shelf. The MOPP integrates requirements of the Australian National and State plans including:

- National Plan (National Plan to Combat Pollution of the Sea by Oil and Other Noxious Substances)
- WestPlan-MOP (Western Australian Marine Oil Pollution Emergency Management Plan)
- WestPlan-HAZMAT (Western Australia Hazardous Materials Emergency Management Plan)
- Port Oil Spill Contingency Plans.

The response arrangements in the OSORP will be tested as per the requirement of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cwlth).

Existing spill response resources on Barrow Island would be expected to be available in the event of a spill associated with the Fourth Train Proposal. During construction and operation of the Fourth Train Proposal, Chevron Australia will also have access to the extensive resources of the Australian Marine Oil Spill Centre (AMOSC). AMOSC operates Australia's major oil spill response equipment stockpile on 24-hour stand-by for rapid response anywhere around the Australian coast. Through AMOSC, Chevron Australia will be able to mobilise the personnel and equipment necessary to combat a major oil spill.

4.5.2 Relief Well

Chevron Australia currently has two semi-submersible drill rigs on contract drilling wells in the Greater Gorgon Area. At the time of drilling for the Fourth Train Proposal it is likely that Chevron Australia may have more than one rig operating in the region given that development drilling for the Wheatstone project is also scheduled.

Chevron Australia is also party to the current Mutual Aid Agreement drafted for the industry through the Australian Petroleum Production & Exploration Association. This agreement involves the sharing of equipment for use in a loss of well control situation with other operating companies, and includes access to rigs. The North West Shelf is a region of considerable petroleum activity and currently the following deepwater rigs are operating in the region:

- Maersk Discoverer (Dynamic Positioning (DP))
- Ocean America (moored)
- Jack Bates (moored)
- Saipen 10,000 (DP).

In the unlikely event of an uncontrolled blowout on a Fourth Train Proposal well, it is expected that Chevron Australia would mobilise the first available of these rigs into position to drill a relief well to kill and seal the uncontrolled well, after safely securing the well it was drilling.

Depending on circumstances, it may also be possible to control the spill earlier using a capping stack while the relief well is being drilled.

5.0 RESOURCE SENSITIVITY

Environmental resources within the spatial extent of potential spills associated with the Fourth Train Proposal, as defined in Section 3.0 and APASA (2012; Appendix 1), are described in the following sections. Matters of NES and Key Ecological Features (KEFs) are also described, as well as their sensitivity to spilled hydrocarbons.

5.1 Matters of National Environmental Significance

5.1.1 Threatened and Migratory Species

5.1.1.1 Fish

Although laboratory studies have shown a range of lethal and sub-lethal effects of oil on fish (Neff & Anderson 1981) the hydrocarbon concentrations at which these have occurred have generally been considerably higher than those occurring during oil spills (Volkman et al. 1994). Fish appear to be more sensitive to short-term acute toxicity from the lighter aromatic components (NRC 1985; Neff & Anderson 1981) probably because they possess the enzymes necessary to metabolise sub-lethal concentrations of hydrocarbons (Volkman et al. 1994).

Laboratory studies have shown that adult fish are able to detect oil in water at very low concentrations, and large numbers of dead fish have rarely been reported after oil spills (Hjermann et al. 2007; Edwards & White 1999). This suggests that juvenile and adult fish are capable of avoiding water contaminated with high concentrations of oil. However, sub-lethal impacts to adult and juvenile fish may be possible, given long-term exposure (days to weeks) to PAH concentrations (Hjermann et al. 2007). The effects of exposure to oil on the metabolism of fish appears to vary according to the organs involved, exposure concentrations and route of exposure (waterborne or food intake). Oil reduces the aerobic capacity of fish exposed to aromatics in the water and to a lesser extent affects fish consuming contaminated food (Cohen et al. 2005). The liver, a major detoxification organ, appears to be the organ where anaerobic activity is most impacted, probably increasing anaerobic activity to facilitate the elimination of ingested oil from the fish (Cohen et al. 2005).

Fish are perhaps most susceptible to the effects of spilled oil in their early life stages, particularly during egg and planktonic larval stages, which can become entrained in spilled oil. Contact with oil droplets can mechanically damage feeding and breathing apparatus of embryos and larvae (Fodrie & Heck 2011). The toxic compounds of oil in water can result in genetic damage, physical deformities and altered developmental timing for larvae and eggs exposed to even low concentrations over prolonged timeframes (days to weeks) (Fodrie & Heck 2011). More subtle, chronic effects on the life history of fish as a result of exposure of early life stages to oil include disruption to complex behaviours such as predator avoidance, reproductive and social behaviour

(Hjermann et al. 2007). Prolonged exposure of eggs and larvae to weathered concentrations of oil in water has also been shown to cause immunosuppression and allows expression of viral diseases (Hjermann et al. 2007). However, the effect of an oil spill on a population of fish in an area with fish larvae and/or eggs, and the extent to which any of the adverse impacts may occur, depends greatly on prevailing oceanographic and ecological conditions at the time of the spill and its contact with fish eggs or larvae.

Whale sharks, which feed in a similar manner to baleen whales, could be at risk of exposure to spilled hydrocarbons through ingestion. Possible effects from the consumption of oil include causing damage to the lining of the stomach and intestine, as well as effects to motility, digestion and absorption (Kirwan & Short 2003).

Biologically important areas for listed Threatened and Migratory fish in the North-west Marine Region that may be impacted by an oil spill associated with the Fourth Train Proposal are restricted to two key foraging areas for whale sharks (DSEWPaC 2012b):

- foraging in the Ningaloo Marine Park and adjacent Commonwealth waters from March to July

- foraging northward from Ningaloo Marine Park along the 200 m isobath from July to November.

A spill outside of the aggregation period would likely have negligible impacts on whale sharks, as few whale sharks would be expected to be present (Meekan & Radford 2010).

While the listed Threatened dwarf sawfish may be present in the area, the north-west bioregion does not contain any biologically important areas for this species (DSEWPaC 2012b).

5.1.1.2 Marine Mammals

Air breathing fauna such as marine mammals may be at risk through inhalation of evaporated components once the condensate has surfaced. A blowout that occurred during the migration periods of species such as the humpback whale could potentially expose a substantial number of animals. Possible effects of oil spills on cetaceans can be grouped into three categories; direct surface fouling, inhalation of toxic vapours, and ingestion (Volkman et al. 1994).

While empirical evidence of the effect of spilled oil on marine mammals is low (Law et al. 2011), studies and field observations (Geraci & St. Aubin 1990; Butler et al. 1974) suggest that cetaceans show very little reaction to surface contact with oil and in some cases are able to detect surface oil and avoid it altogether (Gubbay & Earll 2000; Geraci & St. Aubin 1990). Matkin et al. (2008) studied the effect of the oil pollution impacts on killer whales from the Exxon Valdez' oil spill in Prince William Sound, Alaska. The authors concluded that the whales are unable to detect or avoid lighter oil sheens at the water's surface and are thus susceptible to inhalation of vapours and/or oil, skin contact, and ingestion. However, effects of spills on cetaceans can be species dependant (Gubbay & Earll 2000). Many cetaceans are able to detect oil, with the possible exception of thin sheens, but may not actually avoid it in the wild. Studies have shown that cetaceans do prefer to avoid oil and predominately rely on vision to do so (Geraci & St. Aubin 1990). However, this was generally limited to darker substances. Lighter fractions that spread quickly into sheens such as gasoline and diesel fuel are therefore harder to detect, if at all (Geraci & St. Aubin 1990).

Direct, physical oiling of cetaceans (including contact with entrained hydrocarbon concentrations) is not considered a serious risk to their thermoregulation capabilities, as the skin of cetaceans contains a resistant dermal shield acting as a barrier to any toxic effects of oil (Volkman et al. 1994). However, this does largely depend on the effectiveness of the cetacean epidermis as a barrier to the noxious substances found in petroleum (Gubbay & Earll 2000).

Spilled oil may be toxic to cetaceans through two pathways; inhalation of petroleum vapours during surfacing to breathe, and consumption of hydrocarbons while feeding. While the likelihood of petroleum vapours being consumed at the point of air intake is likely if a cetacean surfaces to breathe while passing through the area of a surface slick, concentrations of vapours (typically the aromatic compounds of hydrocarbons) may need to be in the realm of 1000 ppb to potentially cause harm (Kirwan & Short 2003). Such concentrations would only be available immediately upon the spill reaching the surface, prior to the slick undergoing weathering and the loss of volatile aromatic compounds through evaporation. Nevertheless, effects from inhalation of vapours include the possibility of death at concentrations greater than 10,000 ppb. Inflammation, haemorrhage, congestion of the lungs, central nervous system disorders, brain degeneration, liver damage, adrenal damage, acute (and possibly fatal) pneumonia and reproductive failure at levels of up to 1000 ppb and above are also possible (Kirwan & Short 2003).

Baleen whales may be at particular risk of ingestion of hydrocarbons given their preference for feeding at or near the surface. Possible effects from the consumption of oil by cetaceans include causing damage to the lining of the stomach and intestine, as well as effects to motility, digestion and absorption (Kirwan & Short 2003). The ingestion of oil may also result in baleen fouling, although this would likely only result in a temporary disturbance to feeding behaviour, as baleen plates typically clear of oil relatively quickly (Geraci & St. Aubin 1990).

Little is known of the effects of oil spills on dugongs, with conflicting reports as to whether dugongs suffered mortalities following the Gulf War spill (Sadiq & McCain 1993; Preen 2004). In common with other air breathing fauna, it seems likely they may be most susceptible to impacts from inhalation of volatised hydrocarbons (AMSA 2011). Dugongs could also be indirectly affected by spill impacts to their preferred food source of seagrasses. Direct contact with oil, including entrained components, can smother and kill seagrasses if it coats their leaves and stems (Taylor & Rasheed 2011). However, long-term impacts to seagrass are unlikely unless oil is retained within the seagrass meadow for a sustained duration (Wilson & Ralph 2010). Species of *Halodule* and *Halophila* exposed to dissolved Arabian crude oil showed no significant changes in respiration or photosynthesis (Saenger 1994) and subtidal seagrass beds in the Arabian Gulf were apparently unaffected by the Gulf War spill (Sadiq & McCain 1993; Saenger 1994). Studies and field observations suggest that *Zostera* and *Halophila* species were not adversely affected by even high concentrations of water soluble fractions of hydrocarbons (Wilson & Ralph 2010). Dugongs are highly migratory and populations in the north of WA are thought to move to alternate feeding areas following natural (cyclonic) disturbances to local seagrass communities (Hodgson 2007).

Biologically important areas for marine mammals that may be affected by a hydrocarbon spill associated with the Fourth Train Proposal include (Figure E; DSEWPaC 2012b):

- the north-south humpback whale migration corridor, centred on the 200 m isobath
- both Shark Bay and Exmouth Gulf (important resting areas for south bound humpback whale cows and calves, foraging and nursing areas for dugongs)
- Ningaloo Reef (foraging area for dugongs).

5.1.1.3 Marine Reptiles

The impacts of condensate spills on turtles are not well documented, although all life cycle stages are considered susceptible to adverse effects from hydrocarbon exposure (NOAA 2010). Hatchlings are at an increased risk of exposure because of their poor motility, relatively small size and tendency to spend more time swimming on the water surface (NOAA 2010). In addition to direct effects on turtles, spills may indirectly reduce viability by affecting food sources, increasing susceptibility to predation and reducing foraging ability. Both lethal and sub-lethal effects are possible, particularly as a result of inhalation, but also via ingestion of hydrocarbons, and irritation/damage to sensitive tissues may result through direct contact.

There have been reports of lesions and mortalities being apparent in turtles following several major spills, including the Ixtoc blowout and the Gulf War spill (NOAA 2010). Ingestion of tar balls has frequently been cited as a source of adverse effects to turtles following exposure to hydrocarbons, but this is unlikely to be relevant to a spill of Chandon condensate, which has only low levels of persistent components that do not possess the characteristics likely to result in solidification.

Biologically important areas for marine turtles that may be affected by a hydrocarbon spill associated with the Fourth Train Proposal include the following (Figure F; DSEWPaC 2012b):

- Barrow Island:
  - Flatback turtle mating and nesting with an 80 km internesting buffer
  - Green turtle nesting from November to April and foraging in inshore waters, including a 20 km internesting buffer
  - Hawksbill turtle nesting during summer (peak in October to December) with a 20 km internesting buffer.
- Montebello Islands:
  - Flatback turtle nesting and mating during summer with an 80 km internesting buffer
  - Green turtle nesting during summer with a 20 km internesting buffer
  - Hawksbill turtle nesting during spring and early summer (peak in October) with a 20 km internesting buffer
  - Loggerhead turtle nesting peaking in December to January with a 20 km internesting buffer.
- Lowendal Islands:
  - Hawksbill turtle nesting during spring and summer with a 20 km internesting buffer
  - Loggerhead turtle nesting peaking in December to January with a 20 km internesting buffer.
- Dirk Hartog Island:
  - Loggerhead turtle nesting December to March with a 20 km internesting buffer.
- Thevenard and Varanus Islands:
  - Hawksbill nesting with a 20 km internesting buffer.
- Ningaloo:
  - Green turtle nesting at North West Cape and Muiron Islands during summer with a 20 km internesting buffer
  - Hawksbill turtle nesting on the Ningaloo and Jurabi Coast with a 20 km internesting buffer

- Loggerhead turtle nesting on the Muiron Islands, Ningaloo and Jurabi coasts from December to January with a 20 km internesting buffer.

5.1.1.4 Marine Avifauna

Seabirds can be particularly susceptible to oiling, and may be affected through fouling of plumage, ingestion of oil, effects on reproduction and physical disturbance (Volkman et al. 1994). Seabirds that spend most of their time afloat (swimming), certainly those that cannot survive onshore for any length of time, are the most sensitive to oiling, particularly those fully restricted to marine prey resources (Kees 2011).

Seabirds are most vulnerable to oil pollution during the breeding season near their colonies and at other times of the year over the feeding grounds. Oiling of the plumage destroys its integrity as insulation and can cause the animals to die of hypothermia or by drowning (Volkman et al. 1994; Kees 2011). Birds may ingest oil by preening feathers or by ingestion of contaminated food. The effects of ingested oil can include anaemia, pneumonia, intestinal irritation, kidney damage, decreased growth, and decreased production and viability of eggs (Volkmann et al. 1994; King & Lefever 1979). Exposure of eggs to as little as 5 µL of fresh oil can cause embryo mortalities, with exposure to concentrations as low as 1 µL known to cause reductions in hatching rates in some species (Volkman et al. 1994).

Whether seabirds are adversely impacted by oil spills, and the degree of adverse effects, are largely dependent on the characteristics, feeding strategies and habitat preferences of the species involved. Birds that spend much of their time on the sea surface (such as the wedge-tailed shearwater) are particularly vulnerable to spills. Shorebirds, such as waders and waterfowl, are not often as badly affected by oil as seabirds, which rest or feed on the water. The main concern for waders and waterfowl is that the oil will damage their feeding grounds. Evidence suggests that in most cases, spills are unlikely to have long term effects on overall bird populations unless a substantial portion of the population is restricted to the immediate area of the spill (Volkman et al. 1994). Some heavy oils immobilise individual birds immediately, and it is likely that such oil types are difficult to remove. Lighter oils, but also warmer seasons and less cold waters, may enhance the possibilities for self-cleaning in individual seabirds and therefore the effect of oil on their populations (Kees 2011). Oil ingested by birds may be lethal, but the most common cause of death is from drowning, starvation, and loss of body heat following damage to the plumage by oil. Even small amounts of oil in their plumage cause such birds to give up diving, which means they cannot any longer feed (Kees 2011). Feathers and down lose their waterproofing and insulating properties when affected by oil. Feather fouling from oil is the primary cause of mortality in seabirds exposed to oil pollution (O'Hara & Morandin 2010).

Biologically important areas for seabirds and migratory shore birds are defined as breeding areas (including surrounding waters where a species is likely to forage) and resting areas (DSEWPaC 2012b). Biologically important areas that may be affected by a hydrocarbon spill associated with the Fourth Train Proposal include the following (Figure G; DSEWPaC 2012b):

- Ningaloo Coast, North West Cape and Muiron Islands:
  - Roseate tern (*Sterna dougallii*)
  - Fairy tern (*Sterna nereis nereis*)
  - Wedge-tailed shearwater (*Ardenna pacifica*).

- Islands of the Southern Island Group (APASA 2012) and Thevenard Island:
  - Roseate tern (*Sterna dougallii*)
  - Fairy tern (*Sterna nereis nereis*)
  - Lesser-crested tern (*Sterna bengalensis*)
  - Wedge-tailed shearwater (*Ardenna pacifica*).

- Barrow and Montebello Islands and Lowendal Islands Group:
  - Roseate tern (*Sterna dougallii*)
  - Fairy tern (*Sterna nereis nereis*)
  - Lesser-crested tern (*Sterna bengalensis*)
  - Wedge-tailed shearwater (*Ardenna pacifica*)

- Islands off the Pilbara Coast at Karratha:
  - Lesser frigatebird (*Fregata minor*).

- Mermaid Reef:
  - White-tailed tropicbird (*Phaethon lepturus lepturus*).

- Seringapatam Reef:
  - Little tern (Sternula albifrons sinensis).

5.1.2 Commonwealth Marine Environment

5.1.2.1 Seabed, Benthic Habitats and Fauna

Within areas near the well site and/or central axis of the slick, effects on productivity would be possible given the extended duration of the release. The biological effects of oil on the seabed and benthos depend largely on the fate of the spilled oil and the additive toxicity of aromatic hydrocarbons. Lethal and sub-lethal effects to the benthos may include mortality, alterations in recruitment, growth and reproduction, as well as changes in community structure, including species richness (Wei et al. 2012). Non-selective deposit feeders such as polychaetes and nematodes have demonstrated resilience to the adverse effects of spilled oil contacting the sediment, and it can be expected that their density would increase in benthic habitats affected by oil (Wei et al. 2012). Conversely, the density of crustaceans such as amphipods and copepods would be expected to decline due to their known sensitivity to the effects of oil (Wie et al. 2012).

5.1.2.2 Water Column

Whether the physical presence of a large slick would cause considerable changes to physico-chemical parameters of marine water quality, such as reduced light or oxygen levels, is uncertain. Changes in the physico-chemical characteristics of the water column to the extent that it may affect marine biota depends to a large extent on the prevailing conditions, and it seems likely that the dynamic shape and location of the slick would restrict the area over which any extended effect of this nature occurred.

5.1.2.3 Pelagic Marine Fauna and Habitats

Laboratory toxicity studies have demonstrated great variation amongst planktonic organisms in response to the effects of spilled oil, with phytoplankton generally considered less sensitive to effects than zooplankton (Volkman et al. 1994). Toxic effects including decreases in growth rate and inhibition of photosynthesis have been observed in phytoplankton exposed to water soluble fractions of oil concentrations ranging from 1,000 ppb to 10,000 ppb (Neff 1991). Acute lethal effects to zooplankton have been observed from contact with water soluble fractions in concentrations greater than 200 ppb (Volkman et al. 1994). Sub-lethal effects to zooplankton, including physiological, biochemical and behavioural effects have been observed at one-tenth of lethal concentrations (Volkman et al. 1994). However, such laboratory toxicity studies have been shown to be of little relevance for predicting long-term effects on natural populations. Such studies are typically short-term and use robust, easily handled species not representative of the wide variety of planktonic organisms that exist naturally. Although such experiments demonstrate oil spill effects to plankton, field observations have typically showed minimal or transient effects (Volkman et al. 1994).

5.1.2.4 Commercial Fisheries

A blowout could potentially affect commercial fisheries in the region via:

- fouling of fishing gear
- reduced catches due to stock mortalities
- tainting of product.

Major commercial fisheries within the area of possible exposure as indicated by the trajectory modelling include:

- Commonwealth managed fisheries:
  - North West Slope Trawl Fishery
  - Western Deepwater Trawl Fishery
  - Western Tuna and Billfish Fishery.

- State managed fisheries:
  - Onslow Prawn Fishery
  - Northern Demersal Scalefish Fishery
  - West Coast Rock Lobster Fishery
  - Gascoyne Deep Sea Crab Fishery

- Gascoyne Demersal Scalefish Fishery
- Exmouth Gulf Prawn Fishery
- Shark Bay Prawn and Scallop Managed Fisheries
- Gascoyne Coast Blue Swimmer Crab Fishery
- North Coast Demersal Fishery.

The potential effects of spilled hydrocarbons on fish are discussed in Section 5.1.1.1. While prawns are known to be sensitive to hydrocarbons, documented cases of hydrocarbon spills from offshore oil and gas operations causing measurable impacts upon commercial prawn stocks are rare. The Ekofisk and Uniacke blowouts had no discernible effect upon prawn fishery resources even though, in both cases, some evidence of hydrocarbon exposure was apparent (Whittle et al. 1978; Zitko et al. 1984). Impacts on prawn stocks may have occurred as a result of the Ixtoc blowout, although it has been suggested that the measured decline following this incident may have been due to co-incidental environmental perturbations (Boehm et al. 1983).

5.1.3 Ningaloo Coast National Heritage Place and Adjacent Commonwealth Waters

The Ningaloo Coast National Heritage Place (NHP), included in the National Heritage List in January 2010, includes the North West Cape (Ningaloo Coast), approximately 250 km south of the Chandon field, and the Muiron Islands, approximately 230 km south of Chandon (Figure C). The values of the Ningaloo Coast were similarly recognised by the World Heritage Committee and the area was declared a World Heritage Area in June 2011.

The Ningaloo NHP includes a high diversity of marine habitats, most notably Ningaloo Reef, the largest fringing reef in Australia, as well as the Commonwealth waters adjacent to Ningaloo Reef. Ningaloo Reef comprises more than 300 species of coral and supports diverse and abundant communities of both tropical and temperate species of marine fauna and flora (CALM 2005). Globally significant populations of marine megafauna pass through or reside in the waters, including whale sharks, humpback whales, marine turtles and dugongs. Ningaloo Reef is characterised by high energy fringing reef environments and low energy lagoonal areas backing the landward side of the reef (CALM 2005).

The Commonwealth Waters Adjacent to Ningaloo Reef KEF includes the Ningaloo Marine Park (Commonwealth Waters), covering an area of approximately 2,435 km^2 (Figure D; DSEWPaC 2012b). Upwellings associated with the canyons on the nearby slope and interactions between the Leeuwin and Ningaloo current support rich aggregations of large marine species at Ningaloo Reef. Further offshore, the shelf water and nutrient rich upwellings support aggregating or migrating whale sharks, manta rays, humpback whales, sharks, large predatory fish and seabirds (DSEWPaC 2012b). The deepwater biodiversity of the Commonwealth waters includes demersal fish species, molluscs, sponges, soft corals and gorgonians (DSEWPaC 2012b).

The Ningaloo Coast NHP provides nesting habitat for four species of marine turtle, including biologically important nesting and internesting habitat for green, hawksbill and loggerhead turtles. Critical habitat exists for loggerhead turtles on the Muiron Islands and surrounding waters (20 km radius), where up to an estimated 600 females annually nest (DEC 2009). The North West Cape is also a major nesting habitat for hawksbill and green turtles, with an estimated 1,000 to 1,500 green turtles annually nesting in the area (DEC 2009).

There are approximately 33 species of seabirds found in the Ningaloo Marine Park, 13 of which are resident and the other 20 are Migratory birds or occasional visitors (CALM Seabird Database). The main rookeries in the Ningaloo Marine Park are found at Mangrove Bay, Mangrove Point, Point Maud, the Mildura wreck site and Fraser Island (10 km NNW of Pt Cloates). Listed Migratory birds with biologically important areas known to exist in the Park include the wedge-tailed shearwater, roseate tern and the fairy tern.

Dugong are known to forage along the reef year round, with a population of approximately 1,000 recorded in the Exmouth Gulf – Ningaloo Reef area (DSEWPaC 2012b). Consequently, the reef and surrounding waters have been recognised as a biologically important area for the species (Figure E; DSEWPaC 2012b).

One of the key values of the Ningaloo NHP is the diverse subterranean anchialine systems of the Cape Range Peninsula (Commonwealth of Australia 2010a). The combination of both seawater and freshwater incursion into the caves and waterways results in a unique assemblage of cave-dwelling fauna (Commonwealth of Australia 2010b).

Likely impacts to inshore areas of the Ningaloo Coast NHP, including those that represent important habitat for Threatened or Migratory species, would depend on a complex suite of interacting physical, chemical and biological factors. Of particular importance will be the dose and condition of the condensate involved in exposure, the prevailing sea, weather and tidal conditions, the pre-existing stress and energy levels of the location and the species composition of the biological communities affected. The timing of an incident in relation to the life cycle stages of the species impacted could also have considerable significance.

5.2 Key Ecological Features

5.2.1 Canyons Linking the Argo Abyssal Plain and Scott Plateau

The Canyons Linking the Argo Abyssal Plain with the Scott Plateau are located approximately 785 km north-east of the Chandon Field location (Figure D). The area is recognised as a KEF due to the high biodiversity and productivity values of the benthic and pelagic habitats (DSEWPaC 2012b). The canyons cut into the south-west of the

Scott Plateau at depths of approximately 2,000-5,000 m, and transport sediments to depths of more than 5,000 m (DSEWPaC 2012b). Strong currents transport sediments and organic matter down the continental slope and supply the benthos with particulate organic matter. The canyons tend to be dominated by sessile filter feeders (Falkner et al. 2009). Surface waters of the area are characteristically low in nutrients; however levels increase rapidly below the surface mixed layer from nutrient rich water masses (Brewer et al. 2007). Primary producers are dominated by pelagic, vertically migrating zooplankton, with secondary pelagic consumers likely to consist of jellyfish, nekton and transient small fish schools. Tertiary consumers typically include highly migratory pelagic species such as juvenile southern bluefin tuna (*Thunnus maccoyii*) and sharks, which either migrate seasonally through the canyons or range through the canyons following schools of small pelagic fish (Brewer et al. 2007). It is thought that sperm whales may aggregate over the Scott Plateau (DSEWPaC 2012b).

DSEWPaC determined that impacts of oil pollution on the values of the Canyons Linking the Argo Abyssal Plain and Scott Plateau were “not of concern” (DSEWPaC 2012b).

5.2.2 Glomar Shoals

The Glomar Shoals are a submerged littoral feature, located on the Rowley Shelf in 33-77 m of water (DSEWPaC 2012b), approximately 245 km east of the Chandon Field blowout location (Figure D). The shoal’s relatively high concentrations of coarse material in comparison to surrounding areas indicate a high energy environment influenced by strong sea floor currents (Falkner et al. 2009). Much of the biodiversity of the Glomar Shoals has not been studied, however it is considered to be an important area for commercially and recreationally important species of fish, including rankin cod (*Epinephelus multinotatus*), red emperor (*Lutjanus sebae*) and crimson snapper (*Lutjanus erythopterus*), with historical recordings of high catch rates associated with the Glomar Shoals indicating the high productivity of the area (DSEWPaC 2012b).

DSEWPaC determined that impacts of oil pollution on the values of the Glomar Shoals were “of less concern” (DSEWPaC 2012b).

5.2.3 Wallaby Saddle

The Wallaby Saddle covers approximately 7880 km^2 of the sea floor in water depths ranging from 4000-4700 m (Falkner et al. 2009), and is located approximately 665 km south of the Chandon Field blowout location (Figure D). The Wallaby Saddle is a regionally unique geomorphic feature in the North-west Marine Region. The area is thought to have relatively enhanced productivity in comparison its surrounds (DSEWPaC 2012b). However, diversity of the Wallaby Saddle is likely to be low, given the abyssal depths (>2000 m) (Falkner et al. 2009). Sediments of the Wallaby Plateau are likely to be dominated by siliceous clays, with the benthic infauna dominated by small invertebrates, bioturbators and deposit feeders (Falkner et al. 2009).

DSEWPaC determined that impacts of oil pollution on the values of the Wallaby Saddle were “not of concern” (DSEWPaC 2012b).

5.2.4 Ancient Coastline at 125 m Depth Contour

The Ancient Coastline at the 125 m Depth Contour represents the most prominent terrace/steps that reflect sea level rise across the North West Shelf during the Holocene period, extending from North West Cape to waters to the east of Cape Londonderry in the north Kimberley (DSEWPaC 2012b). At its closest point, the Ancient Coastline is located approximately 110 km east form the Chandon Field (Figure D). The Ancient Coastline is characterised by ridges of hard substrate that may provide for higher diversity and enhanced species richness compared to surrounding soft sediment habitats (DSEWPaC 2012b). Little is known about the fauna of the area, however its biodiversity values relate to both its benthic and pelagic habitats. It is thought that the Ancient Coastline may provide for increased availability of nutrients in some locations along the Pilbara coast, facilitating enhanced vertical mixing of water layers. This enhanced productivity may attract larger marine fauna to feed in the area, including whale sharks and larger pelagic fish (DSEWPaC 2012b).

DSEWPaC determined that impacts of oil pollution on the values of the Ancient Coastline at 125 m Depth Contour were "not of concern" (DSEWPaC 2012b).

5.2.5 Canyons Linking the Cuvier Abyssal Plain and Cape Range Peninsula

The Canyons Linking the Cuvier Abyssal Plain and Cape Range Peninsula are located (at their closest point) approximately 190 km south of the Chandon Field (Figure D). The canyons are thought to interact with the Leeuwin Current, producing eddies resulting in cooler water masses being drawn into the shallower depths onto the North West Shelf (Brewer et al. 2007). The narrow shelf width facilitates nutrient upwelling, and the canyons are thought to be a factor in the enhanced productivity of the Ningaloo Reef system. Typically for the North West Shelf, surface waters are relatively low in nutrients, resulting in low surface primary productivity, providing food to primary producers comprising mainly pelagic zooplankton (Brewer et al. 2007). Pelagic secondary consumers are likely to include transient schools of small fish. The main tertiary consumers are likely to be highly migratory species such as juvenile southern Bluefin tuna (*Thunnus maccoyii*) on their southward migration, and other large pelagic predators such as sharks, following the schools of small pelagic fish as they move through the area (DSEWPaC 2012b).

DSEWPaC determined that impacts of oil pollution on the values of the Canyons Linking the Cuvier Abyssal Plain and Cape Range Peninsula were "of less concern" (DSEWPaC 2012b).

5.2.6 Continental Slope Demersal Fish Communities

The Continental Slope Demersal Fish Communities occupy two distinct demersal community types associated with the upper slope (in depths of 225-500 m) and the mid slope (750-1,000 m). At their closest point, the Continental Slope Demersal fish communities are located approximately 95 km from the Chandon Field (Figure D). The continental slope between North West Cape and the Montebello Trough has more than

500 recorded species of fish, of which 76 species are endemic, making the area the most diverse slope bioregion in Australia (DSEWPaC 2012b). Bacteria and fauna associated with the benthos form the basis of the food web for this system, and hence the benthic habitats are thought to be biologically important to support the species richness and endemism of the demersal fish communities (DSEWPaC 2012b).

DSEWPaC determined that impacts of oil pollution on the values of the Continental Slope Demersal Fish Communities were “not of concern” (DSEWPaC 2012b).

5.2.7 Exmouth Plateau

The Chandon Field well location assumed by the modelling is within the Exmouth Plateau (Figure D), with the plateau itself covering an area of approximately 49,310 km^2 in water depths of 800-4,000 m (Falkner et al. 2009). The Exmouth Plateau is thought to modify deepwater flows of the area, contributing to upwelling of deeper, nutrient rich waters to the surface (Brewer et al. 2007). The plateau may provide a conduit for the movement of sediments and other materials from the plateau surface to the deeper waters of the abyss (DSEWPaC 2012b). Sediments of the Exmouth Plateau are typically dominated by a combination of sand and mud, potentially supporting a range of benthic scavengers, filter feeders and epifauna (Brewer et al. 2007). The pelagic water column is characterised by low productivity, and is expected to be dominated by nekton and small pelagic species, including schools of small pelagic fish. Larger pelagic predatory fish may traverse the plateau, following schools of smaller prey species.

DSEWPaC determined that impacts of oil pollution on the values of the Exmouth Plateau were “not of concern” (DSEWPaC 2012b).

5.2.8 Mermaid Reef and Commonwealth Waters Surrounding Rowley Shoals

The Mermaid Reef and Commonwealth Waters Surrounding Rowley Shoals KEF is approximately 525 km from the Chandon Field, covering an area of approximately 4,746 km^2 (DSEWPaC 2012b). The Rowley Shoals are an area of high productivity and species richness surrounded by deep waters, allowing re-suspension of deep water nutrients and interaction with a range of pelagic species (DSEWPaC 2012b).

DSEWPaC determined that impacts of oil pollution on the values of the Mermaid Reef and Commonwealth Waters Surrounding Rowley Shoals KEF were “of potential concern” (DSEWPaC 2012b).

5.2.9 Seringapatam Reef and Commonwealth Waters in the Scott Reef Complex

Located approximately 990 km from the Chandon Field and covering an area of approximately 2,419 km^2, the Seringapatam Reef and Commonwealth Waters in the Scott Reef Complex support high productivity and high species richness (DSEWPaC 2012b). The reefs support diverse aggregations, including migratory birds (Falkner et al. 2009; DSEWPaC 2012b).

DSEWPaC determined that impacts of oil pollution on the values of the Seringapatam Reef and Commonwealth Waters in the Scott Reef Complex KEF were “of potential concern” (DSEWPaC 2012b).

5.2.10 Ashmore Reef and Cartier Island and Surrounding Commonwealth Waters

The Ashmore Reef and Cartier Island and Surrounding Commonwealth Waters KEF covers an area of approximately 2,259 km^2 and is located approximately 1,230 km from the Chandon Field (DSEWPaC 2012b). The KEF is regionally important for feeding and breeding aggregations of marine life and is an area of high primary productivity (DSEWPaC 2012b). Ashmore Reef has the greatest number of coral species of any reef off Western Australia (DSEWPaC 2012b).

DSEWPaC determined that impacts of oil pollution on the values of the Ashmore Reef and Cartier Island and Surrounding Commonwealth Waters KEF were “of potential concern” (DSEWPaC 2012b).

5.2.11 Other Key Ecological Features

The Carbonate Bank and Terrace System of the Sahul Shelf and the Pinnacles of the Bonaparte Basin (DSEWPaC 2012b) were determined to be outside of the spatial extent of the modelled spill contours (APASA 2012; Appendix 1).

6.0 ENVIRONMENTAL RISK ASSESSMENT

6.1 Risk Assessment Methodology

An assessment of environmental risk was undertaken for each of the key spill scenarios. The risk assessment used the Fourth Train Proposal Risk Matrix (Table 1) and followed the procedures outlined in the Australian and New Zealand Standards *AS/NZS ISO 31000:2009 – Risk Management – Principles and Guidelines,* and Handbook (HB) 203:2012 (Managing Environment-Related Risk). The risk assessment comprised a qualitative evaluation of risk likelihood and severity, with the Fourth Train Proposal Risk Matrix (Table 1) applied to categorise consequences and likelihood, and to assess the resulting level of environmental risk, given the management measures that would be implemented to mitigate the impacts.

In accordance with HB 203:2012, the likelihood of a defined consequence occurring was characterised with consideration of the environment impact management measures that are likely to be implemented. Quantitative data for primary and secondary risk were used to inform the assessment of likelihood. Consequence rankings were completed with reference to Chevron Australia's internal risk assessment and management process (PER/Draft EIS Appendix F1 – Risk Assessment Consequence Criteria).

In an environmental risk assessment, the likelihood component of the assessment is a function of the event occurring and subsequently affecting a sensitive resource (i.e. having an impact). Detail on the methods applied to the probability calculations is provided in Appendix 3. For a hydrocarbon spill, the likelihood is a combination of:

- the probability of a spill occurring, and the volume of that spill at source (primary risk from industry databases)
- the probability of a spill reaching a sensitive part of the environment (secondary risk from spill modelling)
- qualitative assessment of the likelihood of the oil having the worst consequence possible (tertiary risk from scientific literature).

Statistical probabilities for primary risk for each of the spill scenarios were derived from industry databases. Databases reviewed for the purpose of this assessment include:

- Historical incident data, including blowout frequencies, collected by OGP (2010).
- Pipeline release frequencies collated in Pipeline and Riser Loss of Containment (PARLOC) 2001 (Mott MacDonald Ltd. 2003), refined by DNV and published by OGP (2010).
- Fuel spill frequencies collated by DNV (2011) and OGP (2010).

OGP (2010) data were deemed to provide a relevant, and generally conservative, indication of primary risk probabilities for the relevant scenarios in Australian conditions (DNV 2011).

The probabilities of spilled hydrocarbons reaching sensitive areas in the event of a spill (secondary risk) were quantified by the spill trajectory and fates modelling for each spill scenario. The modelling incorporated a number of conservative features (Section 3.0), notably including no allowance for post-spill intervention to alter volumes remaining at sea and/or reaching shoreline areas. In practice, the on-site spill response capability that will be maintained by Chevron Australia, along with the additional support available, may substantially reduce the potential for spilled hydrocarbons to affect sensitive environmental resources (Section 4.5). Secondary risks were presented seasonally, as generated by the spill modelling, as well as annually. Annual probabilities were calculated by incorporating the proportions of a year that the seasons used in the spill modelling represent (see Appendix 3 for a description of the calculation).

The environmental resources within the spatial extent of predicted spill trajectories that were considered during the risk assessment have been described in Section 5.0. Shoreline contact of spilled hydrocarbons was considered to be the “worst case” scenario, as this is where the hydrocarbons would have the greatest environmental impact (Volkman et al. 1994). The highest likelihoods of shoreline contact (as predicted by the APASA models) were therefore used in the likelihood calculations, rather than those of contact with offshore, non-shoreline features.

For the purposes of the qualitative risk analysis completed using the Fourth Train Proposal Risk Matrix (Table 1), the likelihood of each scenario occurring and resulting in the environmental consequences identified was evaluated and assigned a likelihood ranking (i.e. Rare – Likely). Likelihood rankings used in the assessment are outlined in Table 6. Note that likelihood rankings account for management measures and therefore do not always correspond directly to the annual probability for a given scenario.

Table 6: Likelihood Rankings and Corresponding Annual Probabilities

Ranking	Likelihood
Likely	$<9.99 \times 10^{-1}$
Occasional	$1.00 \times 10^{-2} – 9.99 \times 10^{-2}$
Seldom	$1.00 \times 10^{-3} – 9.99 \times 10^{-3}$
Unlikely	$1.00 \times 10^{-4} – 9.99 \times 10^{-4}$
Remote	$1.00 \times 10^{-5} – 9.99 \times 10^{-5}$
Rare	$>9.99 \times 10^{-5}$

6.2 Upstream Scenarios

6.2.1 Well Blowout

6.2.1.1 Consequences

If there were no efforts to stem release rates, recover spilled oil and/or to protect sensitive areas, a spill of this volume and duration has the potential to result in Minor to Moderate environmental consequences as defined in the Fourth Train Proposal Consequence Criteria (Appendix F1 of the PER/Draft EIS – see Chevron Australia (2013)). There would be the possibility that hydrocarbons could migrate to inshore areas of conservation significance and water quality would be temporarily reduced over a relatively large area, with substantial volumes of condensate entrained and/or dissolved into the water column as a result of the high sub-sea release rates.

Threatened and Migratory Species and their Biologically Important Areas

Fish

While the potential impacts of spilled hydrocarbons on whale sharks is largely unknown, the modelling (APASA 2012) suggests that any potential impacts to whale sharks foraging along the 200 m isobath would be greatest during October. Entrained hydrocarbons <500 ppb were almost certain (100% probability) to be present along the 200 m isobath, however elevated concentrations above 500 ppb were shown to have a reduced (50%) probability of reaching the foraging area. This, combined with the travel times involved for the entrained concentrations (approximately 14 to 26 days), suggested that toxic effects to whale sharks and their prey were unlikely and would be limited to the release location as the weathering process would have attenuated the toxicity of the condensate (French-McCay & Payne 2001). Given the transitory nature of whale sharks that may be foraging along the 200 m isobath, prolonged exposure that may lead to sub-lethal effects was unlikely. The foraging area did not represent any critical habitat for whale sharks, and the modelling results suggested that even under “worst case” scenarios, biologically important areas would not to be affected to the extent that may cause species decline.

Marine Mammals

The humpback whale breeding and calving grounds from the Lacepede Islands to north of Camden Sound were not contacted by oil in any form (surface, entrained or dissolved aromatics) during any season, as a result of a modelled “worst case” well blowout scenario.

Modelling (APASA 2012) for the Chandon Field blowout scenario during winter and spring conditions (when humpback whales would be migrating through the area potentially affected by an oil spill) indicated that a resulting surface slick presenting as a metallic sheen (>10 µm thick) would remain seaward of the main humpback migration corridor, and not even a rainbow sheen (>1 µm thick) of surface condensate would reach the aggregation (resting) area in Exmouth Gulf (Figure H). Combined with the limited area over which fresh (unweathered) surface condensate would be present, this suggested that extended exposure of high numbers of animals to potentially toxic vapours, leading to substantial impacts to any of the species involved, would be unlikely. Entrained oil would almost certainly (100% probability) reach the main humpback migration route (in concentrations of <500 ppb), and may reach the humpback whale resting areas of Exmouth Gulf and Shark Bay (30% probability of concentrations <100 ppb). However, direct contact with entrained or dissolved hydrocarbons appears to have little deleterious effect on marine mammals, possibly due to their skin's effectiveness as a barrier to toxicity (Volkman et al. 1994). In addition, long-term effects to dugongs through localised impacts to their food source from a blowout would not be expected, given the low probabilities and low entrained concentrations (worst case 30% probability at <100 ppb) that may contact seagrass meadows in the important foraging areas of Shark Bay and Exmouth Gulf.

The modelling results indicate a limited potential for adverse effects to marine mammals as a result of a well blowout at the Chandon Field, indicating that any impacts that may result in species decline or reduce the area of occupancy of a population would not be expected.

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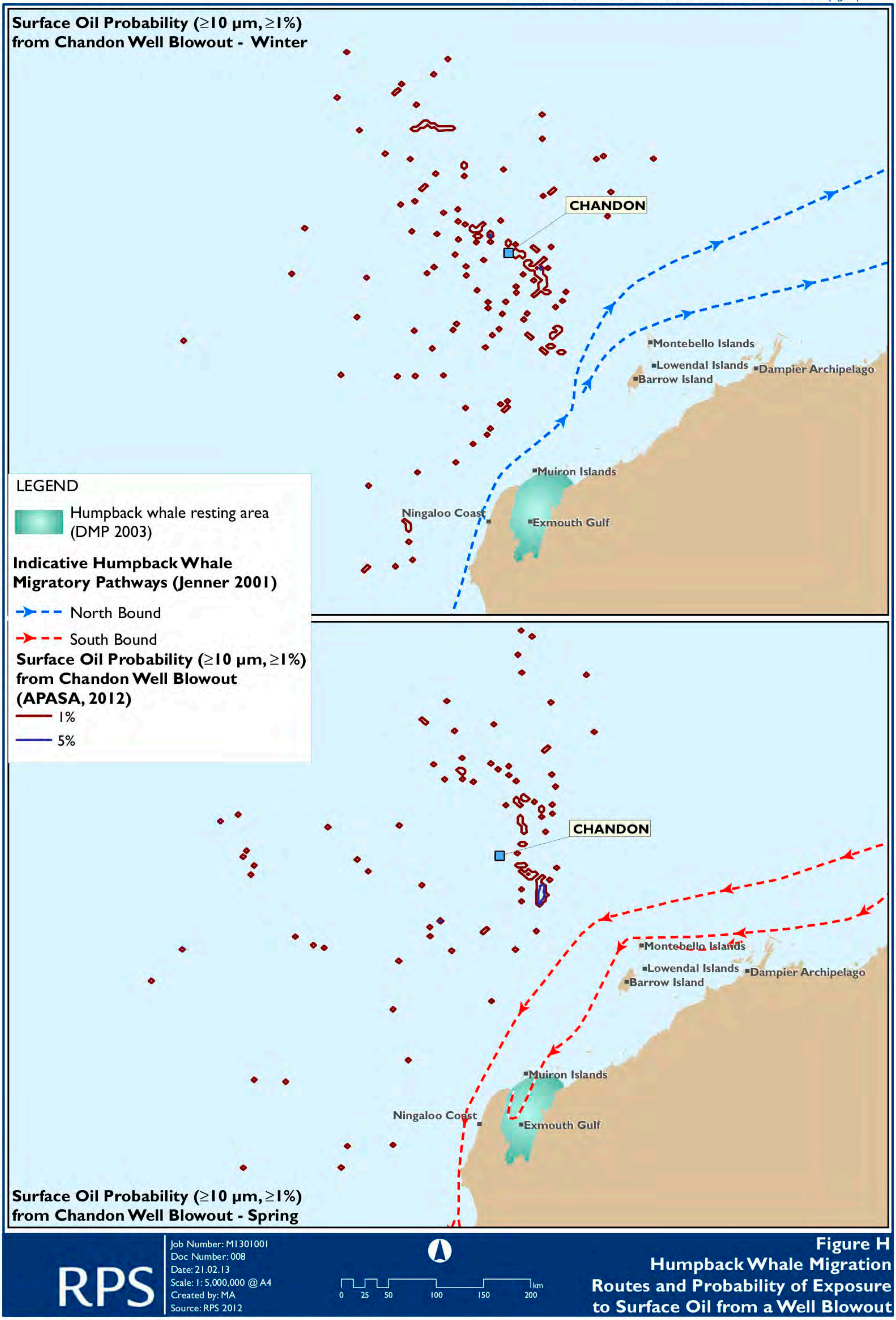

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Figure H
Humpback Whale Migration Routes and Probability of Exposure to Surface Oil from a Well Blowout

Marine Reptiles

The modelling indicates that a surface sheen (>1 μm thick) would not reach any of the biologically important turtle nesting sites following a spill during any season. Surface slicks (>10 μm) that might generate significant vapour concentrations may potentially occur (1% probability) in the internesting buffer for flatback turtles west of Barrow and Montebello Islands during seasons when flatbacks would be nesting, however this would remain outside of the area considered as critical habitat (Environment Australia 2003) for flatback and hawksbill turtles. No other internesting buffer areas were contacted by surface slicks during any season. The likelihood of large numbers of any turtle species suffering impacts from inhalation of volatised hydrocarbons is therefore considered low.

Concentrations of entrained and dissolved hydrocarbons reaching biologically important areas or critical habitat to marine turtle species in the region were also predicted to generally remain well below levels at which adverse effects would be expected, particularly as the minimum transport duration involved extended periods and the potential toxicity of entrained oil would have significantly attenuated. "Worst case" probability for entrained concentrations that may be present in internesting buffers was 100% for concentrations <100 ppb for flatback internesting buffer area approximately 70 km west (outside of identified critical habitat) of Barrow and Montebello Islands, well below the acute toxicity levels for condensate (as oil in water) reported by French (2000). Entrained concentrations >500 ppb were predicted to have a reduced chance (40% probability during spring, 20% during summer) of reaching any biologically important internesting areas at times when turtles would be most likely to be nesting (Figure I). Aromatic concentrations were not predicted to approach levels that might result in acute toxicity effects at any biologically important or critical habitat from a spill during any season.

The aromatic components of Chandon condensate have high volatility and solubility, and it is unlikely that condensate reaching biologically important areas after extended periods of weathering would retain significant toxicity. Therefore, potential environmental effects would generally be expected to be limited to those associated with physical oiling by residues. As a very light oil, Chandon condensate has limited potential for physical oiling effects (Section 2.2).

Turtles migrating to/from the offshore islands in the immediate region, including Barrow and Montebello Islands (Figure F), would potentially be at risk of some exposure if a release coincided with migration periods which peak from September to March (Pendoley Environmental 2008, not seen, cited in Chevron Australia 2009).

Given the reduced potential for adverse effects to marine turtles (including disruption to breeding cycles) and their biologically important areas and critical habitats, it is unlikely that a well blowout at the Chandon Field would result in the decline of any species.

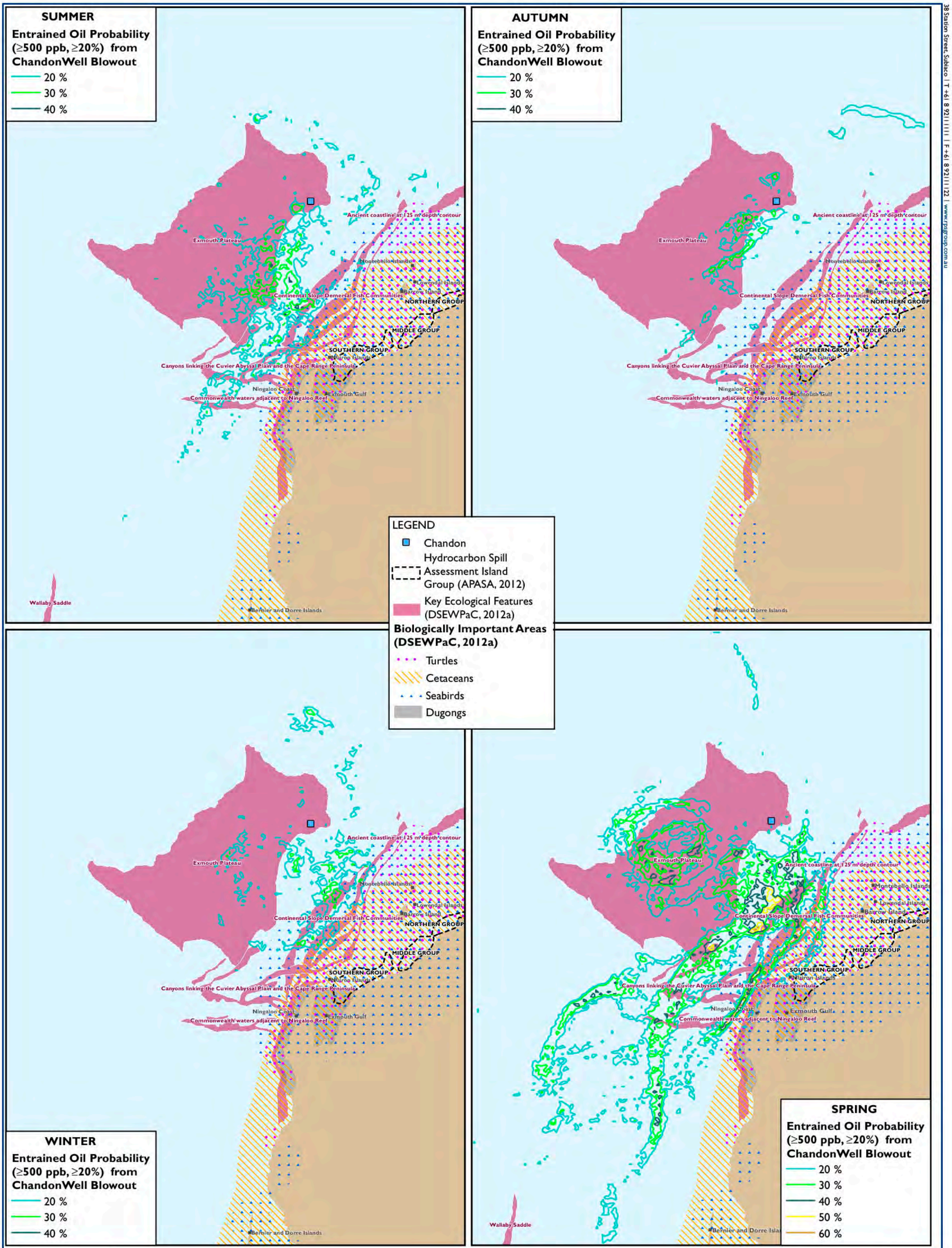

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Figure 1
Important Habitats and Probability of Exposure to Entrained Oil from a Well Blowout

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Marine Avifauna

The biologically important area for migratory shore birds at Ashmore Reef was not predicted to be affected by a well blowout in the Chandon Field for any season.

The modelling indicated that surface concentrations >1 µm thick (a rainbow sheen) may coincide (20% probability) with biologically important foraging areas for the wedge-tailed shearwater, with surface concentrations >10 µm thick (a metallic sheen) unlikely (1% probability). Given the long travel times involved, the condensate would have weathered, allowing for the attenuation of toxicity (French-McCay & Payne 2001). This suggested limited potential for adverse effects through physical oiling, or through the contact of eggs with fresh condensate from parent birds during nesting seasons. The wedge-tailed shearwater is a wide-ranging species in northern WA, and modelling indicated that species level impacts were unlikely. No other biologically important area for migratory seabirds was expected to be affected by surface hydrocarbons as a result of a well blowout at the Chandon Field.

Concentrations of entrained and dissolved hydrocarbons reaching biologically important areas recognised for migratory seabirds in the region were also predicted to generally remain well below levels at which adverse effects would be expected, particularly as the minimum transport periods involved extended durations and the potential toxicity of entrained oil would have significantly attenuated. “Worst case” maximum entrained concentrations for nesting areas were predicted at the Southern Island Group following a spill during winter, with a “worst case” maximum of 2,105 ppb. The islands in this group support breeding and/or roosting of listed Migratory bird species, such as the wedge-tailed shearwater and little tern, although they do not have the significance of more important sites in the region, such as Barrow and Montebello islands (Commonwealth of Australia 2008). Entrained concentrations at offshore islands where nesting activity occurs, including the Barrow/Montebello/Lowendal complex, were below the acute toxicity levels for condensate (as oil in water) reported by French (2000). Aromatic concentrations were not predicted to approach levels that might result in acute toxicity effects at any location from a spill during any season. The potential (70% probability) for entrained concentrations <500 ppb where predicted for wedge-tail shearwater foraging areas west of Barrow Island, with only a very low chance (1% probability) of these concentrations affecting foraging areas for other species.

While the “worst case” entrained concentration at the Southern Island Group was relatively high, mean maximum entrained concentrations predicted by the modelling were an order of magnitude lower, suggesting that widespread adverse oiling impacts to these fauna or their habitats in the majority of conditions would be unlikely. Given that the seabirds involved are part of larger regional populations that utilise other areas that would remain unaffected, population level direct or indirect impacts that may result in species decline are considered unlikely.

Commonwealth Marine Environment

Seabed, Benthic Habitats and Fauna

Sedimentation of spilled oil generally has the greatest potential for impacts on benthic habitats (Volkman et al. 1994; Denoyelle et al. 2010). However, sedimentation of oil is typically an extremely slow process in deeper areas remote from the shore (Patin 1999) and the light nature of Chandon condensate and generally low levels of turbidity (suspended sediment) in the oceanic waters of the region preclude sedimentation of condensate in the event of a well blowout at the Chandon gas field (APASA 2012). Given the water depths (1,200 m) at the release site and associated lack of important coral, algal or seagrass communities, the significance of this effect regionally or in the long-term was considered to be low. Effects from spills on plankton are typically minimal or transient (Volkman et al. 1994) and the benthos surrounding the release location is of low conservation significance, typical of the low abundance, richness and diversity observed in other deep water regions of the North West Shelf (Mobil Australia 2011).

Water Column

Whether the physical presence of a large slick would cause considerable changes to physico-chemical parameters of marine water quality, such as reduced light or oxygen levels, is uncertain. Changes in the physico-chemical characteristics of the water column to the extent that it may affect marine biota depends to a large extent on the prevailing conditions, and it seems likely that the dynamic shape and location of the slick would restrict the area over which any extended effect of this nature occurred.

Pelagic Marine Fauna and Habitats

The extended size of both surface slick and subsurface plume under this "worst case" scenario would increase the probability that marine fauna, including Threatened or Migratory sharks, seabirds, cetaceans and/or turtles, are present in the area coincident with condensate and may suffer adverse effects. The elevated concentrations of dissolved aromatic hydrocarbons and entrained hydrocarbons in the area immediately surrounding the well site would likely be acutely toxic to many pelagic organisms. However, the rapid dissolution that would result following pressurised release of Chandon condensate into the water column near the seabed, and high rate of evaporation at the surface, would tend to limit the spatial extent of these effects. The modelling indicated that dissolved aromatic concentrations would not exceed 50 ppb beyond the immediate vicinity (approximately 1.5 km^2) of the release, which is an order of magnitude lower than the ANZECC/ARMCANZ guidelines (2000) for the aromatic benzene.

With the relatively remote location of the Chandon field, the numbers of any species involved would seem unlikely to present the risk of adverse impacts at a population level.

The possible effects and potential for affects to pelagic marine fauna of concern are presented and discussed in *Threatened and Migratory Species and their Biologically Important Areas*.

Commercial Fisheries

Most of the commercial fisheries operating in the vicinity of the Chandon oil field have wide ranging fishing zones that would likely be only partially affected via any individual spill event. Most fisheries are discussed in general terms, as impacts of spilled oil on fish are discussed in *Threatened and Migratory Species and their Biologically Important Areas* and *Key Ecological Features*. Those not covered in other sections (i.e. prawns and pearl farming) are discussed more specifically.

Fouling of fishing gear is unlikely to be a substantial impact as most fishing equipment used by these fisheries is attended during use and would be removed in the event of a spill. Widespread fish stock mortalities are also unlikely given the very restricted area over which elevated dissolved aromatic concentrations would result from a spill of Chandon condensate and that the majority of these fisheries are primarily targeting demersal species at depth. Reports of fish kills from oil spills are relatively rare, especially in open waters (Scholz et al. 1992). Fodrie and Heck (2011) found no significant shifts in community composition and structure or biodiversity measures following the Deepwater Horizon oil spill.

The likelihood of any seafood tainting is considered to be very small. The predominant cause of seafood tainting is the aromatic components of oil (Volkman et al. 1994) and the modelling shows that significantly elevated aromatic concentrations would be restricted to the immediate vicinity of the release. In the unlikely event that tainting occurred, the affected organisms would be expected to depurate contaminants relatively quickly, indicating that any closures would be temporary (Volkman et al. 1994; Lord & Michel 2003); however, this largely depends on the spill volume, oil type and species tainted (Lord & Michel. 2003).

While a well blowout at the Chandon field would likely expose some of the Onslow Prawn Managed Fishery fishing grounds to entrained condensate, fisheries data shows that trawling activity is generally restricted to nearshore waters around Onslow (DOF 2011), which are unlikely to be exposed to elevated levels (>500 ppb) of entrained condensate (6% probability at the Southern Island Group). Any exposure of prawn stocks to entrained condensate would be highly localised and temporary. Documented cases of oil spills from offshore oil operations causing measurable impacts upon commercial prawn stocks are rare (Whittle et al. 1978; Boehm et al. 1983; Zitko et al. 1984).

Potential impacts to the pearl oyster (*P. maxima*) farmed at the Montebello Islands were evaluated through toxicity testing on the rock oyster (*Saccostrea commercialis*), which is considered to be comparable (Ecotox 2009). The NOEC for different weathered condensates ranged from approximately 9,000 to 28,000 ppm. The concentrations reaching the Montebello Islands (worst case maximum of 155 ppb) are well below levels these no effects levels for various North West Shelf condensates.

Key Ecological Features

Canyons Linking the Argo Abyssal Plain and Scott Plateau

The modelling (APASA 2012) indicated that surface and dissolved aromatic concentrations of condensate resulting from a well blowout in the Chandon Field were not likely to reach the canyons during any season. Likewise, elevated concentrations (>500 ppb) of entrained hydrocarbons were not predicted for any season (Figure I), with only a reduced potential (10% during winter and spring) for the presence of entrained hydrocarbons <100 ppb. Given the travel times involved, indicating the reduced toxicity of any entrained concentrations (French-McCay & Payne 2001), and the low concentrations expected, adverse effects to ecosystem functioning and integrity at the canyons would be unlikely.

Glomar Shoals

The modelling did not predict any contact from surface concentrations or dissolved aromatics at the Glomar Shoals from a well blowout during any season. Low concentrations of entrained oil (<100 ppb) might reach the shoals (10% probability) during summer, winter and spring, with a reduced potential (5%) for entrained concentration <500 ppb during summer and spring (Figure I). This suggested that acute and long-term adverse effects to fish and other pelagic fauna were unlikely, given the reduced concentrations, travel time resulting in loss of volatile components of entrained concentrations, and the reduced potential for long-term exposure (Chandon condensate is not considered a persistent hydrocarbon). Therefore it is considered unlikely that adverse effects to the ecosystem functioning and integrity of this KEF would result from a well blowout.

Wallaby Saddle

Surface concentrations of hydrocarbons from a Chandon well blowout were predicted as unlikely to contact waters above the Wallaby Saddle, with only a limited potential (1% probability) of a rainbow sheen (>1 μm thickness) during autumn. Entrained concentrations <100 ppb were almost certain (100% probability) during autumn, with the potential for elevated levels >500 ppb (5% probability) (Figure I). Given the depths involved, impacts through sedimentation of hydrocarbons on the benthos were extremely unlikely. Possible adverse effects to productivity in the water column would also be limited, given that entrained concentrations were expected to remain well below the levels (1000-10,000 ppb) known to cause adverse lethal and sub-lethal effects to plankton (Neff 1991). Adverse effects as a result of a well blowout at the Chandon Field to the ecosystem functioning and integrity of this KEF would be unlikely.

Ancient Coastline at 125 m Depth Contour

Surface concentrations of hydrocarbons from a Chandon well blowout that would present as a thin rainbow sheen (>1 μm thick) are not likely to occur along the Ancient Coastline during any season, with only a low potential (5% probability) for contact during summer months, and even then, this would be spatially restricted to that part of the KEF closest to the Chandon Field. Low concentrations of entrained hydrocarbons (<100 ppb) would be almost certain to occur along the Ancient Coastline during autumn, particularly where it is closest proximity to the Chandon Field. However, elevated concentrations (>500 ppb) during any season would be unlikely (Figure l). There is some potential for exposure to dissolved aromatics (10% probability >5 ppb) during summer and autumn months, however concentrations would likely be well below levels known to cause harm to marine organisms. The low concentrations of hydrocarbons expected, combined with the loss of toxic components given the travel times involved (French-McCay & Payne 2001), suggests that adverse impacts to the area's productivity and marine fauna would be unlikely. Therefore impacts to the ecosystem functioning and integrity of this KEF are not expected.

Canyons Linking the Cuvier Abyssal Plain and Cape Range Peninsula

The modelling indicated that surface concentrations of hydrocarbons from a Chandon well blowout present as a rainbow sheen (>1 μm thick) would be unlikely to affect the canyons during any season, with the greatest probability of contact (10% probability) in autumn. Higher concentrations of surface oil (that would present as a metallic sheen) are unlikely during any season (1% probability). Low concentrations of entrained hydrocarbons (<100 ppb) would be expected during any season, however elevated levels (>500 ppb) that may cause acute toxic effects are unlikely (Figure l). Therefore effects to zooplankton (the main primary producer of the canyons) would be unlikely, as entrained levels were likely to remain well below levels known to cause adverse effects (Neff 1991). The migratory nature of marine fauna likely to be present (fin fish and sharks) suggests that prolonged exposure to even low concentrations of entrained concentrations that could cause sub-lethal effects was unlikely. A well blowout at the Chandon Field is therefore not expected to have adverse impacts on the ecosystem functioning and integrity of the Canyons Linking the Cuvier Abyssal Plain and Cape Range Peninsula.

Continental Slope Demersal Fish Communities

Modelling results suggest that low levels of entrained hydrocarbon concentrations (<100 ppb) from a Chandon well blowout would be expected during any season, although this would be spatially limited to the portion of this KEF closest to the Chandon Field. Elevated levels (>500 ppb) may be present during winter and spring (40% and 50% probability respectively); however, such concentrations would again be restricted to small areas of the KEF (Figure l). Impacts to populations of juvenile and adult demersal fish species were unlikely to be widespread, given the ability of some species to detect and avoid elevated levels of oil in water, the loss of the toxic (PAH) components of condensate known to cause acute toxic effects in fish, and the spatially limited extent of elevated concentrations suggesting that prolonged exposure would be unlikely. Eggs and larvae may be at greater risk of adverse toxic effects (acute and chronic), however the limited extent of elevated entrained concentrations suggested that exposure to numbers of pelagic eggs and larvae that may cause population level impacts would be unlikely. The eggs of species that lay in the sediment, if coinciding with areas of elevated entrained concentrations, were unlikely to be effected on a scale large enough to cause population level effects, given that the depths involved (225-1,000 m) suggest that sedimentation of oil would not be likely. Therefore it is expected that the ecosystem functioning and integrity of this KEF would be unlikely to be adversely impacted by a well blowout in the Chandon Field.

Exmouth Plateau

Low concentrations of surface hydrocarbons from a Chandon well blowout that may present as a thin surface (rainbow) sheen (>1 µm) could potentially be present during any season. However, given the depth of release (1,200 m), the tendency for condensate released under high pressure at depth to entrain before reaching the surface (APASA 2012), and the highly evaporative nature of condensate that does surface (APASA 2012), probabilities would be reduced (30–50%). Slicks of greater thickness (metallic sheen) would be unlikely (5% probability during winter and spring). This suggests that any adverse effects from surface hydrocarbon concentrations to the range of pelagic marine species that may traverse the plateau would unlikely to be widespread. The reduced potential for surface slicks >10 µm thick indicated that any impacts to the productivity in upper layers of the water column would be unlikely to be adversely affected by reduced light penetration.

Given that the Chandon Field is located within the Exmouth Plateau, low concentrations (<500 ppb) of entrained hydrocarbons would be expected during any season. However, elevated concentrations (>500 ppb) would be less likely (50% probability during spring), and would be spatially limited in extent, limiting the potential for acute toxic effects (Figure 1). The pelagic nature of the species likely to be present, combined with the limited spatial extent of elevated entrained concentrations suggests a reduced potential for prolonged exposure, limiting any chronic effects. The depths of the plateau (800–4000 m) indicate that sedimentation of hydrocarbons and adverse impacts on the benthos would be unlikely.

Dissolved aromatic concentrations of hydrocarbons >5 ppb may be present during all seasons (40% during autumn and winter, 30% during spring and summer). However the 5 ppb threshold represents a conservative no effects concentration, and the volatile (PAH) components of the condensate would be expected to evaporate immediately upon surfacing. Given the plateau's distance from areas of biological importance for air-breathing marine fauna, only low numbers of marine fauna susceptible to inhaling toxic vapours on the ocean's surface would be expected to be present, greatly limiting the potential for extensive impacts to a population or species.

Given the reduced potential for extensive impacts as a result of a blowout at the Chandon Field, adverse impacts on the ecological functioning and integrity of the Exmouth Plateau would not be expected.

Mermaid Reef and Commonwealth Waters Surrounding Rowley Shoals

The modelling (APASA 2012; Appendix 1) predicted with very low probability (5%) that only low concentrations (10 ppb) of entrained oil would reach the Mermaid Reef and Commonwealth Waters Surrounding the Rowley Shoals. Entrained oil of this concentration is highly unlikely to impact the values of this KEF.

Seringapatam Reef and Commonwealth Waters in the Scott Reef Complex

Only low concentrations of entrained oil (10 ppb) were predicted (APASA 2012; Appendix 1) to reach the Seringapatam Reef and Commonwealth Waters in the Scott

Reef Complex KEF, with very low probability (1%). This is a NOEC for entrained oil and is therefore highly unlikely to cause substantial impacts to the values of this KEF.

Ashmore Reef and Cartier Island and Surrounding Commonwealth Waters
The modelling (APASA 2012; Appendix 1) indicated that the Ashmore Reef and Cartier Island and Surrounding Commonwealth Waters would not be exposed to any surface, entrained or dissolved aromatic hydrocarbons as a result of a well blowout at the Chandon Field.

Ningaloo Coast National Heritage Place and Commonwealth Waters Adjacent to Ningaloo Reef

Overview
The trajectory modelling indicated that only trace concentrations of surface condensate would reach inshore areas of the Ningaloo Coast NHP under most conditions, suggesting that adverse effects to shorelines or intertidal habitats were unlikely. There was a very low (3%) probability that a visible rainbow sheen (>1 μm thick) of condensate would reach the area following a spill during winter, but it would take over four weeks (29 days) to travel from the spill site, by which time its toxicity would have attenuated via weathering. The relatively low concentrations (<26 g/m^2) of weathered biodegradable residues of surface condensate that might persist to strand on shorelines would be unlikely to cause substantial physical oiling or longer term reductions in the habitat values of intertidal or shallow sub-tidal areas.

Entrained condensate was predicted to take at least 10 days to reach inshore areas of the Ningaloo Coast NHP, with more than two weeks of transport required for concentrations reported to cause adverse impacts in sensitive species to arrive. There were low probabilities of elevated levels (>500 ppb) of entrained condensate reaching the Ningaloo Coast NHP and adjacent Commonwealth Waters (Figure I). “Worst case” maximum entrained concentrations predicted to reach the Ningaloo Coast NHP (2,940 ppb) may result in toxic effects to corals and/or the possibility of physical oiling if prolonged exposure to these levels occurred in reef lagoons. However, after the periods of weathering indicated by the modelling, entrained condensate would be unlikely to retain the potential for toxicity effects. The modelling showed that dissolved aromatic concentrations that might be toxic to marine life would not result in the Ningaloo Coast NHP from a spill during any season of the year.

Commonwealth Waters Adjacent to Ningaloo Reef
Surface concentrations of hydrocarbons from a Chandon well blowout would be unlikely reach the Commonwealth Waters adjacent to Ningaloo Reef during any season, with a very low probability (1%) of a visible rainbow sheen (>1 μm thick) predicted by the modelling, suggesting that adverse effects to migratory seabirds through physical oiling that may feed in the area would be unlikely. Low probabilities (10%) of dissolved aromatic concentrations, and the reduced potential for the inhalation of toxic vapours given weathering effects, indicate that impacts to air-breathing fauna potentially present including humpback whales and marine turtles would be limited.

Entrained condensate from a spill would be present in the area in low concentrations (<100 ppb) during any season, with low probabilities (10% during summer and spring, 5% during winter and 1% during autumn) of elevated concentrations (>500 ppb) predicted (Figure 1). This suggests that any potential adverse impacts to marine fauna known to occur in the waters, including whale sharks, humpback whales and large pelagic fish, would be unlikely.

Benthic Habitats

Whether the concentrations of entrained oil predicted for the Ningaloo Coast NHP would present the potential for physical oiling of corals or other benthic habitats, including seagrass, is uncertain. The modelling indicated "worst case" maximum concentrations would range from 400 to 2,940 ppb. Mean maximum levels of entrained oil were considerably lower (50-300 ppb), and the likelihood of widespread oiling impacts to any fauna or habitats from these concentrations is therefore considered low under the majority of conditions. A subsurface plume of condensate reaching the Ningaloo Coast NHP during the coral spawning event in autumn (maximum "worst case" entrained concentration of 560 ppb) would potentially have greater effects if prolonged exposure was to affect the majority of that year's coral recruitment.

Whilst the modelling suggested that corals could be exposed to entrained hydrocarbons at concentrations that may have adverse effects, the toxicity of any entrained concentrations would have attenuated within the two weeks the oil took to reach Ningaloo (French-McCay & Payne 2001).

Whale Sharks

Whale sharks are unlikely to be affected by direct contact with, or ingestion of, condensate. While the "worst case" concentrations of entrained oil (1,265 ppb) are relatively high, moderate or elevated concentrations of aromatic hydrocarbons (>50 ppb) are not predicted to reach Ningaloo as a result of a blowout in autumn-winter when the whale sharks aggregate off Ningaloo. A blowout outside of the aggregation period would likely have negligible impacts on whale sharks, which migrate away from Ningaloo following this period (Meekan & Radford 2010). Therefore a well blowout at the Chandon location is unlikely to result in the decline of the species.

Marine Reptiles

The concentrations of surface condensate predicted to reach the Ningaloo Coast NHP by the modelling indicate that adverse effects from volatilised hydrocarbons to the green, loggerhead or hawksbill turtles that nest on the beaches in the area would be very unlikely. There would be a low potential for nesting females to become oiled and transfer condensate to eggs, causing a decrease in hatching rates as well as an increase in deformities in hatchlings.

Exposure to the elevated "worst case" entrained concentrations that may result following a hydrocarbon release during summer or spring could induce irritation or injury in soft tissues of exposed green, hawksbill and loggerhead turtles present in biologically important internesting areas between egg laying episodes. However, the modelling indicated that elevated concentrations (>500 ppb) of entrained hydrocarbons would be unlikely (20% and 10% probabilities during spring and summer, respectively) (Figure I).

Turtles exhibit cyclical nesting patterns, typically only returning to nest every two to five years for loggerhead, three to five years for green and two to four years for hawksbill turtles. These species that occur in the Ningaloo Coast NHP are part of populations that extend over greater areas in the region (Limpus 2002; DEC 2009). Given that only a proportion of the population would be exposed to a spill in any given year, and that hydrocarbons stranded on nesting beaches are unlikely to have adverse impacts in subsequent nesting seasons (NOAA 2010), it is unlikely that a condensate spill would cause considerable reduction in nesting success, or the quality of critical and biologically important nesting and internesting habitat for any turtle species at a population (or species) level.

Marine Mammals

Ningaloo Reef is a biologically important area for dugongs (Figure E). Little is known of the effects of oil spills on dugongs. In common with other air breathing fauna, it seems likely they may be most susceptible to impacts from inhalation of volatised hydrocarbons (AMSA 2011). As discussed in previous sections, the very low volumes and extended periods of transport for surface condensate from a well blowout at Chandon would suggest that extensive adverse impacts via this mechanism would be unlikely.

Dugongs could also be indirectly affected by spill impacts to their preferred food source of seagrass. Direct contact with oil, including entrained components, can smother and kill seagrasses if it coats their leaves and stems (Taylor & Rasheed 2011). It is uncertain whether the levels of entrained oil that might reach areas of seagrass in the Ningaloo Coast NHP would generate similar effects, and it is likely that any oil would need to be retained in seagrass meadows for prolonged periods for adverse effects to occur (Wilson & Ralph 2010). Dugongs are highly migratory, and the Ningaloo Coast NHP population is thought to move to alternate feeding areas following natural (cyclonic) disturbances to local seagrass communities (Hodgson 2007). It is expected that the dugong population would similarly migrate to other feeding areas in the event of a hydrocarbon spill impacting a particular area, as any impacts on seagrass would be restricted to only a portion of the available dugong habitat of the region. Therefore, long-term effects to dugongs through localised impacts to their food source and biologically important areas from a Chandon blowout would not be expected.

Migratory Seabirds

The modelling indicated that surface concentrations that may present as a rainbow sheen (>1 μm thick) may coincide (10% probability) with biologically important foraging areas for the wedge-tailed shearwater, roseate tern and fairy tern during spring, with surface concentrations >10 μm thick (a metallic sheen) not expected during any season. Given the travel times involved, the condensate would have weathered, allowing for the attenuation of toxicity (French-McCay & Payne 2001). This suggests limited potential for adverse effects through physical oiling, or through the contact of eggs with fresh condensate from parent birds during nesting seasons. The limited volumes (<26 g/m^2) of weathered condensate that may strand onshore indicated that impacts to nesting areas would be limited.

Low concentrations (<100 ppb) of entrained hydrocarbons reaching biologically important areas were also predicted to result from a well blowout during any season. Elevated levels (>500 ppb) were predicted to have a limited potential (10%) to contact with biologically important foraging areas during any season (Figure I). A maximum shoreline concentration of 2,940 ppb was predicted by the modelling; however, mean maximum concentrations were expected to be almost an order of magnitude lower at 315 ppb for Ningaloo shorelines and 300 ppb at the Muiron Islands. The travel times involved (10–15 days) indicated that entrained hydrocarbons would have undergone toxicity attenuation (French-McCay & Payne 2001), and the potential for contamination of eggs by contact with oiled parent birds would be limited, as would the potential for adverse impacts to biologically important areas for any of the species present.

Only one of the three species known to breed in the Ningaloo Coast NHP is listed as Threatened and all have widespread regional distributions, indicating that long-term consequences to populations from exposure to condensate following a blowout at Chandon would be unlikely.

Anchialine Communities

There was a low (≤23%) probability of elevated (>500 ppb) concentrations of entrained condensate reaching the Ningaloo Coast NHP. No contact of elevated concentrations of dissolved aromatics (>50 ppb) were predicted, likely due to the long travel time required to reach the shoreline (16 days). These concentrations are unlikely to be sufficient for contaminated seawater to diffuse through subterranean connections, into anchialine communities and retain sufficient toxicity.

Consequence Ranking

Applying the definitions of the Fourth Train Proposal Risk Matrix (Table 1), the potential environmental consequences of this scenario were considered to be Minor to Moderate.

6.2.1.2 Likelihood

The likelihood of a loss of well control (blowout) occurring during drilling in Australia is considered very low (Swan et al. 1994). Project planning, including well design, well control procedures and use of blowout prevention systems (BOPs) suitable for all conditions that may be encountered during well construction, will ensure that the probability of a blowout is minimised to as low as reasonably practicable (ALARP).

The Fourth Train Proposal is targeting gas, and the predominant hydrocarbons involved in a loss of well control incident would most likely be in gaseous form, which would be expected to have minimal impact on the marine environment.

Statistical probabilities for primary risk for a well blowout scenario were derived from historical incident data collated by OGP (2010). Probabilities were based on data from the Gulf of Mexico, UK and Norway during 1980–2004, with adjustment for trends.

They are relevant for well operations of "North Sea standard", defined as operations with BOP, including shear rams installed and a two-barrier principle applied.

The development wells are considered to fall within the "Development Drilling, deep water, non-high pressure, high temperature (HPHT) wells" category. For well operations of North Sea standard, the blowout frequency for gas development drilling was reported to be 7.0×10^{-5}, of which the sub-sea fraction was 0.33 (OGP 2010). Probabilities increase if well completions are included, but these have no sub-sea fraction. Therefore, this category of gas wells has a calculated sub-sea blowout probability of 2.31×10^{-5}. DNV (2011) also described a frequency distribution model for blowouts in Australia that incorporated spill size into the probability, including the recent Montara incident. Applying this model to the Chandon blowout scenario, a lower probability would be estimated. Therefore, the more conservative OGP (2010) probability was adopted in the likelihood calculations.

To assess secondary risk, the highest probabilities for shoreline exposure to liquid hydrocarbons from an uncontrolled blowout were investigated for each season (APASA 2012; Appendix 1). Quantitative estimates of the likelihood that a blowout would result in exposure to inshore areas were then derived (by combining primary and secondary risk).

From the modelling, the highest probabilities for shoreline exposure (i.e. "worst case" scenario) resulting from a blowout involved entrained hydrocarbons with a concentration of 10 ppb were as follows:

- summer – 40% at Ningaloo Coast
- autumn – 70% at Ningaloo Coast
- winter – 36% at Ningaloo Coast
- spring – 50% at Ningaloo Coast.

The overall likelihood of a "worst case" blowout scenario affecting any shoreline was:

- summer: $([2.31 \times 10^{-5}] \times 0.417) \times 0.40 = 0.00000385$ or 3.85×10^{-6}
- autumn: $([2.31 \times 10^{-5}] \times 0.083) \times 0.70 = 0.00000135$ or 1.35×10^{-6}
- winter: $([2.31 \times 10^{-5}] \times 0.417) \times 0.36 = 0.00000347$ or 3.47×10^{-6}
- spring: $([2.31 \times 10^{-5}] \times 0.083) \times 0.50 = 0.000000963$ or 9.63×10^{-7}.

Annualised, this corresponds to an event occurrence probability of 9.63×10^{-6} (a 1 in 103,842 chance).

Likelihood Ranking

The likelihood of a well blowout at the Chandon gas field having Minor to Moderate consequences is considered to be Rare.

6.2.2 Pipeline Release

6.2.2.1 Intrafield Flowline Rupture – Chandon Manifold Tie-in

Consequences

Modelling for a condensate spill resulting from a flowline rupture at the Chandon Manifold Tie-in location (1,200 m water depth) indicated that a high proportion of the volume released would be entrained or dissolved into the water column, with a relatively small volume (maximum at any point in time is less than 20 m^3 (APASA 2012; Appendix 1)) of condensate reaching the surface.

The resulting surface sheen of condensate would rapidly thin and lose toxicity through evaporation and dissolution of aromatic components. The modelling indicated that the condensate sheen would remain offshore following a spill during any season and not extend beyond 100 km of the release location under 90% of conditions. There was predicted to be only a remote potential for exposure to inshore areas, or shorelines, of the mainland or islands in the region that may represent biologically important areas and critical habitat for Threatened or Migratory species.

Consequently, surface condensate would have a limited potential for substantial adverse effects to marine fauna, including foraging seabirds or surfacing turtles and marine mammals. A surface slick presenting as a metallic sheen (>10 µm thick) from a spill during the humpback migration season would remain offshore of the migration corridor under 99% of conditions modelled. Given the remote location of the release site and rate of weathering that would occur during transport to other areas, the potential for physical oiling, toxicity or inhalation impacts from surface condensate to any population of Threatened or Migratory fauna, or habitats of importance to them, is considered to be low.

Biologically important areas and critical habitats of Threatened or Migratory fauna are similarly not expected to suffer adverse effects from subsurface release of condensate. A very low (1%) probability of exposure to entrained oil concentrations above trace levels (10 ppb) was predicted for the Ningaloo Reef from a spill during spring, but only after an extended period (13 days) of transport from the spill site. After this period of weathering, toxicity or physical oiling impacts to biota or habitats from the very low (60 ppb) concentrations involved would be extremely unlikely. Similarly, the modelling indicated that biologically important areas and critical habitat for marine turtles and migratory seabirds, including waters surrounding Barrow Island and the Montebello Islands, would have a very low probability (1%) of exposure to even low levels of entrained hydrocarbons (<100 ppb). Therefore, the potential for entrained condensate to have population level impacts on any Threatened or Migratory fauna or its biologically important or critical habitat is considered to be low.

The trajectory modelling suggested that any impacts to ecosystem functioning and integrity of any KEF would be unlikely. The "worst case" probability of a rainbow sheen of surface condensate (1 µm thick) was 10%, for the Exmouth Plateau. The potential for entrained hydrocarbons to have adverse effects was also low, with the "worst case" being 20% probability for low concentrations (<100 ppb) at the Exmouth Plateau.

Marine water quality could be affected at distances of up to 300 km from the release site, although due to the dynamic nature of the resulting surface and subsurface plumes, effects would be temporary at any location and of diminishing intensity with distance from the release site. This would likely result in toxicity or physical oiling to any pelagic fauna that were present in the vicinity of the offshore spill site coincident with the rupture, however, the geographical extent and duration of any impact would be limited. Dissolved aromatic hydrocarbons would remain below no effects concentrations (5 ppb) beyond the immediate spill site and elevated (>500 ppb) entrained oil concentrations were not predicted to extend beyond the immediate vicinity (1.5 km^2) of the release location.

Pelagic and demersal fish, including commercially important species, may be at risk if transiting through the immediate vicinity of a spill resulting from a pipeline rupture. However, the restricted area over which elevated concentrations (<500 ppb) of entrained oil may be present, combined with the low potential (<20% probability) of these concentrations occurring, suggest that widespread impacts to fish would be unlikely. The commercial fisheries of the region have wide ranging fishing zones of which only a small portion would potentially be affected by a spill, and the area surrounding the spill site in which the potential for toxic effects would be greatest does not represent important habitat for any commercially important species. There is a remote chance that oil as a result of a spill could reach inshore nursery areas, however given the extended travel times and associated extensive weathering (French-McCay & Payne 2001), considerable impacts to fish stocks would be unlikely.

Consequence Ranking

Applying the definitions of the Fourth Train Proposal Risk Matrix (Table 1), the potential environmental consequences of this scenario were considered to be Minor.

Likelihood

OGP (2010) provides a frequency for sub-sea flow lines ("small pipelines containing unprocessed well fluids") of 5.0×10^{-4} per pipeline – km year, based on North Sea data. Applying the spill size distribution model (DNV 2011) and incorporating the approximate length (55 km) of the Chandon Intrafield Flowline, this provides a primary risk value for this scenario of 2.40×10^{-3}.

From the modelling, the highest probabilities for exposure to sensitive areas resulting from a rupture at the Chandon Intrafield Flowline Tie-in were as follows:

- summer – no contact predicted
- autumn – no contact predicted
- winter – no contact predicted
- spring – 1% for entrained oil >10 ppb at the Ningaloo Coast.

Therefore, the overall likelihood of a "worst case" flowline rupture scenario affecting any shoreline in each season is:

- spring: ([2.4 × 10^{-3}] x0.083) × 0.01 = 0.000002 or 2.00 × 10^{-6}.

Annualised, this corresponds to an event probability of 2.00 × 10^{-6} (a 1 in 500,000 chance).

Likelihood Ranking
The likelihood of a pipeline rupture at the Chandon manifold having Minor consequences is considered to be Rare.

6.2.2.2 Intrafield Flowline Rupture – Jansz PTS Tie-in

Consequences
The low volumes of condensate that would reach the sea surface a rupture at the tie-in would have limited potential to adversely affect fauna at or near the water surface, including foraging seabirds or surfacing turtles and/or cetaceans and their biologically important or critical habitat, with a rainbow sheen of condensate (1 μm thick) predicted to remain within 80 km of the release site under 90% of conditions. While there was a very low possibility (1-5%) of biologically important areas for marine turtles, migratory seabirds and dugongs being exposed to a surface rainbow sheen of weathered condensate, no exposure to a surface slick >10 μm thick would occur under 99% of conditions modelled, including for the humpback migration corridor during the migration season. Given the remote location of the release site and rate of weathering that would occur during transport to other areas, the potential for physical oiling, toxicity or inhalation impacts to any populations of Threatened or Migratory fauna and their biologically important or critical habitat is considered to be low.

Effects to Threatened and Migratory fauna and their biologically important areas or critical habitat from entrained condensate were unlikely, based on the modelling results. There was a very low potential for entrained hydrocarbons to migrate into inshore areas of conservation significance, but only at very low concentrations and after extended periods of weathering, suggesting adverse impacts would be very unlikely. The only exposure to entrained oil concentrations above 10 ppb predicted for inshore areas involved a very low potential (1% probability) of very low (25 ppb) concentrations reaching the Ningaloo Coast during summer, and involving an extended period (12 days) to reach the coast. Toxicity or physical oiling impacts to biota or biologically important areas and critical habitats from these levels of weathered condensate would not be expected.

The trajectory modelling suggested that any impacts to ecosystem functioning and integrity of any KEF would be unlikely. There were only low probabilities of hydrocarbons at concentrations well below those known to cause ecological harm (French 2000; Neff 1991) being present on, or in, the waters at any KEF. The "worst case" possibilities for surface concentrations were for a rainbow sheen (1 μm thick) at both the Exmouth Plateau and Continental Slope Demersal Fish Communities (5%

probability for each). “Worst case” possibilities (20% probability) for entrained concentrations (<100 ppb) were also predicted to occur at the Exmouth Plateau and Continental Slope Demersal Fish Communities. However, elevated concentrations of entrained hydrocarbons were unlikely (1% probability), suggesting that any adverse impacts to the water column and pelagic fauna within it would be limited.

A condensate spill resulting from a pipeline rupture at the Jansz PTS Tie-in location (1,345 m water depth) would result in localised reduction in water quality, potentially involving acute toxicity and/or oiling of marine organisms. Pelagic fauna in the vicinity of this spill site would potentially be exposed to toxicity or physical oiling effects from entrained or dissolved condensate, but the temporal and spatial extent of impact would be limited. Elevated (500 ppb) entrained oil concentrations were not predicted to extend beyond the immediate vicinity of the spill location (generally within a 100 km radius of the release location) and dissolved aromatic hydrocarbons were predicted to remain below no effects concentrations. Any adverse impacts to the offshore marine environment were likely to be localised and temporary, possibly affecting a relatively small proportion of benthic and/or pelagic assemblages that have widespread distributions.

Widespread, adverse impacts to pelagic and demersal fish, including commercially important species, were unlikely, although individuals traversing the spill site immediately after a spill may be at risk of toxic effects. The area surrounding the spill site did not represent important habitat for any commercially important species, and elevated (>100 ppb) levels of entrained oil in any location surrounding the spill site were unlikely (<20% probability). There was only a remote chance of oil reaching inshore nursery areas, and extended travel times suggest extensive weathering would reduce the potential for toxic effects to any fish stock (French-McCay & Payne 2001). Commercial fisheries of the region are wide ranging and unlikely to be greatly impacted as a result of this spill scenario.

Consequence Ranking

Applying the definitions of the Fourth Train Proposal Risk Matrix (Table 1), the potential environmental consequences of this scenario were considered to be Minor.

Likelihood

Based on international historical data for flowline failure and applying the spill frequency distribution for Australian flowlines based on it (DNV 2011), the Chandon to Jansz PTS flowline primary risk was calculated to be 2.40×10^{-3}.

From the modelling, the highest probabilities for exposure to sensitive inshore areas (i.e. “worst case” scenario) resulting from an intrafield flowline rupture at the Jansz PTS Tie-in location were as follows:

- summer –1% for entrained oil >10 ppb at the Ningaloo Coast
- autumn – no contact predicted

- winter – no contact predicted
- spring – no contact predicted.

Therefore, the overall likelihood of a "worst case" flowline rupture scenario affecting any shoreline is:

- summer: ([2.4×10^{-3}] × 0.417) × 0.01 = 0.00001 or 1.00×10^{-5}.

Annualised, this corresponds to an event occurrence probability of 1.00×10^{-5} (a 1 in 100,000 chance).

Likelihood Ranking
The likelihood of an intrafield flowline rupture at the Jansz PTS tie-in location having Minor consequences is considered to be Remote.

6.2.2.3 Feed Gas Pipeline Rupture

Consequences
The environmental consequences of a release of condensate from the Feed Gas Pipeline would be largely dependent on the location at which the spill occurred. Modelling described in the assessment for the Foundation Project (Chevron 2005) was undertaken for a rupture occurring (i) near Barrow Island (200 m west), and (ii) approximately 14 km offshore of Barrow Island.

The modelling results (APASA 2005) indicated that a rupture from the Feed Gas Pipeline that occurred close to shore (200 m west) on the west coast of Barrow Island could result in up to 44 km of shoreline exposed to onshore volumes of 159 m^3. Effects on water quality were possible, with relatively large volumes of condensate reaching inshore areas and generating high dissolved aromatic concentrations during all seasons.

The modelling predicted that levels of dissolved aromatics would likely be acutely toxic in some areas, with maximum concentrations of 4,524 ppb on the west coast of Barrow Island, and mean concentrations of 2,534 ppb (APASA 2005).

Although sedimentation effects were likely to be limited by the light nature of condensate, seabed sediments and benthic communities may be directly contacted by condensate entrained during release or via wave action in inshore areas.

The benthic habitats in the coastal waters off the west coast of Barrow Island are dominated by macroalgal assemblages, with seagrass and coral colonies present in low abundance (DEC 2007). Macroalgae may be affected by the exposure to condensate predicted by the modelling, although subtidal macroalgae have been reported not to die or have reduced growth rates following oil spills (Peckol et al. 1990; Edgar & Barret 2000; Lobon et al. 2008).

Coral communities at Biggada Reef (within the Barrow Island Marine Park), would likely be exposed to high levels of entrained and/or dissolved hydrocarbons and could be directly contacted by a slick in the area during low tides. Inshore communities at the Montebello and Lowendal Islands would also have high probabilities of exposure. Extensive impacts would be expected and, although the high energy characteristics of this environment and distant recruitment sources would promote recovery, impacts would likely be relatively long lived.

No KEFs of the north-west marine region were likely to be affected by a Feed Gas Pipeline rupture, given the distance to the nearest KEF (Ancient Coastline at 125 m Depth Contour) is >60 km away.

Marine fauna in the vicinity of the rupture location, including Migratory and Threatened species, could be exposed to high surface and entrained concentrations of condensate and expected to suffer adverse impacts. The consequences for migrating fauna would be highly dependent on the timing of a spill relative to migratory patterns. For a rupture that occurred during winter, this could include exposure to volatilised hydrocarbons by humpback whales that are migrating through the region, and pass offshore of Barrow Island. The extent of impacts would depend on the degree to which prevailing conditions resulted in fresh condensate extending across the main migration corridor, and the timing of the release relative to the peaks in humpback whale abundances in the area. The rapid evaporation rates for the volatile aromatic components of condensate, and the limited volumes that might persist, would reduce the extent and duration of potential exposure.

Other marine fauna, particularly green turtles nesting on the west coast beaches of Barrow Island, would potentially be exposed to relatively fresh condensate entrained through shallow waters or by surface slicks in the intertidal zone from a spill during summer. This would likely have adverse implications for the health of adults as well as to their reproductive success, although the staggered nature of green turtle nesting would restrict these effects to only a portion of the local nesting population.

Critical habitats for marine turtles, as defined in the *Recovery Plan for Marine Turtles in Australia* (Environment Australia 2003), were likely to be contacted by a rainbow sheen, with portions of internesting buffers to Montebello Islands and Lowendal Islands having a <60% probability and a portion of the green turtle internesting buffer associated with Barrow Island certain to be contacted. Therefore it is possible a portion of important populations within critical habitats would be disrupted from breeding, if a condensate spill occurred during the nesting season. However the disruption is unlikely to result in species decline, as green turtles nest elsewhere in the north-west region and effects are not expected to be permanent, and therefore it is likely green turtles would return to Barrow Island at the next five year remigration interval.

Migratory seabirds, such as the wedge-tailed shearwater and lesser crested tern that have biologically important areas in the region, may be affected if they were actively foraging within the areas containing elevated levels of hydrocarbons, however substantial numbers of Migratory birds were not expected to be affected. The highest abundances of Migratory shorebirds occur on the south-eastern and southern shorelines of Barrow Island, particularly in Bandicoot Bay (DEC 2007), which remain unaffected by condensate from a Feed Gas Pipeline rupture. The species likely to be foraging in the area are part of larger regional populations that utilise other areas that would remain unaffected, and substantial direct or indirect impacts to the species involved were considered to be unlikely.

A spill 14 km offshore from Barrow Island would present risks to marine water quality and adverse effects to pelagic fauna, including to humpback whales during the migration season transiting the vicinity of the spill site. Limited effects to inshore areas were predicted, with both low surface slick thicknesses reaching coastlines and low water column concentrations in shallow waters. The modelling (APASA 2005) indicated that potential maximum volumes of condensate onshore could reach 26 m^3 contacting up to 31 km of shoreline.

In summer, a rupture 14 km offshore could potentially result in exposure to surface condensate and elevated maximum aromatic concentrations along the west coasts of Barrow and the Montebello Islands. Aromatic concentrations could reach approximately 1,800 ppb, with exposure for up to 12 hours, suggesting the potential for acute toxicity effects to some biota. However, mean aromatic hydrocarbon levels were considerably lower, with inshore mean aromatic concentrations not exceeding 30 ppb at any location, suggesting that widespread impacts would be unlikely.

No exposure (probability <1%) of aromatic hydrocarbons to inshore areas of offshore islands was predicted for a rupture that occurred during the other seasons of the year.

A number of commercial fisheries may operate in the area affected by the spill (see Section 5.2.1.1). However, large impacts to fisheries are not expected, as most of the commercial fisheries operating in the vicinity of the release site are wide ranging and effects from any spill would affect only a portion of the fishing grounds for a relatively short period. Possible short-term effects may include localised closures of fishing grounds and possible fouling of boats and/or fishing equipment, although the light nature of condensate and the ability of most fisheries to remove gear in the event of a spill would limit the latter. Surface slicks and elevated levels of dissolved aromatic hydrocarbons (up to 1,000 ppb) were predicted to potentially reach the pearl farming leases of the Montebello Islands. Oysters are thought to be sensitive to soluble toxic hydrocarbons and, if caged stocks could not be moved, exposure to hydrocarbons could affect the oysters as well as fouling infrastructure.

Consequence Ranking

Applying the definitions of the Fourth Train Proposal Risk Matrix (Table 1), the potential environmental consequences of this scenario were considered to be Minor to Severe.

Likelihood

Based on historical data for pipeline failures compiled by PARLOC 2001 (Mott MacDonald Ltd 2003), Environmental Risk Solutions (ERS 2005) evaluated the primary risk of rupture of the Feed Gas Pipeline for the Foundation Project. In that report, the annual primary risk for the Feed Gas Pipeline (per km) was determined to be 2.81×10^{-5} (ERS 2005), which is more conservative than the current published values (DNV 2011). Therefore, the primary risk values from the ERS report (2005) were applied to the likelihood calculations for the Fourth Train Proposal.

Trajectory modelling to evaluate the likelihood of released condensate reaching inshore areas was undertaken for a potential release 14 km and 200 m offshore of Barrow Island (APASA 2005).

APASA has reviewed the spill modelling undertaken for the Foundation Project and confirmed that the input parameters and model outputs remain valid for evaluating spill trajectories associated with the Fourth Train Proposal Feed Gas Pipeline, if it is assumed that the Fourth Train Proposal Feed Gas Pipeline will follow a similar alignment to the Foundation Project Feed Gas Pipelines. Therefore, the overall likelihood outcomes for the Foundation Project are considered applicable to the Fourth Train Proposal. These are as follows.

Rupture 200 m from Barrow Island

From the modelling, the highest probabilities for shoreline exposure (i.e. "worst case" scenario) to surface slick concentrations >0.3 g/m^2 at Barrow, Montebello and Lowendal Islands resulting from a pipeline rupture were as follows:

- summer – 99%
- transitional – 100%
- winter – 96%.

Therefore, the overall likelihood of a pipeline rupture scenario affecting sensitive areas in each season of potential effect is:

- summer: $([2.81 \times 10^{-5}] \times 0.5) \times 0.99 = 0.0000139$ or 1.39×10^{-5}
- transitional: $([2.81 \times 10^{-5}] \times 0.167) \times 1.0 = 0.00000468$ or 4.68×10^{-6}
- winter: $([2.81 \times 10^{-5}] \times 0.333) \times 0.96 = 0.00000899$ or 8.99×10^{-6}.

Annualised, this corresponds to an event occurrence probability of 2.76×10^{-5} (a 1 in 36,232 chance).

Likelihood Ranking

The likelihood of a rupture along the Feed Gas Pipeline 200 m from Barrow Island having Major to Severe consequences is considered to be Remote.

Rupture 14 km from Barrow Island

From the modelling, the highest probabilities for shoreline exposure (i.e. "worst case" scenario) to surface slick concentrations >0.3 g/m^2 at Barrow, Montebello and Lowendal Islands resulting from a pipeline rupture were as follows:

- summer – 63%
- transitional – 12%
- winter – 4%.

Therefore, the overall likelihood of a pipeline rupture scenario affecting sensitive areas in each season of potential effect is:

- summer: $([2.81 \times 10^{-5}] \times 0.5) \times 0.63 = 0.0000088$ or 8.8×10^{-6}
- transitional: $([2.81 \times 10^{-5}] \times 0.167) \times 0.12 = 0.000000562$ or 5.62×10^{-7}
- winter: $([2.81 \times 10^{-5}] \times 0.333) \times 0.04 = 0.000000375$ or 3.75×10^{-7}.

Annualised, this corresponds to an event occurrence probability of 9.79×10^{-6} (a 1 in 102,145 chance).

Likelihood Ranking

The likelihood of a pipeline rupture along the Feed Gas Pipeline 14 km from Barrow Island having Minor to Major consequences is considered to be Rare.

6.2.3 Major Fuel Spill

6.2.3.1 Consequences

The modelling indicates that a major (80 m^3) spill of diesel at the Chandon field location would be unlikely to result in widespread adverse environmental consequences, with approximately 40–50% of the original spill volume evaporating within 48 hours and the majority of the lighter toxic components expected to rapidly dissipate in the prevailing environmental conditions of the area.

The modelling indicated that surface concentrations that might generate toxic impacts were unlikely to affect large numbers of Threatened or Migratory fauna, with a slick presenting as a metallic sheen (>10 μm thick) likely to remain offshore of humpback whale migration routes during the humpback whale migration period and unlikely (1% probability) to contact biologically important areas or critical habitat to turtles, whale sharks, seabirds or dugongs. Given the low numbers of any Migratory or Threatened species expected to occur at the remote offshore location of the spill, and the limited extent and duration of potential exposure to fresh, unweathered diesel, extensive impacts to any species are considered unlikely.

There is a very low (1%) probability of entrained diesel reaching inshore waters at the Ningaloo Coast following a spill during spring, but only after 12 days of transport by which time the weathered residues would be unlikely to retain toxicity and the concentrations involved (120 ppb maximum) would not be expected to cause physical oiling effects to biologically important areas or critical habitats, or biota. No exposure to entrained diesel was predicted for any other inshore area during any other season and dissolved aromatic concentrations were not predicted to exceed no effects concentrations at any inshore location. Consequently, a major fuel spill at Chandon was unlikely to have adverse consequences to inshore habitats of importance to any Migratory or Threatened fauna, and would not result in the decline of any species

The remote spill location and relatively small volume of fuel oil involved suggests that adverse effects to KEFs and their ecosystem functions and integrity would not be expected. There was an increased probability (90%) of a surface slick (metallic sheen) >10 µm thick on the surface of waters over the Exmouth Plateau, however any adverse effects would likely be limited due to the rapid degradation and dispersion of diesel (Neff et al. 2000). Low concentrations of entrained hydrocarbons (<100 ppb) may be present (50% probability) in waters over the Exmouth Plateau, particularly nearer the release location. However, there would only be very low (1%) to low (10%) possibilities of entrained concentrations <100 ppb contacting any other KEF. Elevated concentrations (>500 ppb) were unlikely to contact any KEF under any conditions, except at the Exmouth Plateau nearer to the release site (5% probability).

Fauna present in the water column in the vicinity of operations at the time of a spill may be exposed to acute toxicity or physical oiling effects, although the temporal and spatial extent of these effects would be limited given the rapid natural degradation and dispersion of diesel in the open ocean (Neff et al. 2000).

Diesel entrained into the water column could affect water quality over a greater area, with the potential for concentrations above 10 ppb in areas up to 250 km from the spill site under 90% of conditions. However, dissolved aromatic concentrations were not predicted to exceed 50 ppb beyond the immediate spill site (approximately 1.5 km^2), suggesting widespread toxicity effects to pelagic marine life and the water column would be very unlikely.

Offshore benthic habitats or fauna were unlikely to be affected, as diesel would not be expected to come into contact with the seabed given the depths at the spill site (1,200 m) and sedimentation of diesel was unlikely to be substantial. Diesel is much lighter than water and, although diesel that is dispersed in the water column can adhere to suspended sediments that settle-out and get deposited on the seafloor, this process is typically associated more with fine-grained sediments typical of river mouths rather than open marine settings (NOAA 2006). The concentrations of diesel predicted to reach areas distant from the spill site suggests substantial sedimentation rates were unlikely even in shallower areas with higher turbidity.

Widespread effects to fish and fisheries were also unlikely. Large pelagic fish targeted by fisheries operating on the North West Shelf are generally found in water depths of 100-200 m, and due to the light nature and rapid evaporation of diesel, are unlikely to be affected by a diesel spill on the sea surface. No exposure to the pearl farm leases at the Montebello Islands was predicted under any conditions.

Consequence Ranking

Applying the definitions of the Fourth Train Proposal Risk Matrix (Table 1), the potential environmental consequences of this scenario were considered to be Minor.

6.2.3.2 Likelihood

DNV (2011) reviewed historical spill frequencies for diesel loading and reported that the annual (platform year) frequency for Australian operations was less than 8.6×10^{-4}. A spill size frequency distribution model was developed, and applying this model, the expected probability for an 80 m^3 diesel spill was calculated to be 2.58×10^{-5}.

From the modelling, the highest probabilities for inshore exposure (i.e. "worst case" scenario) resulting from a major diesel spill at the Chandon location were as follows:

- summer – no contact predicted
- autumn – no contact predicted
- winter – no contact predicted
- spring – 1% for entrained diesel >10 ppb at Ningaloo Coast.

Therefore, the overall likelihood of a major diesel spill scenario affecting sensitive areas in each season of potential effect is:

- spring: $([2.58 \times 10^{-5}] \times 0.417) \times 0.01 = 1.08 \times 10^{-7}$

Annualised, this corresponds to an event occurrence probability of 1.08×10^{-7} (a 1 in 9,259,259 chance)

Likelihood Ranking

The likelihood of a major fuel spill at the Chandon manifold location having Minor consequences is considered to be Rare.

6.2.4 Minor Fuel Spill

6.2.4.1 2.5 m^3 Diesel Spill at the Chandon Gas Field

Consequences

A spill of this small volume of diesel at the remote field location would be unlikely to result in substantial adverse environmental consequences, with limited potential to affect water quality or to affect large numbers of any marine fauna.

The fates and trajectory modelling indicated that the resulting surface rainbow sheen (>1 μm) would be unlikely to extend further than 75 km from the release location under 90% of conditions, and would remain distant from humpback whale migration routes during the migration season. Inshore areas including biologically important areas or critical habitat for any Threatened or Migratory species would only have a remote possibility (1%) of exposure to hydrocarbons following a spill during any season.

Effects on offshore marine water quality would be highly localised and temporary, with entrained concentrations above 100 ppb unlikely to occur outside of the immediate vicinity of the spill location, and entrained concentrations not predicted to reach levels reported to be acutely toxic or likely to cause physical oiling. Dissolved aromatic hydrocarbons would not exceed trace concentrations (5 ppb) beyond the immediate spill site.

The remote spill location and reduced volume of oil involved suggested that any adverse effects to KEFs and their ecosystem functions and integrity would not be expected. Whilst there was an increased probability (70%) of a surface slick (metallic sheen) >10 μm thick on the surface of waters over the Exmouth Plateau, the spatial extent would be limited. Low concentrations of entrained hydrocarbons (<100 ppb) would only have very low (1%) to low (10%) possibility of contacting any KEF. Elevated concentrations (>500 ppb) would not be expected under any conditions.

Widespread effects to fish and fisheries are also unlikely, as commercially important species are found at depth, and due to the light nature and rapid evaporation of diesel, are unlikely to be affected by a surface diesel spill. No exposure to the pearl farm leases at the Montebello Islands was predicted under any conditions.

Consequence Ranking
Applying the definitions of the Fourth Train Proposal Risk Matrix (Table 1), the potential environmental consequences of this scenario were considered to be Minor.

Likelihood
Based on OGP (then E&P Forum) data for spills resulting from transfer hose rupture, ERS (2005) stated that the primary risk of a diesel spill of this size occurring is 4.1×10^{-3} per fuel transfer, which is similar to the most current published risk values.

A diesel spill during refuelling of the drilling rig at the offshore Chandon gas field would not result in any surface or entrained diesel or any dissolved aromatic hydrocarbons reaching any of the sensitive inshore locations.

Likelihood Ranking
The likelihood of a minor fuel spill at the Chandon gas field location having Minor consequences is considered to be Unlikely.

6.2.4.2 2.5 m^3 Diesel Spill along Feed Gas Pipeline Route

Consequences
The modelling results (APASA 2005) indicated that a small diesel spill along the Feed Gas Pipeline route would have limited potential for widespread toxicity impacts to inshore areas, with maximum entrained concentrations remaining below the acute toxicity levels for marine diesel reported by French (2000) under most conditions, even where the spill occurred close (2.5 km) to Barrow Island. A refuelling spill 2.5 km from Barrow Island in summer would result in maximum entrained concentrations at the

Montebello Islands (440 ppb) that may be toxic to some species, but mean levels were an order of magnitude lower suggesting that widespread adverse effects would be unlikely. Maximum entrained concentrations within inshore waters (Barrow Island) for a spill 10 km from Barrow Island were predicted to be 103 ppb, and a concentration of 56 ppb was predicted for a spill 5 km offshore.

Impacts through physical oiling may result to intertidal areas, including habitats for Migratory or Threatened fauna, or to fauna present in the areas coincident with a diesel slick, particularly for spills occurring close to shore. However, the modelling suggested the extent of these potential impacts would be limited, with the total length of coastline affected by any spill relatively low (<10 km) and volumes reaching shore generally small (≤0.1 m^3).

Threatened marine turtles have critical habitats associated with Barrow, Montebello, Lowendal and Varanus islands (Environment Australia 2003), which includes internesting buffers that may be contacted by the diesel spill if the spill occurs during nesting seasons (Figure F). The probability that flatback and hawksbill internesting buffers would be contacted by a rainbow sheen is <40% for a spill 2.5 km offshore, <50% for a spill 5 km offshore and <30% for a spill 10 km offshore (APASA 2005). Surface slicks were not predicted to reach the shoreline of the Montebello Islands or the Lowendal Islands, with the exception of a spill 5 km offshore which had a <10% probability of contact with the Lowendal Islands. Green turtle critical habitat on Barrow Island is likely (<70% probability) to be contacted by a spill 2.5 km offshore, however the probability decreased with the distance of the spill from shore until the probability of contact from a 10 km spill was <10%. Critical habitat for green turtles would therefore be worst affected, than critical habitat for hawksbill and flatback turtles on other islands. Adverse effects may occur on nesting adults, egg viability and/or hatchling survival rates. Given that turtles nest in a staged approach and diesel would evaporate rapidly in the tropical climate of the north-west, if the spill was to occur during the nesting season, effects were likely to be limited to only a proportion of the nesting population present at the time of the spill. Therefore species decline for listed threatened marine turtles utilising the area or permanent reduction in critical habitat for these species would be unlikely.

No KEFs of the north-west marine region were likely to be affected by a diesel spill along the Feed Gas Pipeline, given that the nearest KEF (Ancient Coastline at 125 m Depth Contour) is >40 km away (Figure D).

The extent of potential effects on water quality would vary, depending on the location of the spill, with modelling indicating that a spill 10 km off Barrow Island could potentially affect areas up to 30 km from the release site (APASA 2005). Diving fauna, including humpback whales during their winter migration, would be at risk of contact with the offshore surface slick (and associated aromatic vapours), but the modelling suggested the extent of exposure would be limited such that impacts at population or species level would be unlikely. Considerable adverse impacts on commercial fisheries of the region would not be expected, considering the limited extent and duration of the slick generated by a spill of this volume and given that they largely target pelagic and demersal species at depths that would be unaffected by a surface diesel spill. No exposure to the pearl farm leases at the Montebello Islands was predicted in the event of a diesel spill along the Feed Gas Pipeline route.

Consequence Ranking

Applying the definitions of the Fourth Train Proposal Risk Matrix (Table 1), the potential environmental consequences of this scenario were considered to be Minor.

Likelihood

Based on OGP (then E&P Forum) data for spills resulting from transfer hose rupture, ERS (2005) calculated the annual primary risk of a 2.5 m^3 diesel spill during pipelay to be 4.1×10^{-3} per fuel transfer, which was similar to the most current published risk values (OGP 2010; DNV 2011). ERS (2005) assumed 10 refuelling operations would occur during pipelay operations and therefore the primary risk was 4.1×10^{-2}. The primary risk values from the ERS report (2005) were applied to the likelihood calculations below.

To provide an indication of the likely trajectories and inshore exposure resulting from a spill during refuelling for pipelay operations along the Feed Gas Pipeline route, modelling was undertaken for a theoretical release of 2.5 m^3 of diesel along the route at three distances west of Barrow Island: 2.5 km; 5 km; and 10 km (APASA 2005).

Diesel Spill during Refuelling 2.5 km West of Barrow Island

From the modelling (APASA 2005), the highest probabilities for shoreline exposure (i.e. “worst case” scenario) at >0.1 g/m^2 for Barrow, Montebello and Lowendal islands resulting from a diesel spill were as follows:

- summer – 84%
- transitional – 72%
- winter – 16%.

Therefore, the overall likelihood of a “worst case” diesel spill scenario affecting sensitive areas in each season of potential effect was:

- summer: $([4.1 \times 10^{-2}] \times 0.5) \times 0.84 = 0.0172$ or 1.72×10^{-2}
- transitional: $([4.1 \times 10^{-2}] \times 0.167) \times 0.72 = 0.00492$ or 4.92×10^{-3}
- winter: $([4.1 \times 10^{-2}] \times 0.333) \times 0.16 = 0.00219$ or 2.19×10^{-3}.

Annualised, this corresponds to an event probability of 2.43×10^{-2} (a 1 in 41 chance).

Diesel Spill during Refuelling 5 km West of Barrow Island

From the modelling, the highest probabilities for shoreline exposure (i.e. "worst case" scenario) at 0.1 g/m^2 for Barrow, Montebello and Lowendal islands resulting from a diesel spill were as follows:

- summer – 60%
- transitional – 16%
- winter – 8%.

Therefore, the overall likelihood of a "worst case" diesel spill scenario affecting sensitive areas in each season of potential effect was:

- summer: $([4.1 \times 10^{-2}] \times 0.5) \times 0.60 = 0.0123$ or 1.23×10^{-2}
- transitional: $([4.1 \times 10^{-2}] \times 0.167) \times 0.16 = 0.00109$ or 1.09×10^{-3}
- winter: $([4.1 \times 10^{-2}] \times 0.333) \times 0.08 = 0.00109$ or 1.09×10^{-3}.

Annualised, this corresponds to a probability of 1.45×10^{-2} (a 1 in 69 chance).

Diesel Spill during Refuelling 10 km West of Barrow Island

From the modelling, the highest probabilities for shoreline exposure (i.e. "worst case" scenario) at >0.1 g/m^2 for Barrow, Montebello and Lowendal Islands resulting from a diesel spill were as follows:

- summer – 16%
- transitional – 12%
- winter – 16%.

Therefore, the overall likelihood of a "worst case" diesel spill scenario affecting sensitive areas in each season of potential effect was:

- summer: $([4.1 \times 10^{-2}] \times 0.5) \times 0.16 = 0.00328$ or 3.28×10^{-3}
- transitional: $([4.1 \times 10^{-2}] \times 0.167) \times 0.12 = 0.00082$ or 8.20×10^{-4}
- winter: $([4.1 \times 10^{-2}] \times 0.333) \times 0.16 = 0.00219$ or 2.19×10^{-3}.

Annualised, this corresponds to a probability of 6.29×10^{-3} (a 1 in 159 chance)

Likelihood Ranking

The likelihood of a minor fuel spill along the Feed Gas Pipeline route having Minor consequences is considered to be Seldom.

6.3 Downstream Scenarios

6.3.1 Diesel Spill during Refuelling Adjacent to MOF

6.3.1.1 Consequences

The modelling (APASA 2005) indicated that a small diesel spill (0.1–10 m^3) from a refuelling accident adjacent the MOF would potentially have toxicity impacts in inshore areas, due largely to the close proximity of the spill (approximately 1 km offshore). A spill during winter or transitional months would result in maximum entrained concentrations (total hydrocarbons) of 2,400 ppb reaching some parts of the eastern shoreline of Barrow Island, with prevailing wind-driven currents expected to push entrained diesel against the shore. Mean levels were an order of magnitude lower at 160 ppb, suggesting that widespread adverse effects may be limited. Surface slicks generated by spills at the MOF were not expected to travel more than 12 km before entraining and dispersing to a thin sheen (Chevron 2005), therefore direct impacts to the Commonwealth marine environment would be limited. No KEFs of the north-west marine region were likely to be affected by a diesel spill during refuelling at the MOF Jetty, given the distance to the nearest KEF (Ancient Coastline at 125 m Depth Contour) is >60 km away.

The *Recovery Plan for Marine Turtles in Australia* (Environment Australia 2003) listed critical habitat for green turtles on Barrow Island and waters within a 20 km radius of the island. Barrow Island is also considered a biologically important area for flatback turtles, including an internesting habitat of 80 km, and hawksbill turtles, including an internesting habitat of up to 20 km. A spill during the nesting season would likely have adverse effects on nesting adults, egg viability and/or hatchling survival rates. The rapid degradation of diesel fuel in the tropical conditions of the marine environment would likely restrict these effects to only a small portion of the nesting population, of one nesting season, and predicted mean maximum concentrations for summer (73 ppb) were well below the levels of diesel expected to cause acute toxicity. Therefore, the potential localised and temporary effects of the spill on turtle nesting at Barrow Island would be unlikely to have a measurable impact on the local or regional turtle population of any species. Hence the spill is unlikely to adversely affect habitat critical to the survival of the green turtle to the extent that the species is likely to decline.

Other air breathing marine fauna, such as bottlenose dolphins and dugongs, may also suffer lethal and/or sub-lethal effects due to inhalation or ingestion of hydrocarbons and irritation/damage to sensitive tissues through direct contact, but this would tend to be limited to the period immediately following a spill while the aromatic components were evaporating. The proportion of any species occurring within the port area is likely to be low and, combined with the rapid evaporation of the volatile components of diesel, widespread impacts to any species would be unlikely.

The Critically Endangered dwarf sawfish (*Pristis clavata*) that may occur in the shallow waters along the southeast coast of Barrow Island could potentially be exposed to elevated concentrations of hydrocarbons, although impacts would likely be limited with the modelling predicting mean total hydrocarbon levels to not exceed 160 ppb in these areas.

Considerable effects to commercially important fish and fisheries were considered unlikely. Whilst several fisheries operate in the region, only the Onslow Prawn Managed Fishery regularly operates between the east coast of Barrow Island and the mainland. Fishing activity is generally restricted to inshore waters near the mainland coast, distant from the spill site and areas predicted to be contacted by a spill. Larger pelagic fish of commercial importance that may transit the area of the spill (e.g. Spanish mackerel) typically swim at depth and are unlikely to be affected by a surface spill to the extent necessary to adversely impact commercial fishing activity. No exposure to the pearl farm leases at the Montebello Islands was predicted under any conditions.

Shorebirds congregating on the sand and mudflats near Town Point are at risk of direct contact by a slick at low tide. However, only 1% of shorebirds on Barrow Island have been recorded from this area, and the main congregation area of Bandicoot Bay is distant from the spill and would not be affected.

Islands off Barrow Island and the adjacent water represent biologically important areas for breeding and foraging of listed Migratory marine seabirds during certain periods of the year (Figure G; Bamford & RPS BBG 2005; DSEWPaC 2012c). A small proportion of the populations of these species may be exposed, depending on the timing of the spill relative to their breeding period:

- Wedge-tailed shearwater (*Ardenna Pacifica*) – approximately 1 million breeding pairs in Western Australia, with a global population of over 5 million (DSEWPaC 2012c).

- Lesser crested tern (*Thalasseus bengalensis*) - approximately 318 birds on Barrow Island (Chevron Australia 2005) of 8170 breeding pairs in Australia (DSEWPaC 2012c).

- Roseate tern (*Sterna dougallii*) – approximately 7300 birds on Barrow Island (Chevron Australia 2005) of a global population of 82,000 individuals (Birdlife International 2013).

The spill may affect seabirds through fouling of plumage, ingestion of oil, effects on reproduction and physical disturbance (Volkman et al. 1994). Given that all species are migratory and would not be restrained from leaving the area of a spill, the small proportion of the population of any species that would be involved, the rapid degradation of the diesel, and that the area does not represent critical habitat to any of these species, it is unlikely a spill would adversely affect habitat to an extent that any species would decline.

Consequence Ranking

Applying the definitions of the Fourth Train Proposal Risk Matrix (Table 1), the potential environmental consequences of this scenario were considered to be Minor.

6.3.1.2 Likelihood

Based on OGP (then E&P Forum) data for spills resulting from transfer hose rupture, ERS (2005) calculated the annual primary risk of a small diesel spill during refuelling at the MOF to be 9.0×10^{-3}, assuming three refuelling operations per year. The latest OGP (2010) data provided a primary risk of 1.7×10^{-3} per cargo transfer for transfer spills from oil tankers. Assuming that refuelling operations will increase from three to four per year as a result of the Fourth Train Proposal, then the annual primary risk becomes 6.8×10^{-3}, and this is the annual primary risk used in the calculations below.

From the modelling (APASA 2005), the highest probabilities for shoreline exposure (i.e. "worst case" scenario) at Barrow, Montebello and Lowendal islands resulting from a diesel spill at the MOF were as follows:

- summer – 84%
- transitional – 72%
- winter – 16%.

Therefore, the overall likelihood of a "worst case" diesel spill scenario affecting sensitive areas in each season of potential effect was:

- summer: $([6.8 \times 10^{-3}] \times 0.5) \times 0.84 = 0.00286$ or 2.86×10^{-3}
- transitional: $([6.8 \times 10^{-3}] \times 0.167) \times 0.72 = 0.000816$ or 8.16×10^{-4}
- winter: $([6.8 \times 10^{-3}] \times 0.333) \times 0.16 = 0.000363$ or 3.63×10^{-4}.

Annualised, this corresponds to a probability of 4.03×10^{-3} (a 1 in 248 chance).

Likelihood Ranking

The likelihood of a minor fuel spill at the MOF having Minor consequences is considered to be Seldom.

6.3.2 Release from Grounded Tanker Adjacent LNG Jetty

6.3.2.1 Consequences

Condensate

A condensate spill from a tanker grounded adjacent the LNG Jetty could temporarily reduce water quality over an extended area, possibly affecting areas up to 90 km from the release site, and potentially expose up to 60 km of shoreline. The modelling (APASA 2005) suggested there would be limited potential for toxicity impacts to shorelines and inshore areas, with predicted maximum inshore aromatic concentrations (117 ppb at

Barrow Island) remaining below relevant ANZECC/ARMCANZ guideline levels (2000) during all seasons.

Fauna that were present in the vicinity of the spill and exposed to fresh condensate would potentially suffer acute toxicity effects, with the modelling indicating that aromatic concentrations near the spill site may exceed 1,000 ppb. Air breathing animals, including bottlenose dolphins, dugongs and turtles, surfacing within the slick may also suffer effects due to inhalation, ingestion and/or direct contact with fresh surface hydrocarbons, but this would tend to be limited to the period immediately following a spill. As the modelling indicated that the condensate slick from a tanker grounding would persist for less than three days (APASA 2005), this is unlikely to involve large numbers of any Threatened or Migratory species.

Barrow Island and the surrounding waters within a 20 km radius is critical habitat for green turtles during November to April each year (Figure F). It is possible that a condensate spill during this period may disrupt the breeding cycle of an important population. However the reduction in water quality associated with a spill was predicted to be temporary (<3 days) and given the maximum concentrations inshore are below relevant guideline levels, species decline or a permanent reduction in critical habitat is unlikely. Internesting areas of critical habitat of other turtles species (hawksbill, flatback) nesting on other nearby islands (Montebello, Varanus and Lowendal) were likely to be exposed (<60% probability) to lower concentrations of aromatics inshore than Barrow Island, and species decline or a permanent reduction in habitat for these species is highly unlikely.

Migratory seabirds may breed and forage on islands and waters offshore from Barrow Island, which represent biologically important areas for the wedge-tailed shearwater, roseate tern and little crested terns (Figure G; Bamford & RPS BBG 2005; DSEWPaC 2012c). These areas may temporarily be affected by a condensate spill. Given all species are migratory and would not be restrained from leaving the area of a spill, the small proportion of the population of any species that would be involved, and that the area does not represent critical habitat for any of these species, it is unlikely a spill would adversely affect habitat to an extent that any species would decline.

Modelling (APASA 2005) indicated KEFs of the north-west marine region would be unaffected by a condensate spill due to the long distance of the nearest KEF (Ancient Coastline at 125 m Depth Contour >60 km) from the LNG Jetty. Benthic habitats may be affected by condensate entrained through the water column in shallow areas or by the settlement of condensate-contaminated sediments. However, the light nature of condensate and limited volumes of heavier residual components suggests sedimentation would be unlikely and the extent of these effects would be limited.

Pelagic fish, including those of commercial importance, may be at risk if transiting through the immediate vicinity of a spill, but are unlikely to be affected in other areas of the slick as they typically swim at depth. Commercial fishing activity would not likely be impacted, due to isolation from the spill site and the limited potential for physical oiling of gear. The pearl farms at the Montebello Islands were not predicted to be contacted by surface slicks or dissolved aromatics under any conditions.

Mangal and riverine habitats that may potentially support the dwarf sawfish have a low probability (<30%) of being contacted by condensate, and dissolved aromatic concentrations would not exceed 100 ppb, indicating that the potential for any adverse impacts would be limited.

Consequence Ranking

Applying the definitions of the Fourth Train Proposal Risk Matrix (Table 1), the potential environmental consequences of this scenario were considered to be Minor to Moderate.

Light Crude Oil

A light crude oil spill from a grounded tanker was predicted to persist for longer than a condensate spill, with a correspondingly greater potential for physical oiling effects. Maximum "worst case" volumes of surface oil reaching inshore areas were generally relatively low (20 m^3 over 70 km of shoreline), with mean total volumes onshore during the turtle nesting season less than 6 m^3 during spring and 2 m^3 for summer conditions. Before exposure to inshore areas, the surface slick would be weathered and reduced in toxicity, due to the characteristics of light crude oil (APASA 2005).

Impacts, through physical oiling and/or toxicity, may result to fauna that occurred in the area of the spill. The waters off the east coast of Barrow Island are an important area for flatback turtles and support foraging by the Migratory wedge-tailed shearwater (*Ardenna pacifica*) and bridled tern (*Onychoprion anaethetus*), with nesting flatback turtles and Migratory shorebirds using the eastern shorelines of the island and the dwarf sawfish possibly present in sheltered inshore areas. The shallow waters over the Barrow Shoals are also known to be a feeding area for dugongs, although populations are greater in Exmouth Gulf or Shark Bay than around Barrow Island (Chevron Australia 2005).

The marine turtle habitat that had the highest probability of contact by a rainbow sheen is Varanus Island, which is a critical habitat for hawksbill turtles, and the Lowendal Islands, a biologically important area for hawksbill and loggerhead turtles. Internesting areas have <70% probability of contact depending on the timing of the spill in relation to breeding periods (spring and early summer), with lower probabilities of contact at nesting sites. Given the reduced toxicity of the slick, and that turtle nesting is staged therefore limiting the portion of the population that may be affected, species decline and permanent reduction of the quality of critical habitat from a spill of light crude oil would be unlikely.

Biologically important breeding and feeding areas for migratory seabirds (wedge-tailed shearwater, roseate tern and little crested terns; Figure G) is likely to be contacted by a light crude oil spill. All species have widespread distributions, and long-term adverse consequences to regional populations would be unlikely. The area does not represent critical habitat to any of these species, so it is unlikely that a spill would adversely affect habitat to an extent that any species would decline.

Given the limited extent over which the modelling indicated concentrations that may cause adverse impacts would persist, and the relatively low numbers of Threatened or Migratory fauna likely to occur coincident with the slick, it is unlikely that impacts to regional populations would result. Nevertheless, the recovery of local populations of fauna with extended reproductive cycles, such as wedge-tailed shearwaters and turtles, may be slow.

Modelling (APASA 2005) indicates the nearest KEF of the north-west marine region, being the Ancient Coastline at 125 m Depth Contour, located 60 km to the north-west of the LNG Jetty may be contacted by a light crude oil spill. The probability of contact is low (<5%) but may result in a rainbow sheen. The ecological value of the Ancient Coastline is related to both benthic and pelagic habitats within the feature, both of which will be unaffected by the rainbow sheen due to the weathering and reduced toxicity of the slick on reaching the water above the Ancient Coastline.

Water quality would potentially be temporarily affected over a relatively large area, with the modelling predicting exposure to areas more than 120 km from the spill site under certain conditions. Maximum entrained concentrations of aromatic hydrocarbons along the eastern shorelines of Barrow Island were predicted to remain low during all seasons (264 ppb), with mean levels not expected to exceed very low levels (8 ppb) under any conditions, suggesting the potential for widespread impacts would be limited.

Considerable effects on commercial fish stocks would be unlikely, but fisheries could be temporarily affected through short-term closures of fishing grounds. The distance to areas of importance to commercial fisheries make it likely that fishing equipment could be removed from the water and oiling of gear is unlikely. However, the modelling indicated that a surface slick may reach pearl farm leases at the Montebello Islands under certain conditions and this may pose greater risk of physical oiling effects. No exposure to elevated (>100 ppb) dissolved aromatics was predicted for these areas under any conditions, and the potential for surface hydrocarbons to affect gear or shell held below the surface would seem limited.

Consequence Ranking

Applying the definitions of the Fourth Train Proposal Risk Matrix (Table 1), the potential environmental consequences of this scenario were considered to be Minor to Moderate.

Bunker Fuel Oil

A bunker fuel oil spill from a grounded tanker adjacent the LNG Jetty would have limited potential for toxicity impacts to inshore areas, but would potentially expose fauna to physical oiling effects over an extended area. Surface slicks were predicted to extend for up to 100 km from the spill site potentially contacting up to 51 km of shoreline.

The maximum onshore volume of oil was predicted to be 47 m^3 and fauna susceptible to adverse effects from direct contact with oil, particularly seabirds, may suffer mortalities due to physical coating or oil ingestion, either directly or through contamination of food sources. In seabirds, contact with an egg via fouled plumage can damage an embryo

(Volkman et al. 1994) and ingested oil may depress egg laying or reduce the fertility of eggs laid. Whilst the islands offshore of Barrow Island are biologically important areas for seabirds, the seabirds potentially at risk from a spill have widespread distributions, generally nest in sheltered areas (e.g. surrounded by vegetation) and forage over large areas, long-term consequences to regional populations would be unlikely.

The intertidal flats of south-east Barrow Island represent an important area for Migratory shorebirds and if oil reached these areas it would have the potential to persist in the sediments, potentially affecting large numbers of Migratory shorebirds. Further to the south-east, the shallow waters of the Barrow Shoals provide a feeding area for dugongs, although numbers of dugongs in the region of Barrow Island are much lower than the mainland coastal waters (Chevron Australia 2005).

The modelling (APASA 2005) indicated that there is the potential for surface slicks to contact the intertidal areas of Barrow, Lowendal and Montebello islands. Critical habitat and biologically important areas occur for four species of marine turtle (green, flatback, hawksbill and loggerhead) that utilise the islands and surrounding waters. The islands have a <30% probability of surface contact, with the internesting buffers associated with Barrow and Lowendal islands an increased probability of contact of <60%. Potential impacts may include; increased egg mortality and developmental defects, direct mortality due to oiling in hatchlings, juveniles and adults, and physiological damage (Milton et al. 2003).

Bunker fuel oil may be highly persistent in the marine environment with the potential for long-term sediment contamination, particularly in intertidal areas (Irwin et al 1997). If the shoreline of Barrow Island was impacted by bunker oil, it may persist to the extent that may permanently adversely affect critical habitat. Studies on persistent oils indicated they may persist on shorelines for >25 years if no remedial action was taken (Kingston 2002).

The nearest KEF of the north-west marine region, the Ancient Coastline at 125 m Depth Contour, located 60 km to the northwest of the LNG Jetty may be contacted by a bunker fuel spill. The probability of contact is low (<5%) but may result in a rainbow sheen in the water column above sections of the Ancient Coastline. The ecological value of the Ancient Coastline relates to both benthic and pelagic habitats within the feature. The rainbow sheen may weather slowly, and may sink and impact the quality of pelagic and benthic habitats. This settlement is likely to occur in relatively small portion of the hard substrate available to species, given the Ancient Coastline spans the majority of the north-west marine region and benthic communities would be expected to be of a similar composition in areas unaffected by sedimentation.

As a heavier oil, bunker fuel has the potential for relatively high levels of sedimentation, particularly in turbid, inshore waters. Impacts on the benthic communities of inshore and intertidal areas are likely, and given that bunker fuel oil is slow to weather and highly persistent in sediments, it would introduce the potential for ongoing adverse effects to local water and sediment quality.

The low propensity for bunker fuel oil to cause toxicity effects through the water column would result in limited potential for adverse effects to pelagic fish of commercial importance, either through toxicity or tainting, but sedimentation could result in impacts to benthic species, possibly including the dwarf sawfish. Closure of some areas of fishing grounds may be required to avoid contamination of catches or gear for relatively long periods and the modelling indicates a surface spill would potentially extend to the pearl farm leases at the Montebello Islands.

Consequence Ranking

Applying the definitions of the Fourth Train Proposal Risk Matrix (Table 1), the potential environmental consequences of this scenario were considered to be Moderate to Major.

6.3.2.2 Likelihood

Based on historical data, DNV (1997) provided a probability of 2.0×10^{-3} per ship year for oil tanker groundings, with a probability of an oil spill resulting from any grounding of 0.2. Therefore, the probability of a tanker grounding and spilling oil was calculated to be 4×10^{-4}. ERS (2005) assumed vessel movements in and out of the LNG Jetty for the Foundation Project would include two hours each way for LNG tankers to transit the shipping channel to the docking station, and one hour each way for condensate tankers. Therefore the proportion of a year that vessels were in the terminal area and considered to be at risk of grounding was calculated to be $512/(365 \times 24)$ or 0.058 of a year. ERS (2005) applied this value to the DNV (1997) probability of 4×10^{-4} to determine an annual probability of grounding for tankers associated with the Foundation Project of 2.34×10^{-5}. The DNV (1997) data for spills from tanker groundings is slightly more conservative than more recent data and has therefore been retained for the likelihood calculations for the Fourth Train Proposal.

The number of additional LNG and condensate tanker movements estimated for the Fourth Train Proposal will be approximately 75 and five per year, respectively. It was assumed that the time taken to transit the shipping channel to the docking station will remain the same as assumed by ERS (2005) for the Foundation Project, whereby each LNG tanker takes two hours each way to transit the shipping channel to the docking station, and condensate tankers take one hour each way. Therefore, for the Fourth Train Proposal, vessels would spend $310/(365 \times 24)$ or 0.03 of a year in the terminal area. Applied to the DNV (1997) probability of 4×10^{-4} of an oil spill resulting from an oil tanker grounding, the likelihood of a condensate, light crude oil or bunker fuel oil spill from a grounded tanker adjacent the LNG Jetty for the Fourth Train Proposal is 1.4×10^{-5}.

Condensate

From the APASA (2005) modelling, probabilities of condensate reaching any shoreline following a spill from a grounded tanker were:

- summer – 25%
- transitional – 57%
- winter – 95%.

Therefore the overall likelihood of a "worst case" condensate spill reaching any shoreline after a spill from a grounded tanker is:

- summer: ([1.4 × 10^{-5}] × 0.5) × 0.25 = 0.00000175 or 1.75 × 10^{-6}
- transitional: ([1.4 × 10^{-5}] × 0.167) × 0.57 = 0.00000133 or 1.33 × 10^{-6}
- winter: ([1.4 × 10^{-5}] × 0.333) × 0.95 = 0.00000443 or 4.43 × 10^{-6}.

Annualised, this corresponds to a probability of 7.51 × 10^{-6} (a 1 in 133,156 chance).

Light Crude Oil

From the APASA (2005) modelling, probabilities of light crude oil reaching any shoreline following a spill from a grounded tanker were:

- summer – 51%
- transitional – 91%
- winter – 95%.

Therefore the overall likelihood of a "worst case" light crude oil spill reaching any shoreline after a spill from a grounded tanker is:

- summer: ([1.4 × 10^{-5}] × 0.5) × 0.51 = 0.00000357 or 3.57 × 10^{-6}
- transitional: ([1.4 × 10^{-5}] × 0.167) × 0.91 = 0.00000212 or 2.12 × 10^{-6}
- winter: ([1.4 × 10^{5}] × 0.33) × 0.95 = 0.00000443 or 4.43 × 10^{-6}.

Annualised, this corresponds to a probability of 1.01 × 10^{-6} (a 1 in 990,099 chance).

Bunker Fuel Oil

From the APASA (2005) modelling, probabilities of bunker fuel oil reaching any shoreline following a spill from a grounded tanker were:

- summer – 32%
- transitional – 68%
- winter – 95%

Therefore the overall likelihood of a "worst case" bunker fuel oil spill reaching any shoreline after a spill from a grounded tanker is:

- summer: ([1.4 × 10^{-5}] × 0.5) × 0.32 = 0.00000224 or 2.24 × 10^{-6}
- transitional: ([1.4 × 10^{-5}] × 0.167) × 0.68 = 0.00000159 or 1.59 × 10^{-6}
- winter: ([1.4 × 10^{-5}] × 0.333) × 0.95 = 0.00000443 or 4.43 × 10^{-6}.

Annualised, this corresponds to a probability of 8.26 × 10^{-6} (a 1 in 121,065 chance).

Likelihood Ranking

The likelihood of spill from a grounded tanker adjacent the LNG Jetty having Minor to Major consequences is considered to be Rare.

6.4 Resultant Risk

The resultant risk for each spill scenario has been analysed, using the qualitative categorisations of consequence and likelihood defined in the Fourth Train Proposal Risk Matrix (Table 1). The environmental risk assessment for each spill scenario is summarised in Table 7. The assessment indicated that the residual environmental risk for a spill resulting from the scenarios considered relevant to the Fourth Train Proposal ranges from Trivial to Medium.

Table 7: Summary of Environmental Risk Assessment for Each of the Key Spill Scenarios

Scenario	Scenario Location	Potential Impacts	Severity of Consequence (Magnitude)	Likelihood of Consequence	Residual Risk
Well Blowout at Gas Field During Drilling	Chandon Well	Degradation or loss of habitat for marine fauna. Potential smothering or acute/chronic toxic effects on marine organisms from liquid hydrocarbons.	**Minor to Moderate** Condensate has limited potential for physical oiling effects and modelling indicates that slicks would have thinned to <10 µm thick sheen before reaching inshore areas, with no exposure predicted for most locations. Likely to adversely affect pelagic species in the vicinity of the well site. Air breathing species, including Migratory or Threatened cetaceans and turtles, at risk of inhalation impacts if spill occurs during seasonal presence and they surface within a fresh slick. Levels of hydrocarbons predicted to reach KEFs are unlikely to affect ecosystem functioning. Spill site distant from aggregation areas of Threatened fauna, slick remains seaward of main humpback migration corridor and does not affect aggregation (resting) area in Exmouth Gulf. Combined with rapid weathering characteristics of condensate, suggests impacts at population level are unlikely. Only very low levels of surface condensate predicted to reach inshore areas, with extended time at sea before exposure (>29 days) indicating a surface slick would be significantly weathered and expected to have no or low toxicity. Levels of entrained oil and aromatic hydrocarbons predicted to reach most inshore areas. Due to periods of weathering, low persistence and generally high energy environments, entrained condensate reaching the Ningaloo Coast NHP unlikely to retain the potential for toxicity effects. Potential for entrained condensate to result in widespread oiling impacts to fauna or habitats at any inshore location appear low.	**Rare** Safeguards in place (including well integrity standards / best practice, BOPs, weekly function testing, hydrocarbon spill response resources) reduce probability of loss of well control to ALARP. Historical international data indicates 2.31×10^{-5} frequency of blowout incidents. Extended duration blowout has lower probability. The overall statistical probability of the event occurring and entrained hydrocarbons (exceeding 10 ppb) reaching Ningaloo Coast NHP is 9.63×10^{-6} annualised. Intervention via deployment of response capacity likely to be feasible within the period before the slick would reach shorelines (10 days).	Low

Scenario	Scenario Location	Potential Impacts	Severity of Consequence (Magnitude)	Likelihood of Consequence	Residual Risk
Pipeline Release	Intrafield Flowline rupture – Chandon Manifold	Degradation or loss of habitat for marine fauna. Potential smothering or acute/chronic toxic effects on marine organisms from liquid hydrocarbons.	**Minor** Temporary reduction of water quality and acute toxicity to marine organisms, as dissolved aromatic hydrocarbons are limited to the waters of the immediate release location. Pelagic fauna in the vicinity of the offshore spill site would potentially be exposed to similar effects as described for a blowout, but over a significantly reduced area and period. Substantial impacts to any listed Threatened or Migratory species unlikely. The Exmouth Plateau KEF would only be exposed to a rainbow sheen of surface condensate (1 µm thick). Potential impacts on benthic habitats and fauna limited to localised area around manifold location. Low volumes of condensate predicted to reach the surface and surface slicks are not predicted to reach any inshore areas. Very low potential for shoreline exposure to entrained oil only at the Ningaloo Coast. Adverse impacts on the Ningaloo Coast NHP are not expected, given levels reaching the Ningaloo Coast are very low (maximum of 60 ppb), and take an extended period of time to reach the coast (13 days).	**Rare** Safeguards in place (including pipeline and flowline design according to industry standards, implementation of a corrosion management plan, regular integrity inspection, monitoring and routine maintenance according to an IMR Plan) reduce probability of a pipeline rupture to ALARP. Historical international data indicates 2.40×10^{-3} frequency of pipeline rupture. The overall statistical probability of the event occurring and entrained hydrocarbons (exceeding 10 ppb) reaching Ningaloo Coast NHP is 2.00×10^{-6} annualised. Intervention via deployment of response capacity likely to be feasible within the period before the slick would reach shorelines (13 days).	Trivial

Scenario	Scenario Location	Potential Impacts	Severity of Consequence (Magnitude)	Likelihood of Consequence	Residual Risk
	Intrafield flowline rupture – Jansz PTS Tie-in	Degradation or loss of habitat for marine fauna. Potential smothering or acute/chronic toxic effects on marine organisms from liquid hydrocarbons.	**Minor** Temporary reduction of water quality and acute toxicity to marine organisms, as dissolved aromatic hydrocarbons are limited to the waters of the immediate release location. Pelagic fauna in the vicinity of the offshore spill site would potentially be exposed to similar effects as described for a blowout, but over a significantly reduced area and period. Substantial impacts to any listed Threatened or Migratory species unlikely. The Exmouth Plateau and Continental Slope Demersal Slope Fish Communities KEFs would likely only be exposed to low levels of entrained condensate (<100 ppb). Potential impacts on benthic habitats and fauna limited to localised area around manifold location. Low volumes of condensate predicted to reach the surface, and surface slicks are not predicted to reach any shoreline. Very low potential for shoreline exposure to entrained oil only at the Ningaloo Coast at insignificant concentrations (maximum of 25 ppb). Adverse impacts on the Ningaloo Coast NHP are not expected, given levels reaching the Ningaloo Coast are well below toxicity levels (maximum of 25 ppb), and take an extended period of time to reach the coast (12 days).	**Remote** Safeguards in place (including pipeline and flowline design according to industry standards, implementation of a corrosion management plan, regular integrity inspection, monitoring and routine maintenance according to an IMR Plan) reduce probability of a pipeline rupture to ALARP. Historical international data indicates 2.40×10^{-3} frequency of flowline rupture. The overall statistical probability of the event occurring and entrained hydrocarbons (exceeding 10 ppb) reaching Ningaloo Coast NHP is 1.00×10^{-5} annualised. Intervention via deployment of response capacity likely to be feasible within the period before the slick would reach shorelines (12 days).	Low
	Feed Gas Pipeline rupture 200 m offshore BWI	Degradation or loss of habitat for marine fauna. Potential smothering or acute/chronic toxic effects on marine organisms from liquid hydrocarbons.	**Major to Severe** High concentrations of entrained oil and aromatic hydrocarbons predicted to reach the shorelines of Barrow Island and Montebello Islands likely to impact water quality of inshore areas, and affect Migratory and Threatened species and their habitat. No exposure to any KEF from this scenario is predicted. High probabilities of exposure for benthic habitats including macroalgal assemblages and coral communities in marine parks with potential for extensive and relatively long lived impacts. Impact on fisheries, including pearl farming, not likely to be substantial.	**Remote** Safeguards assumed to be in place (including pipeline and flowline design according to industry standards, implementation of a corrosion management plan, regular integrity inspection, monitoring and routine maintenance according to an IMR Plan) reduce probability of a pipeline rupture to ALARP. Historical international data indicates 2.81×10^{-5} frequency of pipeline rupture. The overall statistical probability of the event occurring and a surface slick (0.3 g/ m^2) that is 200 m away reaching Barrow Island is 2.76×10^{-5} annualised.	Medium

Scenario	Scenario Location	Potential Impacts	Severity of Consequence (Magnitude)	Likelihood of Consequence	Residual Risk
	Feed Gas Pipeline rupture 14 km offshore BWI	Degradation or loss of habitat for marine fauna. Potential smothering or acute/chronic toxic effects on marine organisms from liquid hydrocarbons.	**Minor to Major** Impacts on water quality from dissolved aromatics limited to spill site. Impacts from sedimentation unlikely at spill site and inshore areas of offshore islands. Effects to Migratory species dependent on prevailing conditions and timing relative to migration patterns, possibly impacting migrating humpback whales in winter. No exposure to any KEF from this scenario was predicted. In summer, a rupture 14 km from Barrow Island could potentially result in exposure to surface condensate and aromatic hydrocarbons along west coasts of Barrow Island and Montebello Islands. No exposure of aromatic hydrocarbons to offshore islands was predicted for a rupture 14 km from Barrow Island during other seasons of the year. Surface slick concentration would be weathered and expected to have reduced toxicity and potential adverse impacts to fauna and habitats. Widespread adverse impacts from toxicity levels not expected. Impacts to fisheries not likely to be substantial. Potential impacts to pearl oyster stocks, if stocks cannot be moved.	**Rare** Safeguards in place (including pipeline and flowline design according to industry standards, implementation of a corrosion management plan, regular integrity inspection, monitoring and routine maintenance according to an IMR Plan) reduce probability of a pipeline rupture to ALARP. Historical international data indicates 2.81×10^{-5} frequency of pipeline ruptures. The overall statistical probability of the event occurring and a surface slick (0.3 g/m^2) that is 14 km away reaching inshore areas is 9.79×10^{-6} annualised.	Low

Scenario	Scenario Location	Potential Impacts	Severity of Consequence (Magnitude)	Likelihood of Consequence	Residual Risk
Major Fuel Spill (80 m^3)	Chandon Well	Degradation or loss of habitat for marine fauna. Potential smothering or acute/chronic toxic effects on marine organisms from liquid hydrocarbons.	**Minor** Temporary reduction of water quality over a large area and acute toxicity to marine organisms in vicinity of spill site only. Likely to adversely affect pelagic species in the vicinity of the spill. Air breathing species including Migratory cetaceans and turtles passing through the offshore field area at increased risk. Extent and duration of potential exposure limited due to rapid degradation and dispersion of spill in open ocean. Extent of impacts likely to be low. Low probabilities of oil reaching any KEF were predicted, apart from the Exmouth Plateau which had higher probabilities. However, levels of surface and entrained hydrocarbons were predicted at levels unlikely to impact ecosystem functioning. Surface slick not predicted to reach any inshore waters or coastline. Low potential for entrained oil to reach the Ningaloo Coast at very low concentrations (maximum 120 ppb), well below toxic levels and unlikely to result in long-term beach contamination or chronic effects.	**Rare** Safeguards in place (including compliance with COLREGS, 500 m safety zone around rig, Notice to Mariners, Automated Radar Plotting Aid, and required navigation lighting) reduce probability of a diesel spill to ALARP. Historical international data indicates 2.58×10^{-5} frequency of major diesel spill. The overall statistical probability of the event occurring and entrained hydrocarbons (exceeding 10 ppb) reaching the Ningaloo Coast NHP is 1.08×10^{-7} annualised. Intervention via deployment of response capacity likely to be feasible within the period before the slick would reach shorelines (12 days).	Low
Minor Fuel Spill (2.5 m^3)	Chandon Well	Degradation or loss of habitat for marine fauna. Potential smothering or acute/chronic toxic effects on marine organisms from liquid hydrocarbons.	**Minor** Temporary reduction of water quality and acute toxicity to marine organisms in vicinity of spill site only. Very limited potential for adverse environmental impacts, due to low spill volume, rapid degradation and dispersion of spill in open ocean, and offshore location. Low probabilities of oil reaching any KEF were predicted, apart from the Exmouth Plateau which had higher probabilities. However, levels of surface and entrained hydrocarbons were predicted at levels unlikely to impact ecosystem functioning. Surface slick and entrained diesel are not expected to reach inshore areas, and dissolved aromatic hydrocarbons do not exceed 5 ppb beyond the immediate spill site.	**Unlikely** Safeguards in place (including refuelling standards/best practice, appropriate weather conditions, reinforced hoses with flotation collars, dry break and breakaway couplings, continuous visual monitoring, scupper plugs, and drip trays) reduce probability of a diesel spill to ALARP. Historical international data indicates 4.1×10^{-3} frequency of diesel spill. No exposure for any inshore areas was predicted from a spill during any season.	Low

Scenario	Scenario Location	Potential Impacts	Severity of Consequence (Magnitude)	Likelihood of Consequence	Residual Risk
	Feed Gas Pipeline (10, 5 and 2.5 km from BWI)	Loss of habitat for marine fauna. Potential smothering or acute/chronic toxic effects on marine organisms from liquid hydrocarbons.	**Minor** Limited potential for adverse environmental impacts, due to low spill volume and rapid degradation and dispersion of spill in open ocean. No exposure to any KEF from this scenario was predicted. Total length of coastline affected by any spill relatively low (<10 km) and volumes reaching shore generally small (maximum of 0.1 m^3). Long-term beach contamination or chronic effects unlikely. Concentrations of entrained diesel predicted to reach Barrow and Montebello Islands are below levels reported to cause widespread adverse effects, including for pearl farming operations.	**Seldom** Safeguards in place (including refuelling standards/best practice, appropriate weather conditions, reinforced hoses with flotation collars, dry break and breakaway couplings, continuous visual monitoring, scupper plugs, and drip trays) reduce probability of a diesel spill to ALARP. Historical data indicates 4.1×10^{-2} frequency of diesel spill (assuming 10 refuelling operations). The overall statistical probability of the event occurring and a surface slick (0.3 g/m^2) reaching Barrow Island from 2.5 km away is 2.43×10^{-2} annualised. The overall statistical probability of the event occurring and a surface slick (0.3 g/m^2) reaching Barrow Island from 5 km away is 1.45×10^{-2} annualised. The overall statistical probability the event occurring and a surface slick (0.3 g/m^2) reaching Barrow Island from 10 km away is 6.29×10^{-3} annualised.	Low
Minor Fuel Spill (0.1-10 m^3)	MOF	Degradation or loss of habitat for marine fauna. Potential smothering or acute/chronic toxic effects on marine organisms from liquid hydrocarbons.	**Minor** Potential for adverse impacts likely restricted to Town Point shorelines. High probabilities of exposure for benthic habitats including shallow intertidal rock pool communities and macroalgal assemblages, however mean concentrations in inshore waters are low (<160 ppb). Before exposure to shorelines, surface slick would have weathered and reduced in toxicity and extent (60-70% expected to evaporate in the first 48 hrs). Air breathing species including bottlenose dolphins, dugongs and nesting flatback turtles at increased risk. Extent and duration of potential exposure limited due to rapid degradation and dispersion of diesel spill. Extent of impacts likely to be low. No exposure to any KEF from this scenario was predicted. Long-term beach contamination or chronic effects unlikely due to small volumes accumulating inshore areas.	**Seldom** Safeguards in place (including refuelling standards/best practice, appropriate weather conditions, continuous visual monitoring) reduce probability of a diesel spill to ALARP. Historical data indicates 6.8×10^{-3} frequency of a transfer spill. The overall statistical probability of the event occurring and surface or entrained diesel reaching the shorelines of Barrow or Lowendal Islands is 4.03×10^{-3} annualised. Intervention via deployment of response capacity may be feasible, and spill likely to be shut off instantaneously.	Low

Scenario	Scenario Location	Potential Impacts	Severity of Consequence (Magnitude)	Likelihood of Consequence	Residual Risk
Condensate Spill from Grounded Tanker (10–100 m^3)	LNG Jetty	Degradation or loss of habitat for marine fauna. Potential smothering or acute/chronic toxic effects on marine organisms from liquid hydrocarbons.	**Minor to Moderate** Modelling indicates limited potential for substantial environmental impacts. Pelagic fauna in the vicinity of the tanker grounding spill site would potentially be exposed to toxicity or oiling effects, but numbers of any species likely to be low. No exposure to any KEF from this scenario was predicted. Before exposure to inshore areas, surface slick would have weathered and reduced in toxicity and extent (expected to persist <3 days), resulting in limited impact to water quality, and benthic habitats not likely to be greatly impacted by sedimentation. Concentrations of entrained oil predicted to reach inshore areas are below levels reported to cause widespread adverse effects. Long-term beach contamination or chronic effects unlikely due to relatively small volume of the spill and rapid dispersion and degradation of condensate.	**Rare** Safeguards in place (including experienced navigational pilot on bridge when within port boundaries, support from tugs during berthing and departure, tug on standby during cargo loadings and standby at sea during cyclones until favourable docking conditions return), reduce the probability grounding. Historical data indicates 1.4×10^{-5} frequency of an oil spill from a tanker grounding. The overall statistical probability of the event occurring and condensate reaching any shoreline is 7.51×10^{-6} annualised.	Low

Scenario	Scenario Location	Potential Impacts	Severity of Consequence (Magnitude)	Likelihood of Consequence	Residual Risk
Light Crude Oil Spill from Grounded Tanker (10–100 m^3)	LNG Jetty	Degradation or loss of habitat for marine fauna. Potential smothering or acute/chronic toxic effects on marine organisms from liquid hydrocarbons.	**Minor to Moderate** Reduced water quality over a relatively large area and pelagic fauna in the vicinity of the tanker grounding spill site would potentially be exposed to toxicity or oiling effects, but numbers of any species likely to be low. Benthic habitats not likely to be greatly impacted by sedimentation. Low probability of the Ancient Coastline at 125 m Depth Contour KEF being exposure to a rainbow sheen (1 µm thick) of surface oil. Before exposure to inshore areas, surface slick would have weathered and reduced in toxicity and extent (70-80% expected to evaporate in first 48 hrs). Entrained light crude oil concentrations predicted to reach inshore areas are below levels reported to cause widespread adverse effects. Long-term beach contamination or chronic effects unlikely due to relatively small volume of the spill, low shoreline accumulation volumes and rapid dispersion and degradation. Substantial effects to commercial fishing operations are unlikely, and likely restricted to closure of fishing grounds.	**Rare** Safeguards in place (including experienced navigational pilot on bridge when within port boundaries, support from tugs during berthing and departure, tug on standby during cargo loadings and standby at sea during cyclones until favourable docking conditions return), reduce the probability of grounding. Historical data indicates 1.4×10^{-5} frequency of an oil spill from a tanker grounding. The overall statistical probability of the event occurring and light crude oil >0.3 g/m^2 reaching any shoreline is 1.01×10^{-5} annualised.	Low

Scenario	Scenario Location	Potential Impacts	Severity of Consequence (Magnitude)	Likelihood of Consequence	Residual Risk
Bunker Fuel Oil Spill from Grounded Tanker	LNG Jetty	Degradation or loss of habitat for marine fauna. Potential smothering or acute/chronic toxic effects on marine organisms from liquid hydrocarbons.	**Moderate to Major** Modelling indicates limited potential for toxicity to pelagic fauna of offshore areas, but oiling effects to fauna could result over an extended area (surface slicks predicted to extend for up to 100 km potentially exposing up to 51 km of shoreline). Low probability of the Ancient Coastline at 125 m Depth Contour KEF being exposure to a rainbow sheen (1 µm thick) of surface oil. Potential for long-term sediment contamination to intertidal areas of the east coast of Barrow Island, including flatback turtle nesting beaches and habitats for Migratory shorebirds, including the intertidal flats of south-east Barrow Island. Impacts to benthic communities are likely given slow weathering and highly persistent characteristics of bunker fuel oil. Impacts to habitats, including for Threatened and Migratory species, could be relatively long lived and recovery of local populations slow. Effects to Migratory fauna dependent on timing relative to seasonal presence.	**Rare** Safeguards in place (including experienced navigational pilot on bridge when within port boundaries, support from tugs during berthing and departure, tug on standby during cargo loadings and standby at sea during cyclones until favourable docking conditions return), reduce the probability of grounding. Historical data indicates 1.4×10^{-5} frequency of an oil spill from a tanker grounding. The overall statistical probability of the event occurring and bunker fuel oil >0.3 g/m^2 reaching any shoreline is 8.26×10^{-6} annualised.	Medium

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7.0 CONCLUSIONS

Based on the assessment of environmental risks associated with the Fourth Train Proposal, it is concluded that:

- The environmental effects of a hydrocarbon spill are dependent to a large degree on the dosage of hydrocarbons that impacts an environmental resource and the physical and chemical characteristics of the substances involved. These factors are strongly influenced by the location and volume of the spill, as well as a complex interaction of climatic, oceanographic and biological considerations. For this assessment, a conservative approach has been taken to many of these factors and the resulting assessment of risk is likely to be correspondingly conservative.

- The majority of potential spill scenarios associated with the Fourth Train Proposal would involve the release of light hydrocarbons, notably condensate and diesel. The action of light oils on biological resources tends to be acute toxicity of fresh oil rather than the physical smothering associated with heavier oils. This toxicity attenuates rapidly as the lighter components evaporate and/or dissolve following a spill. Consequently, the geographical extent and duration of potential environmental effects is reduced.

- The Fourth Train Proposal introduces some specific upstream spill scenarios, such as a blowout during drilling at a Fourth Train Proposal field or rupture of an Fourth Train Proposal Intrafield Flowline, which differ qualitatively from those of the Foundation Project. The probability of a major spill via these scenarios is very low: 2.31×10^{-5} for a well blowout, 2.40×10^{-3} for rupture, and 2.58×10^{-5} for a major diesel fuel spill. Given the results of the spill modelling for these scenarios and the management that is expected to be implemented to reduce both the probability and extent of impacts, the likelihood of considerable impacts is considered to be remote.

- More likely spill scenarios, involving the loss to the sea surface of relatively small volumes of diesel as a result of refuelling incidents, have limited potential for adverse impacts to marine water quality or marine life unless occurring in close proximity to Barrow Island.

- Many of the potential spill scenarios associated with the Fourth Train Proposal are common to those of the approved Foundation Project, and (in broad terms) the Fourth Train Proposal introduces an increase in the likelihood of environmental consequences consistent with the increase in the scale of risk sources (e.g. number of wells drilled, number of export tanker movements) that it represents. Due to the generally very low statistical probability of these spill incidents, the Fourth Train Proposal can be expected to pose only an incremental increase in spill risks. For example, the approved Foundation Project comprises the drilling of 25 wells, and the Fourth Train Proposal is expected to involve an additional 16 wells. Although each well is an independent 'event' for the purposes of statistical probabilities, the overall increase in the chance of a blowout associated with the Foundation Project from the additional wells of the Fourth Train Proposal can be calculated using binomial probabilities. This indicates that the Fourth Train Proposal would increase the chance of a well blowout by an additional 0.03% over the chance associated with the Foundation Project (0.06%).

- Generally, a major spill (>80 m^3), associated with either upstream or downstream components of the Fourth Train Proposal, has the potential to only temporarily reduce water quality and affect marine fauna and/or habitats within the immediate vicinity of the release location. However, a spill of bunker fuel oil could have more widespread and longer lasting effects, due to the more persistent nature of the oil.

- The likelihood of the Fourth Train Proposal resulting in adverse impacts to habitats of importance to relevant matters of NES is Seldom (for a minor fuel spill) to Rare (e.g. for a "worst case" well blowout).

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APPENDIX 1

Chandon Oil Spill Modelling (APASA 2012)

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Quantitative Oil Spill Risk Assessment for the Gorgon Gas Development Fourth Train Proposal – Chandon Gas Field Development

Revision 3 – 15/06/2012

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EXECUTIVE SUMMARY

Chevron Australia Pty Ltd (Chevron Australia) together with RPS Environment and Planning Pty Ltd (RPS) commissioned Asia-Pacific Applied Science Associates Pty Ltd (APASA) to undertake a quantitative hydrocarbon spill risk assessment for the Gorgon Gas Development Fourth Train Proposal, on the North West Shelf of Western Australia, to inform the assessment of potential environmental impacts. The risk assessment provides guidance on the probability of contact and other quantitative information (expected concentrations, arrival times etc.) for resources surrounding locations within the development, given defined spill scenarios.

The study specifically quantifies risk statistics for the following components that can arise from an oil spill into the marine environment.

1. Floating oil,
2. Physically dispersed oil, and
3. Dissolved hydrocarbon compounds

While the model also calculated for sedimentation of oil if the oil density exceeds water density, either through a change in the oil density by weathering or adherence of sediment to the oil, this outcome was not found to occur for the condensate or diesel oils investigated in this study, for the ocean setting of the study where suspended sediment concentrations are low.

Risk statistics objectively quantify the more likely and less likely outcomes of each modelled spill scenario, accounting for seasonal and episodic variations in the metocean conditions affecting the study area as well as the weathering behaviour of the particular oil types.

The results do not account for the primary likelihood of each scenario occurring in the first place, but are relevant to the expected outcome should defined spill scenarios occur. Furthermore, the results of this study cannot be used alone to infer the risk of environmental impact. Other factors, including the potential for the individual oil to exert an effect through toxicity or other mechanism, such as smothering, given the state of weathering and the sensitivity of particular receptors to the predicted concentrations, should be considered along with the outcomes of this study.

Chevron Australia identified five hydrocarbon spill scenarios for investigation:

1. A 2.5 m³ spill of diesel onto the water surface occurring over a few minutes at the Chandon Well location.

2. An 80 m³ spill of diesel onto the water surface over 6 hours (13.3 m^3/hr) at the Chandon Well location.

3. A sub-surface release of condensate and gas, at 1,200 m depth, resulting from a pipeline rupture at the Chandon Manifold (CM) location, yielding a total discharge of 200 m³ of condensate over 3 hours (66.7 m^3/hr).

4. A sub-surface release of condensate and gas, at 1,346 m depth, resulting from a pipeline rupture at the Jansz Pipeline Termination Structure (PTS) location, yielding a total discharge of 200 m³ of condensate over 3 hours (66.7 m^3/hr).

5. An uncontrolled sub-surface blowout of condensate and gas, at 1,200 m depth, from the Chandon Well location that persists for 11 weeks, releasing condensate at a constant rate of 2,349 bbl/d (373.6 m³/d or 15.57 m^3/d), yielding a total condensate discharge of approximately 180,873 bbl (28,756.5 m³).

The Chandon Well would be located approximately 170 km northwest of the Montebello Islands and 180 km northwest of Barrow Island. The Chandon Manifold would be situated in the same location and water depth as the Chandon Well and the Jansz Pipeline Termination Structure would be located approximately 112 km northwest of the Montebello Islands. Chevron Australia provided specifications for the condensate (Chandon Condensate) and the characteristics of the diesel oil were drawn from standard database information (ADIOS database).for a diesel formulated for the ambient temperatures on the North West Shelf.

For the Chandon Condensate, a low viscosity and high proportion of non-persistent components is indicated (90.9%). Consequently, a significant proportion of the condensate should evaporate if exposed to the atmosphere under environmental conditions off the North West Shelf. However, approximately 9.09% of the whole crude has a boiling point exceeding 380 °C and would not evaporate: hence, will persist in the marine environment until biodegraded. This residual component would be mostly comprised of long-chain compounds with a raised viscosity (> 15 cSt), density lower than the ambient seawater (hence, buoyant) and a collective pour point lower than ambient water temperatures (hence, will flow as a liquid rather than solidify). In a long-term blowout situation, the total volume of the residual component remaining on the water surface would increase as the discharge continues.

The oil spill modelling was performed using a three-dimensional oil spill trajectory and weathering model, SIMAP (Spill Impact Mapping and Analysis Program), which is designed to simulate the transport, spreading and weathering of specific oil types under the influence of changing meteorological and oceanographic forces. Stochastic modelling was carried out using an historic sample of modelled wind and current data that included spatial variation over the full spatial area where oil could migrate to and spanned 5 years (2005 to 2009, inclusive), including years of positive and negative Southern Oscillation Indexes (BOM glossary), at hourly time steps. Thus, this data provided allowances for temporal variations in the wind and current ranging from hourly to inter-annual variations. The analysis separately calculated risks for summer, autumn transition, winter and spring transition seasons. For each season, a large number of replicate simulations of each scenario were modelled, each replicate initialised at a different, randomly selected, point in time.: Hence, under a different time-sequence of wind and current conditions. One hundred replicate simulations of the short term spill scenarios were simulated per season, each spanning 7 or 14 days (post spill) depending upon the volatility of the oil. For the long term blowout scenario, where each replicate spanned 91 days of discharge under varying conditions (77 days with discharge plus a further 14 days), 30 replicates were modelled per season. These levels of replication were chosen after sensitivity testing to ensure that outcomes were representative of the trends and variations in the wind and current data.

Probabilities of contact with surrounding shorelines were calculated in terms of threshold levels of oil concentration. Indicative thresholds of oil mass per surface area were applied for surfaced oil - equivalent to oil films displaying rainbow sheen (1 g/m^2 ~ 1 µm) and dull metallic colours (10 g/m^2 ~ 10 µm thickness). These thresholds are likely to be conservative, in terms of environmental effects. For example, the minimal thickness of floating oil films that will result in harm to seabirds on the water surface has been estimated by different researchers as 10 g/m^2 to 25 g/m^2 (French 1998, Kroops & Van der Veen 2004). However, the 1 g/m^2 threshold may be considered as indicative of the perceived area of effect of a spill, which might trigger economic impacts, for example.

Thresholds for concentrations of entrained oil were defined at 10 and 100 ppb and for dissolved aromatic compounds, more conservative threshold concentrations of 5 and 50 ppb were specified. For the blowout scenarios, a threshold of 500 ppb was also defined for both entrained oil and dissolved aromatics. The lowest concentration is considered a conservatively low estimate of the lowest concentration that may be harmful to sensitive marine organisms with relatively long exposure times (10"s of hours). Because of the requirement for relatively long exposure times, this threshold is more meaningful for larvae and organisms that might be entrained (and therefore moving) within the oil plumes. The higher thresholds are more relevant to short duration (acute) exposure to organisms or fixed habitats affected by the dynamically varying plume.

The main findings of this modelling study are:

- Large scale drift currents will have a significant influence on the trajectory of any oil spilled at the modelled release sites, irrespective of the seasonal conditions. The prevailing drift currents will determine the trajectory of oil that is entrained beneath the water surface.

- Interactions with the prevailing wind will add additional variation in the trajectory of spilled oil and in the case of the long-term blowout scenarios, marked variation in the prevailing drift current and wind conditions would be expected over the duration of the release. This would be expected to increase the spread of oil during any single event.

- Modelling indicated aromatics > 5 ppb is unlikely to be present in the water column or on shorelines at any time in the diesel and pipeline rupture scenarios.

- Surface oil > 1 g/m² is also unlikely to contact any shorelines during any season as a result of the diesel and pipeline rupture scenarios.

- A 1% probability of contact by entrained oil > 10 ppb is predicted at Ningaloo Coast during spring in the 80 m^3 diesel scenario. Entrained oil > 10 ppb was not forecast to contact any shorelines in the 2.5 m^3 scenario.

- For both pipeline rupture scenarios, probabilities < 30% were indicated for surface oil > 1 g/m² to occur in surface waters. The 1% probability contour does not extend further than 300 km from the release site during each of the seasons.

- Entrained oil is predicted to drift towards the south-southwest to southwest in both pipeline scenarios during all seasons. Drift towards the north-northwest is also likely for the Chandon Manifold rupture (summer, winter and spring) and for the Jansz PTS rupture (winter and spring).

- For the Chandon Manifold rupture, a 1% probability for shoreline contact by entrained oil > 10 ppb is forecast for Ningaloo Coast during spring, with an earliest time to shoreline of 13 days, indicating that the entrained oil is likely to have lost highly soluble components. A 1% probability is also predicted for this shoreline during summer in the Jansz PTS rupture scenario, with a minimum time to shoreline of 12 days. No other shorelines are predicted to be contacted.

- Maximum short-term concentrations along Ningaloo Coast could potentially reach 60 ppb from a rupture of the Chandon Manifold and 25 ppb from a rupture of the Jansz PTS during spring and summer respectively.

- For the 11 week blowout scenario, there is a low probability of surface oil > 10 g/m² in waters around the blowout in any season. Surface oil of > 1 g/m^2 is likely to travel with trajectories to the southwest or northwest for blowouts commencing in summer or winter, though almost any direction is possible. Drift is most likely to be towards the northeast or west-southwest in the autumn scenario and towards the north-northwest for the spring scenario, with shorter trajectories to the south-southwest also possible in spring. For all seasons there is a low probability (<20%) of surface oil > 1 g/m^2 travelling more than 300 km from the blowout site.

- A maximum probability of 3% was forecasted for shoreline contact by surface oil > 1 g/m² along shorelines of Ningaloo Coast during the winter scenario, with an earliest arrival time of 29 days, indicating that the oil is likely to be composed of highly weathered wax components. No other shoreline contact by surface oil > 1 g/m² is likely.

- Maximum short-term surface concentrations were calculated to be low for all locations, with the highest being Murion Islands in summer (60 g/m²) and spring (47 g/m²). Short-term concentrations are also forecasted for Ningaloo Coast during winter (26 g/m²) autumn (33 g/m²) and summer (43 g/m²) and Southern Island Group during spring (13 g/m²).

- For the blowout scenario, entrained oil > 10 ppb is highly likely to be transported to the south-southwest to southwest for all of seasons. Likely transport to the west and north were also indicated for winter. Shorter trajectories to the west and northwest (summer) to the north (spring) were also forecast to be highly likely.

- A highest probability of 70% was predicted for entrained oil > 10 ppb to reach waters bordering the Ningaloo Coast in the autumn scenario, with a minimum time to shoreline of 11 days. Lower probabilities were predicted for this shoreline for the summer (40%), winter (36%) and spring (50%) scenarios. Earliest times for shoreline contact were calculated to be 10 days for each of these three seasons.

- During each of the seasons, the potential for contact at > 10 ppb was indicated for the Muiron Islands and Southern Island Group at probabilities of 23 – 46% and 16 – 43%, respectively.
- For contact by entrained oil > 100 ppb, highest probabilities were calculated for the Muiron Islands (43%) and Ningaloo Coast (36%) during spring. These probabilities were reduced to 23% for each shoreline for contact above 500 ppb.
- Highest potential short-term entrained oil concentrations forecast at Ningaloo Coast were 2.9 ppm in spring and 2 ppm in summer. Potential concentrations at the Muiron Islands were forecasted as highest during for spring (2.2 ppm), while highest concentrations at the Southern Island Group were forecasted for winter (2.1 ppm).
- Modelling forecasts aromatics > 5 ppb are most likely to occur in a small region immediately to the east of the blowout location for each of the seasons.
- Probabilities for shoreline contact by aromatics > 5 ppb are forecasted at 23% for Ningaloo Coast, Muiron Islands and Southern Island Group in the spring scenario, with a maximum short-term concentration of 30 ppb along Ningaloo Coast.
- No sedimentation of residual condensate or diesel was indicated by the modelling for any season.

1 INTRODUCTION

Asia-Pacific ASA (APASA) undertook a quantitative hydrocarbon spill risk assessment for the Gorgon Gas Development Fourth Train Proposal to inform the assessment of potential for environmental impacts. Chevron Australia Pty Ltd (Chevron Australia) identified five hydrocarbon spill scenarios for investigation:

1. A 2.5 m³ spill of diesel onto the water surface occurring over a few minutes at the Chandon Well location.

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4. A sub-surface release of condensate and gas, at 1,346 m depth, resulting from a pipeline rupture at the Jansz Pipeline Termination Structure (PTS) location, yielding a total discharge of 200 m³ of condensate over 3 hours (66.7 m^3/hr).

5. An uncontrolled sub-surface blowout of condensate and gas, at 1,200 m depth, from the Chandon Well location that persists for 11 weeks, releasing condensate at a constant rate of 2,349 bbl/d (373.6 m³/d or 15.57 m^3/d), yielding a total condensate discharge of approximately 180,873 bbl (28,756.5 m³).

APASA modelled two diesel spill scenarios and a sub-surface blowout scenario at the Chandon Well location; approximately 170 km northwest of the Montebello Islands (Figure 1-1, Table 1-1). Modelling was also carried out for two pipeline ruptures: one at the Chandon Manifold, situated in the same location as the Chandon Well and at the Jansz PTS, approximately 128 km northwest of Barrow Island (Figure 1-1, Table 1-1).

Table 1-1: Spill modelling locations

Location	Coordinates	Depth (m)
Chandon Well	114.1281º E -19.5756º S	1,200
Chandon Manifold	114.1281º E -19.5756º S	1,200
Jansz PTS	114.6073º E -19.8094º S	1,346

Specifications for the diesel oil were drawn from standard database information (ADIOS database, undated), while Chevron Australia provided detailed assay information for Chandon Condensate for the relevant releases.

Oil spill modelling was undertaken using a three-dimensional oil spill trajectory and weathering model, SIMAP (Spill Impact Mapping and Analysis Program), which is designed to simulate the transport, spreading and weathering of specific oil types under the influence of changing meteorological and oceanographic forces.

The model simulates both surface and sub-surface releases and uses the unique physical and chemical properties of an oil type to calculate rates of evaporation and viscosity change, including the tendency to form oil in water emulsions. Moreover, the unique transport and dispersion of surface slicks and in-water components (entrained and dissolved) are modelled separately. Thus, the model can be used to understand the wider potential consequences of a spill, including direct contact to slick oil for surface features and exposure to entrained and dissolved oil for organisms in the water column.

A stochastic modelling scheme was followed in this study, whereby SIMAP was applied to repeatedly simulate the defined spill scenarios using different samples of current and wind data. These data samples were selected randomly from a historic time-series of wind and current data representative of the study area. Results of the repeated simulations were then statistically analysed and mapped to define contours of risk around the release point.

For this purpose, a long-term archive of spatially-variable wind and current data was assembled that spans 5 years (2005 to 2009, inclusive). Current patterns accounted for temporal and spatial variations in large-scale drift currents, which have largest magnitudes over the outer shelf waters (typically >200 m depth) together with tidal and wind-driven currents. Modelling was carried out using current and wind data sampled from the data archive for periods corresponding to the summer months (November to March), autumn transitional month (April), winter months (May to September) and spring transition month (October) to quantify risks of contact at surrounding locations during each season (Table 1-2).

It is important to note that the modelling results presented in this document relate to the predicted outcomes once a spill event has occurred. The primary risk related to each event is not considered, and therefore the results should be viewed as a guide to the possible outcomes should an event occur. For example, a result suggesting that a certain location has a 90% probability of contact at a particular threshold may seem highly likely; however, when the primary risk of the event is included in the assessment, such an outcome may be considered extremely unlikely. Furthermore, the result maps presented herein do not represent the predicted coverage of a hydrocarbon slick or plume at any particular instant in time. Rather, the results are integrated over the duration of numerous replicates of each scenario, with each replicate simulation influenced by a different set of prevailing conditions. The resulting contours will therefore cover a larger area than any one single spill event. The contours should therefore be judged as contours of probability.

Table 1-2: Spill scenarios modelled in this risk assessment

Oil Type	Amount of oil spilled	Location	Depth of release	Duration of spill	Duration of simulations	Season
Diesel	2.5 m³	Chandon Well	Surface	Instantaneous	7 days	Summer
						Autumn Transition
						Winter
						Spring Transition
Diesel	80 m³	Chandon Well	Surface	6 hours	14 days	Summer
						Autumn Transition
						Winter
						Spring Transition
Chandon Condensate	200 m³	Chandon Manifold	1,200 m	3 hours	14 days	Summer
						Autumn Transition
						Winter
						Spring Transition
Chandon Condensate	200 m³	Jansz PTS	1,346 m	3 hours	14 days	Summer
						Autumn Transition
						Winter
						Spring Transition
Chandon Condensate	180,873 bbl	Chandon Well	1,200 m	1,848 hours (77 days)	91 days	Summer
						Autumn Transition
						Winter
						Spring Transition

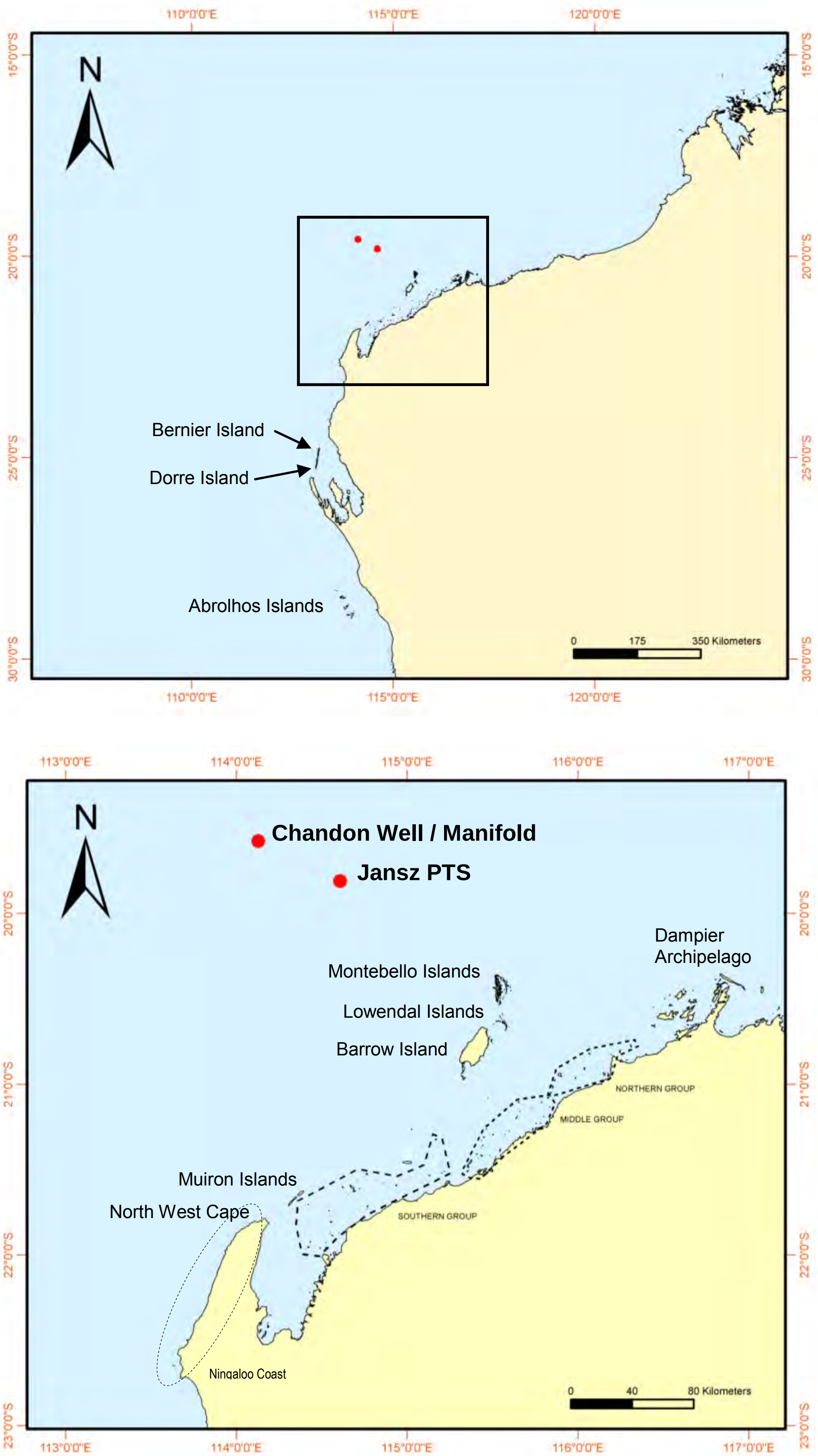


Figure 1-1: Location of the spill sites and the surrounding major geographic features of the North West Shelf of Western Australia. The dotted lines enclose groups of inshore islands and the Ningaloo Coast referred to in the study results and conclusions.

1.1 Terms and Abbreviations

- *Degradation* - the bacterial metabolism or photochemical breakdown of oil components from their long carbon chain form into simpler and biologically inert forms.
- *Dissolution* – the process whereby soluble components of an oil mixture dissolve into the water column to form a hydrocarbon solution. Because dissolution requires migration of the soluble oil compounds across an oil-water interface, the rate of dissolution will be greater where there is a greater surface area to volume ratio. Thus, the rate of dissolution will be faster from entrained droplets than from surface-bound slicks.
- *Entrained oil* – droplets or globules of oil that are physically mixed (but not dissolved) into the water column. Physical entrainment can occur either during pressurised release from a sub-surface location, or through the action of breaking waves.
- *Evaporation* – the process whereby components of the oil mixture are transferred from the sea surface to the atmosphere.
- *Sedimentation* – the process whereby oil droplets sink and adhere to the seabed. The specific gravity of most oil types is lower than marine water. Hence, oil will typically be buoyant. However, sedimentation of some oil types can occur after the evaporation of low molecular weight components, if the residual density is lower than ambient seawater. The adhesion of oil to suspended sediment particles is another mechanism for sedimentation of oil.
- *Stranding* - the process whereby oil slicks or films adhere to coastlines. Stranding is a dynamic process that is affected and limited by the viscosity of the oil and the absorbance of the coastline (e.g. sand versus rock). A proportion of the oil may subsequently resurface and be transported away by currents.
- *Surface bound oil* – oil that remains bound to the surface as a slick or film due to buoyancy and surface tension.

2 MODELLING METHODS

The spill modelling was carried out using a purpose-developed oil spill trajectory and fates model, SIMAP (Spill Impact Mapping and Assessment Program). This model is designed to simulate the transport and weathering processes that affect the outcomes of hydrocarbon spills to the sea and accounts for the specific oil type, spill situation and prevailing wind and current patterns. The SIMAP model is a three dimensional spill model and considers the fate of oil while on the surface and in the water column, in either entrained or dissolved form.

A stochastic modelling approach was applied to gain quantitative estimates of exposure risk for the different spill scenarios under investigation. This involves repeated simulation of each scenario using different samples of metocean conditions each time. These samples of time-varying conditions are selected randomly (and therefore objectively) from a database of historic current and wind data for the study area. The stochastic sampling approach provides an objective measure of the possible outcomes of a spill because environmental conditions will be selected at a rate that is proportional to the likelihood that these conditions would occur for the area. The most commonly occurring conditions would be selected most often, while more unusual conditions will be represented less frequently.

2.1 Description of the models

2.1.1 OILMAPDEEP

Modelling an oil and gas blowout plume can be separated into two phases, near-field and far-field, analogous to a traditional thermal plume modelling exercise. The near-field behaviour of multi-phase hydrocarbon plumes released during subsea blowouts is complex, and is an on-going and active field of research; however, the science is currently at a phase where accurate predictions of plume behaviour can be made.

ASA developed a near-field blowout model, OILMAPDEEP, which is based on the work of McDougall (gas plume model, 1978), Fanneløp and Sjøen (1980a, plume/free surface interaction), Spaulding (1982, oil concentration model), Kolluru, (1993, World Oil Spill Model implementation) and Spaulding et.al. (2000, hydrate formation). A simplified integral jet theory is employed for the vertical as well as for the horizontal motions of the gas-oil plume. The necessary model parameters defining the rates of entrainment and spreading of the jet are obtained from laboratory studies (Fanneløp and Sjøen 1980a). The gas plume analysis is described in McDougall (1978), Spaulding (1982), and Fanneløp and Sjøen (1980a). The hydrate formation and dissociation is formulated based on a unique equilibrium kinetics model developed by R. Bishnoi and colleagues at the University of Calgary. A brief description of the governing equations used in ASA‟s blowout model and the solution methodology are described in Spaulding et al (2000).

The results of the near-field blowout model provide information to the far field fates model about the plume (the three dimensional extent of the mixture of gas/oil/water) and a characterization of the initial dispersion / mixing of the oil discharged during the blowout. Key factors in this analysis are the volume flux of oil and gas, gas to oil ratio (GOR), depth, exit flow velocity and environmental water column conditions (the profile of water temperature and density) which affect both the trap height and the potential for hydrate formation. Other factors such as duration of the blowout and ambient currents are also included but are less important.

The OILMAP Deep blowout model implementation is done in two parts; the first is the plume model, based on the McDougall bubble plume model; the second is the oil droplet size distribution and volume fraction calculation. While they are based on the same discharge scenario specifications (e.g. oil type and flow rate, gas to oil ratio, oil temperature and release depth and pressure), the model predictions are treated separately and do not interact. The two parts of the model predictions only come together at the collapse of the near field plume, at the trap height, where the depth and droplet distribution predictions are used for initialization of the far field particle model simulation.

The plume model prediction is defined by a set of parameters:

- Blowout release depth
- Oil discharge rate
- Oil density
- Gas : oil ratio (GOR) at the source
- Atmospheric pressure
- Ambient seawater density profile
- Plume spreading coefficient (λ)
- Entrainment parameter (α)
- Slip velocity of gas bubbles in the oil plume
- Ambient current velocity

The blowout model predictions for oil droplet size-distribution is based on the CDOG model (Yapa & Zheng, 2001b) which uses a maximum diameter calculation and the Rosin-Rammler (1933) log normal distribution curve to specify the overall droplet size distribution by volume.

The oil droplet size distribution is defined by a sub-set of input parameters:

- Release depth
- Oil discharge rate
- Gas : oil ratio (GOR) at the surface, used to calculate GOR at depth
- Pipe opening diameter
- Blowout jet temperature
- Ambient salinity (used with jet temp for density calculation)

More detail on the OILMAPDEEP model, including the governing equations, can be found in the OILMAPDEEP Technical Manual (ASA 2011).

2.1.2 SIMAP

SIMAP is an evolution of the US EPA Natural Resource Damage Assessment model (French & Rines 1997; French 1998; French *et al*. 1999) and is designed to simulate the fate and effects of spilled oils and fuels for both the surface slick and the three-dimensional plume that is generated in the water column. SIMAP includes algorithms to account for both physical transport and weathering processes. The latter are important for accounting for the partitioning of the spilled mass over time between the water surface (surface slick), water column (entrained oil and dissolved compounds), atmosphere (evaporated compounds) and land (stranded oil). The model also accounts for the interaction between weathering and transport processes.

The physical transport algorithms calculate transport and spreading by physical forces, including surface tension, gravity and wind and current forces for both surface slicks and oil within the water column. The fates algorithms calculate all of the weathering processes known to be important for oil spilled to marine waters. These include droplet and slick formation, entrainment by wave action, emulsification, dissolution of soluble components, sedimentation, evaporation, bacterial and photo-chemical decay and shoreline interactions. These algorithms account for the specific oil type being considered.

Evaporation rates vary over space and time dependent on the prevailing sea temperatures, wind and current speeds, the surface area of the slicks that are exposed to the atmosphere as well as the state of weathering of the oil. Evaporation rates will decrease over time, depending on the calculated rate of loss of the more volatile compounds. By this process, the model can differentiate between the fates of different oil types under different conditions.

Entrainment, dissolution and emulsification rates are correlated to wave energy, which is accounted for by estimating wave heights from the sustained wind speed, direction and fetch (i.e. distance downwind from land barriers) at different locations in the domain. Dissolution rates are dependent upon the proportion of soluble, short-chained, hydrocarbon compounds, and the surface area at the oil/water interface of slicks. Dissolution rates are also strongly affected by the level of turbulence. For example, they will be relatively high at the site of the release for a deep-sea discharge at high pressure. In contrast, the release of hydrocarbons onto the water surface will not generate high concentrations of soluble compounds. However, subsequent wave action will enhance dissolution from surface slicks. Because the compounds that have high solubility also have high volatility, the processes of evaporation and dissolution will be in dynamic competition.

Sedimentation of oil is calculated if the oil density is calculated to exceed the ambient water density (a function of the temperature and salinity profile), either through a change in the oil density by weathering or adherence of sediment to the oil, with the latter process based on a specified suspended sediment load for the water column and assuming random encounter of the oil and sediment particles. Sedimenting particles will sink over time (based on the relative density and allowing for water viscosity) and will be transported by the prevailing current.

Technical descriptions of the algorithms used in SIMAP and validations against real spill events are provided in e.g. French & Rines (1997), French *et al*. (1999, 2001, 2009) and French-McCay (1998, 2010, 2011).

Input specifications for oil types include the density, viscosity, pour-point, distillation curve (volume of oil distilled off versus temperature) and the aromatic/aliphatic component ratios within given boiling point ranges. The model was applied in this study to calculate the distribution of oil mass over time for the following components:

- Surface bound oil
- Entrained oil (non-dissolved oil droplets that are physically entrained by wave action)
- Dissolved hydrocarbons (principally the aromatic and short-chained aliphatic compounds)
- Evaporated hydrocarbons
- Sedimented hydrocarbons
- Decayed hydrocarbons.

Accounting for all of these components is important for predicting the rate of change of the mass that remains on the water surface or in the water column, but mapping of the spatial distribution of the evaporated component or the decayed (biodegraded) component was not commissioned for this study (due to the stated aim of calculating distributions of oil on or in the water column), hence are not reported. Sedimentation of hydrocarbons is reported, with all sedimentation found to be restricted to intertidal zones (shorelines) for the specific oil types and situations specific to this study.

Due to the subsurface release scenarios that are being investigated in this study, condensate will initially be entrained in the water column and must float to the surface before atmospheric weathering can occur. SIMAP used specifications of the depth of release, droplet size distribution of the discharged oil, and dimensions of the associated gas cloud to calculate the surfacing of oil from subsurface locations. The droplet size distributions and gas cloud dimensions were modelled using a specifically designed oil/gas blowout model (OILMAP-deep). The OILMAP-deep model uses information on the discharge rate, gas/oil ratio, hole-size, oil temperature and the vertical temperature and salinity profile of the water column.

High pressure releases (such as a pipeline rupture) tend to generate a distribution with a median size of ~ 300 µm or less (SINTEF 2003). Due to their larger surface area to volume ratio, droplets in this size range will rise more slowly than larger droplets (for example, generated by a slow leak) and may drift further underwater before surfacing. This delayed rise has several implications for the weathering rates of slicks. For example, the slick area will tend to increase and the slick thickness will tend to be reduced. Weathering time can be extended and the dissolution of soluble compounds (such as BTEX and PAH aromatic compounds) will be more rapid if smaller droplets are produced.

The stochastic model within SIMAP performs a large number of simulations for a given spill site, randomly varying the spill time for each simulation. The model uses the spill time to select samples of current and wind data from a long time-series of wind and current data for the area. Hence, the transport and weathering of each slick will be subject to a different sample of wind and current conditions. During each simulation, the model records the grid cells (by horizontal and depth location) that were contacted by oil, as well as the amount of time that had elapsed prior to the contact or exposure. Note that the oil slick or plume may be present at a sub-grid scale in the model, and the model grid is used only as a means of accumulating contacts or information for concentration statistics.

Once the stochastic modelling was completed, the results were compiled from each of the sample trajectories to provide a statistical weighting to the likelihood of exposure for a given location. Results are summarised as:

1. Probability of exposure to locations at the water surface and shorelines, for slicks exceeding a defined threshold concentration;
2. Probability of exposure to locations from entrained oil for in-water concentrations exceeding a defined threshold concentration;
3. Probability of exposure to locations from dissolved aromatic hydrocarbons for in-water concentrations exceeding a defined threshold concentration;
4. Potential concentrations that could arrive on defined sections of shoreline and emergent reefs.

The first three estimates are calculated from the frequency of exposure (> threshold) during all simulations. The latter estimate is the highest concentration in any simulation.

As noted earlier, predictions of individual slicks or plumes at specific times are not presented in this report. All of the result maps show results that are integrated across all relevant simulations for each scenario. Consequently the region of potential exposure will be much larger than the outcome of any single event.

2.2 Inputs to the risk assessment

2.2.1 Current Data

The area of interest for this study experiences strong tidal flows over the shallower regions, particularly among the inshore islands and along the coast of the North West Shelf. Further offshore to the north-west and north, where the water depths exceed 100 - 200 m, significant drift currents are a persistent feature of the circulation. These drift currents can be relatively strong (1-2 knots) and complex, represented as a series of interconnected eddies and connecting flows. These offshore drift currents also tend to persist longer (days to weeks) than tidal current flows (hours between reversals) and thus will have greater influence upon the net trajectory of slicks over time scales exceeding a few hours.

Wind shear on the water surface also generates local-scale currents that can persist for extended periods (multiple hours to days) and result in long trajectories. Hence, the current-induced transport of oil can be variably affected by combinations of tidal, wind-induced and density-induced drift currents. Depending on their local influence, it is critical to consider all these potential advective mechanisms to rigorously understand patterns of potential transport from a given spill location.

To appropriately allow for temporal and spatial variation in the current field, the spill modelling requires the current speed and direction over a spatial grid covering the potential migration of oil. As measured current data is not available for simultaneous periods over a network of locations covering the wider area of this study, the analysis relied upon hindcasts of the circulation which were generated by numerical modelling. Estimates of the net currents were derived by combining predictions of the drift currents, which were available from meso-scale ocean models, with estimates of the tidal currents generated by a model set up for the study area by APASA.

Representation of the drift currents that affect the wider area of the study were available from the output of a global ocean model, named HYCOM (Hybrid Coordinate Ocean Model, see Wallcraft *et al*. 2003), which is operated by the HYCOM Consortium, sponsored by the Global Ocean Data Assimilation Experiment (GODAE). HYCOM is a data-assimilative, three-dimensional ocean model that is run as a hindcast (i.e. for a past period), assimilating time-varying observations of sea-surface height, sea-surface temperature and in-situ temperature and salinity measurements (Chassignet *et al*. 2009). The HYCOM predictions for drift currents are produced at a horizontal spatial resolution of approximately 8.25 km over the region, at a frequency of once per day. Hence, the HYCOM model data provides estimates of meso-scale circulation, with horizontal resolution suitable to resolve eddies of a few 10‟s of kilometres diameter, as well as connecting stream currents of similar spatial scale.

The HYCOM model data was selected for this study because previous investigations (e.g. Brushett *et al.* 2011) indicated that HYCOM was producing more accurate predictions of surface currents than other alternative data sources. Critically, the current data was available for the study area for multiple years, providing for inter-annual variations and the wind data that was used to generate the HYCOM predictions were available for use in the study (see wind data description), providing some consistency in the spill modelling phase of the study. HYCOM data for the period 2005 to 2009 inclusive was sourced for this study after an assessment of trends in the available data with respect to the Southern Oscillation Index (SOI), which gives an indication of the development and intensity of El Niño or La Niña events in the Pacific Ocean and may effect temperature and other gradients in the Indian Ocean. The SOI is calculated using the pressure differences between Tahiti and Darwin. The data was also assessed over longer periods of time (inter-decadal). The chosen period covers positive and negative Southern Oscillation Indexes and there is no evidence of trends that indicate climate change compared to more recent years (as of December 2011). Hence, the data set was assumed to be indicative of the current patterns and magnitudes that should occur over the near future (years).

An example of the variability in currents that is represented by this data for the study region at one point in time (24th March 2006) is shown in Figure 2-1. The image demonstrates the complexity and relatively large magnitudes of the drift current flows over the region deeper than the inner shelf waters (> 100 m typically), which are generated by density and sea height gradient driven flows interacting with the bathymetry. Drift currents that are represented over the inner shelf waters in the HYCOM data are principally due to wind induced drift.

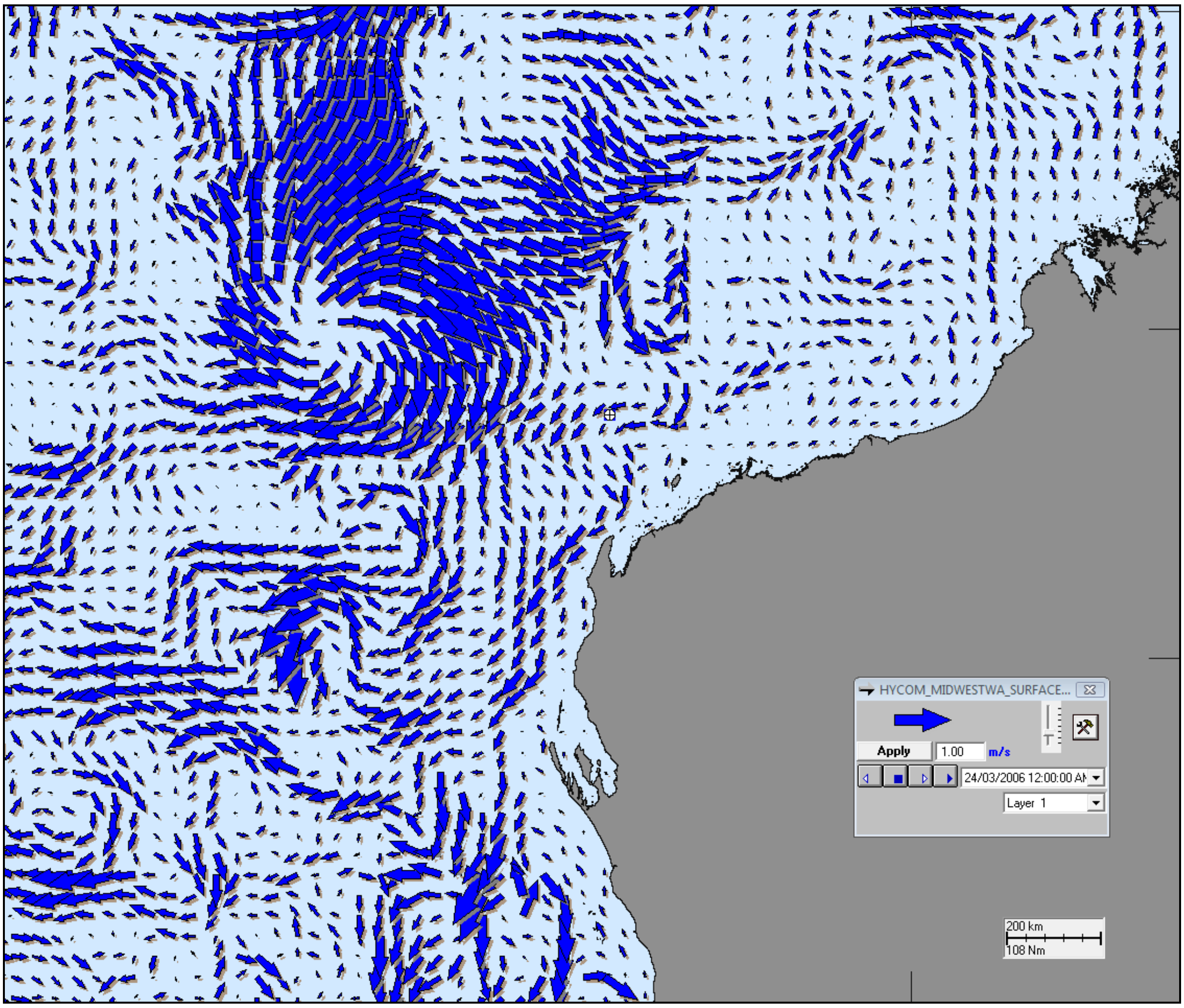


Figure 2-1: Example of the spatial variability in current patterns affecting the study area. (data from HYCOM model analysis, 24th March 2006 0000 GMT). Current direction is indicated by the arrow head. Relative magnitude is indicated by the arrow size. Note the gyres and circular flow patterns.

Extracts from the combined current data set have been made at the modelled spill locations, to provide an insight into the expected early behaviour of any released oil due to prevailing currents alone. Seasonal current roses derived from the data are presented for the Chandon Well and Manifold location (Figure 2-2) and for the Jansz PTS location (Figure 2-3). The roses for the Chandon location show the clear predominance of south westerly flowing currents during transitional autumn, with strongest speeds also recorded during this period. During summer, current directions are most commonly towards the west-southwest with drift towards the west-northwest, southwest and south also probable. Drift towards the west-southwest is also most likely during winter months, with drift towards the north-northwest and south to south-southeast also likely. During the spring transition, current directions are more variable, although the majority of flow is towards the northeastern sector.

At the Jansz PTS location, current directions are less variable and speeds are generally stronger. Drift to the southwest to west-southwest is most likely during each of the seasons, with strongest speeds occurring during transitional autumn and summer. During transitional spring there is also a low probability of drift to the north-northeast.

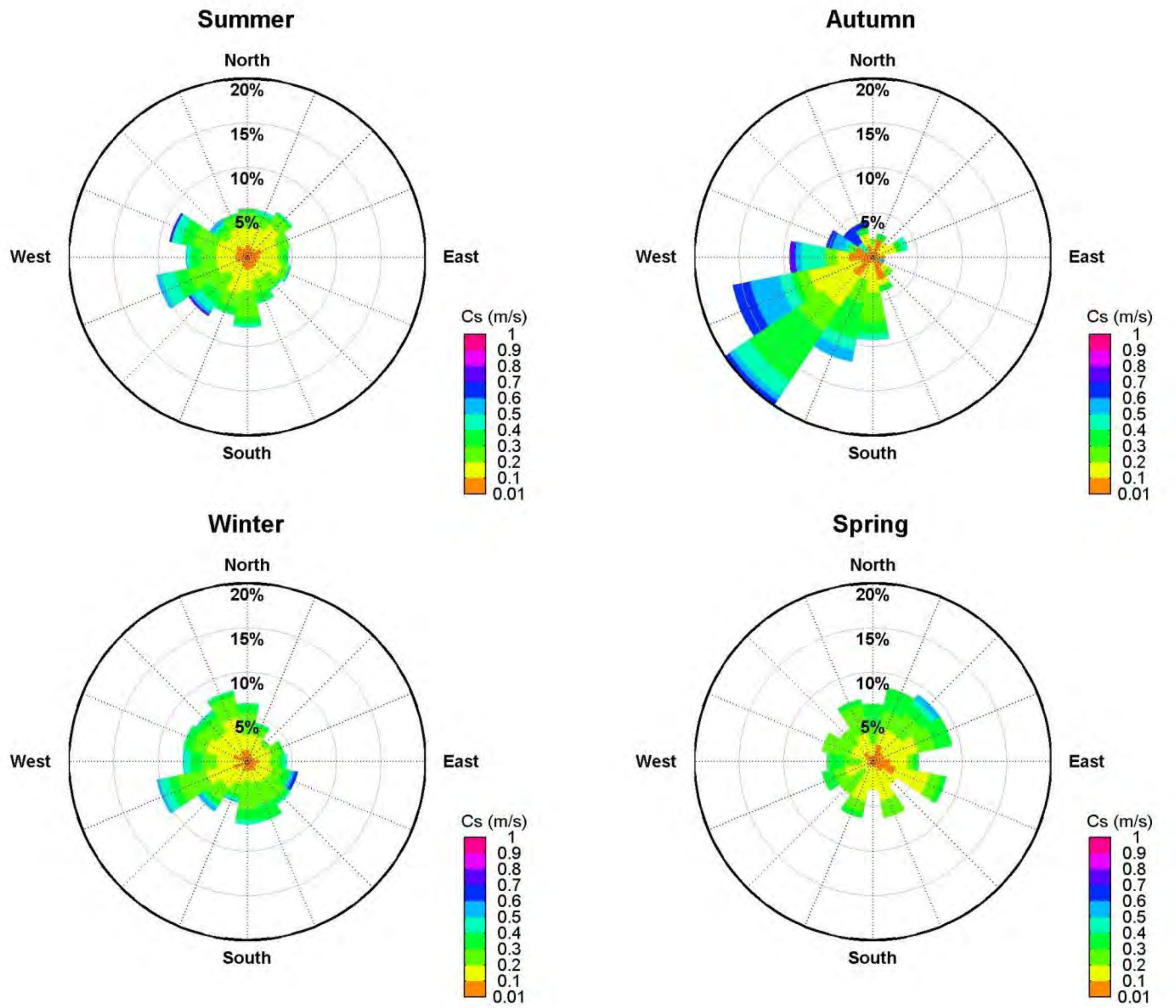


Figure 2-2: Seasonal current roses derived from the HYCOM data set for Chandon Well (-19.58°S, 114.13°E). The colour key shows the current magnitude, the compass direction provides the direction TOWARDS and the length of the wedge gives the percentage of the record for a particular speed and direction combination.

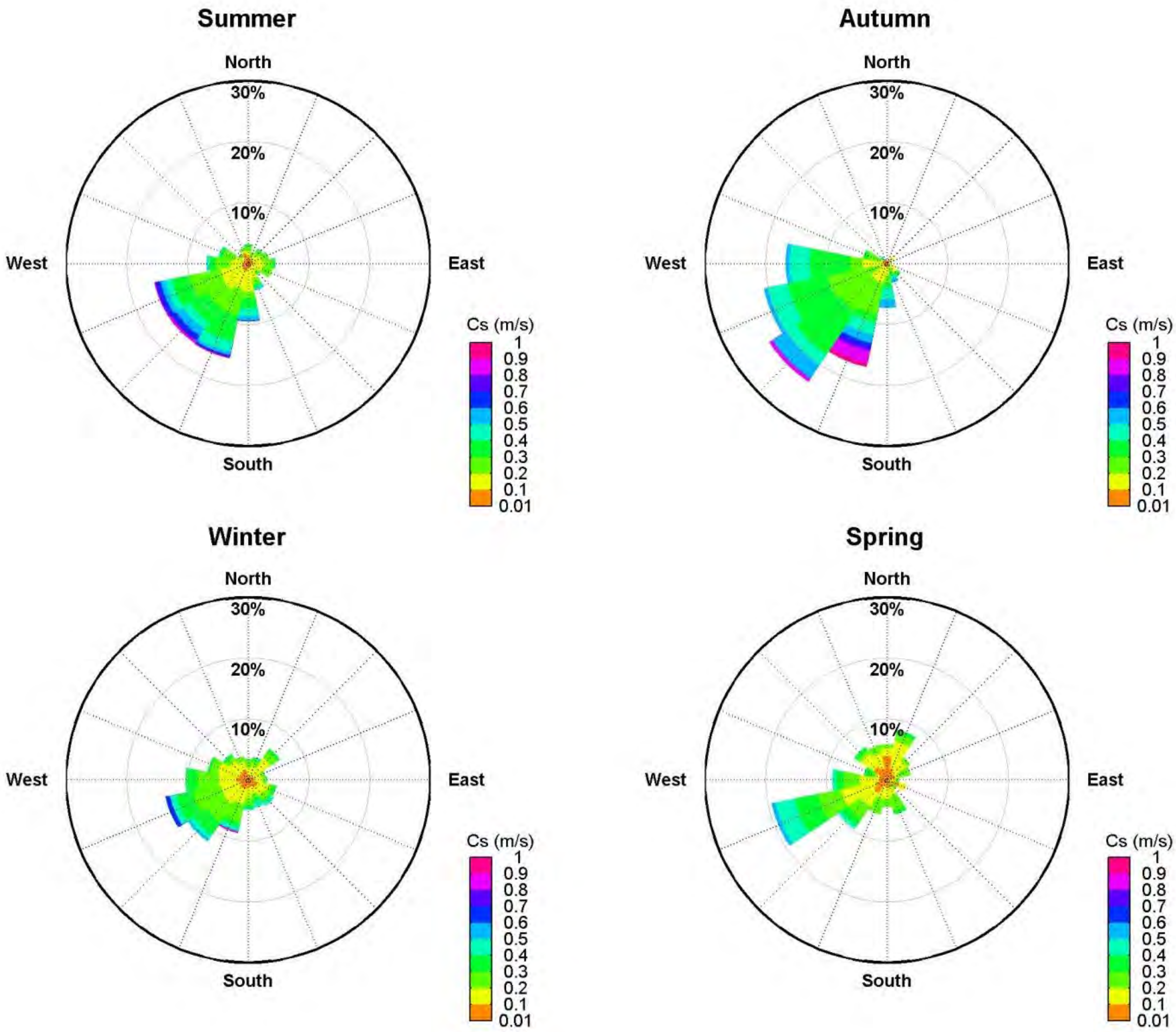


Figure 2-3: Seasonal current roses derived from the HYCOM data set for Jansz PTS (-19.81°S, 114.61°E). The colour key shows the current magnitude, the compass direction provides the direction TOWARDS and the length of the wedge gives the percentage of the record for a particular speed and direction combination.

As the HYCOM model does not include tidal forcing, and because the data is only available at a daily frequency, a tidal model was developed for the study region using a three-dimensional hydrodynamic model, HYDROMAP. The model formulations and output (current speed, direction and sea level) of this model have been validated through field measurements around the world for more than 20 years (Isaji and Spaulding, 1984; Isaji *et al.*, 2001; Zigic *et al.*, 2003). HYDROMAP current data has also been widely used as input to forecasts and hindcasts of oil spill migrations in Australian waters. This modelling system forms part of the Australian National oil spill emergency response system operated by Australian Maritime Safety Authority. The model is also the hydrodynamic engine used by the Western Australian marine search and rescue system (WA Police).

HYDROMAP, set up as a tidal model, simulates the flow of ocean currents within a model region due to forcing by astronomical tides and bottom friction for any location on the globe. The model employs a sophisticated nested-grid strategy, supporting up to six levels of dynamic spatial resolution. This allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, or of particular interest to a study.

The numerical solution methodology follows that of Davies (1977 a, b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji and Spaulding (1984). Estimates for the combined current (drift current plus tidal current) was then calculated, as a function of time, by vector addition.

HYDROMAP was set up over a domain that extended 2,000 km (east – west) by 1,600 km (north - south; Figure 2-4) and covered an area of 1,650,354 km^2. The model covers the section of the Western Australian coastline from Sunday Island (200 km north of Broome) to the north to Jurien Bay to the south.

Four levels of sub-gridding were applied to the model domain to increase the resolution over the coastal region. The resolution of the primary level was set at 8 km. The second, third and fourth levels were defined by subdividing the primary level grid cells into 4, 16 and 64 grid cells respectively. Thus, these grid cells had resolutions of 4 km, 2 km and 1 km respectively. The finer grids were allocated in a step-wise fashion to areas where higher resolution of circulation patterns was required to resolve flows through channels, around shorelines or over more complex bathymetry. Approximately 46,000 cells were used to define the region.

Bathymetric data used to define the three-dimensional shape of the study domain was extracted from the CMAP electronic chart database, which provided a collation of bathymetric data supplied by the Australian Hydrographic Office, including high resolution data in the shallow regions bordering shorelines and over shoals. Depths in the domain ranged from shallow areas that would periodically dry during low tide through to more than 6,000 m in the offshore marine area.

Tidal forcing data, in the form of tidal amplitudes and phases for the eight largest tidal constituents for the study region (K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1) were extracted for the tidal boundaries of the model from the Topex Poseidon global tidal database, which is produced from satellite altimeter data and quality controlled by the US National Atmospheric and Space

Agency. The eight largest constituents were chosen because, collectively, they represented > 95% of the tidal magnitudes.

For the purposes of verification of the tidal predictions, the model output was compared against independent predictions of tides, using the Xtide database. Overall, there are more than 40 locations within the model domain where the tidal constituents are known, however some of these are located in areas that were not sufficient resolved by this large scale ocean model. However, more than 30 stations along the coastline were suitable for comparison of the model performance with the observed data. These stations covered the full extent of the modelled coastline (see Figure 2-4).

The comparison data is summarised in Table 2-1 and time-series comparisons for 10 of the stations are shown in Figure 2-5, for the period of January 2005. All comparisons show that the model is producing an excellent match to the known tidal behaviour for a wide range of tidal amplitudes and is clearly representing the varying diurnal and semi-diurnal nature of the tidal signal. The performance for all comparison stations was also evaluated through a comparison of the predicted and observed tidal constituents, derived from an analysis of the model predictions at each location. Figure 2-6 shows the results graphically for the amplitude (top) and phase (bottom) of the five dominant tidal constituents. The red line on each plot shows the 1:1 line, which would indicate a perfect match between the modelled and observed data. Note that the data is closely aligned to the 1:1 line demonstrating the very good model performance.

Estimates of the combined current, due to both drift and tide-induced circulation were derived by vector addition dynamically within the oil spill trajectory model.

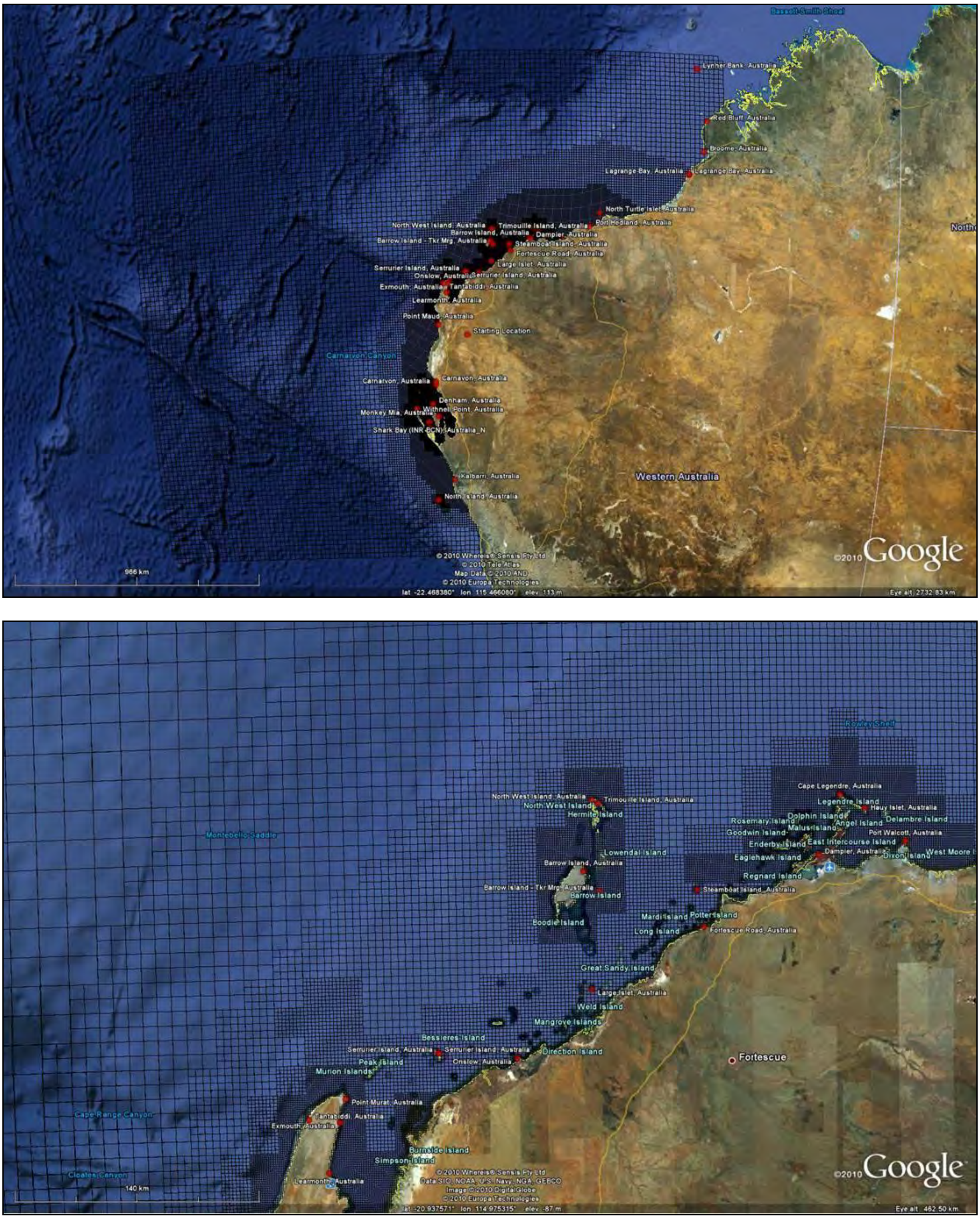


Figure 2-4: Hydrodynamic model grid (black wire mesh) used to generate the tidal currents overlain on Google Earth imagery showing locations available for tidal comparisons (red labelled dots). Top panel shows the full domain in context with the continental land mass, while the bottom panel shows a zoomed subset near the blowout location. Higher resolution areas are shown by the denser mesh zones.

Table 2-1 Comparison of modelled coastal tidal constituents to observed data at relevant stations

			Constituent:	M2		S2		K1		O1		N2	
Station Name	**Longitude**	**Latitude**	**Source**	**Amp. (m)**	**Phase (°)**	**Amp. (m)**	**Phase (°)**	**Amp. (m)**	**Phase (°)**	**Amp. (m)**	**Phase (°)**	**Amp. (m)**	**Phase (°)**
Barrow Island - Tkr Mrg	115.5500	-20.8167	Obs.	1.03	314.5	0.62	26.1	0.22	298.5	0.16	274.9	0.17	284.4
			Mod.	1.02	320.1	0.53	51.1	0.26	308.2	0.14	285.0	0.17	288.3
Barrow Island	115.4667	-20.7167	Obs.	0.80	307.6	0.44	19.2	0.22	297.0	0.14	275.2	0.13	278.0
			Mod.	0.79	310.6	0.40	40.3	0.24	304.6	0.12	283.1	0.13	277.7
Broome	122.2167	-18.0000	Obs.	2.37	297.8	1.48	5.7	0.26	292.5	0.16	273.2	0.41	268.8
			Mod.	2.55	297.3	1.36	24.1	0.29	298.3	0.15	278.7	0.40	269.3
Cape Legendre	116.8333	-20.3500	Obs.	1.13	302.0	0.62	9.4	0.25	287.1	0.15	274.4	0.24	272.0
			Mod.	1.17	303.9	0.59	30.4	0.26	300.6	0.13	278.9	0.19	271.4
Carnarvon	113.6500	-24.8667	Obs.	0.32	306.8	0.14	14.5	0.22	293.6	0.14	276.3	0.06	281.0
			Mod.	0.23	294.0	0.10	28.9	0.23	300.7	0.13	280.7	0.05	264.5
Carnavon (2)	113.6500	-24.7833	Obs.	0.28	303.0	0.15	13.0	0.17	296.0	0.19	278.0	0.06	271.0
			Mod.	0.23	288.8	0.10	23.5	0.23	298.9	0.12	279.0	0.05	259.0
Dampier	116.7167	-20.6500	Obs.	1.12	302.9	0.65	12.2	0.23	291.6	0.15	271.6	0.20	270.9
			Mod.	1.21	307.2	0.62	34.9	0.26	302.8	0.13	280.8	0.20	275.2
Denham	113.5333	-25.4333	Obs.	0.17	7.2	0.08	75.4	0.22	330.0	0.14	311.5	0.03	344.5
			Mod.	0.18	325.8	0.08	59.5	0.22	321.5	0.12	301.0	0.04	296.9
Depuch Island	117.7500	-20.6167	Obs.	1.50	309.2	0.95	14.8	0.25	287.8	0.16	271.9	0.23	292.0
			Mod.	1.69	313.1	0.88	42.6	0.28	305.5	0.14	283.1	0.27	282.5
Exmouth	114.1500	-21.9333	Obs.	0.57	310.1	0.30	24.2	0.21	296.6	0.14	278.4	0.10	280.9
			Mod.	0.51	314.4	0.25	50.3	0.23	307.6	0.12	286.0	0.09	280.7
Fortescue Road	116.1000	-21.0000	Obs.	1.10	318.0	0.60	28.0	0.20	294.0	0.10	280.0	0.21	280.5
			Mod.	1.17	316.1	0.61	46.4	0.27	306.8	0.14	283.8	0.19	284.8
Hauy Islet	116.9667	-20.4167	Obs.	1.26	309.9	0.71	17.1	0.22	288.6	0.14	266.3	0.23	287.2
			Mod.	1.29	306.6	0.65	33.6	0.27	301.5	0.13	278.8	0.21	274.3
Kalbarri	114.1667	-27.7000	Obs.	0.05	322.7	0.03	351.8	0.14	326.3	0.10	309.1	0.01	322.7
			Mod.	0.07	264.9	0.03	316.9	0.19	304.9	0.11	290.9	0.01	283.3
Lagrange Bay	121.7333	-18.7000	Obs.	2.42	296.0	1.47	358.0	0.23	274.0	0.13	277.0	0.47	262.8
			Mod.	2.61	299.4	1.40	26.9	0.29	299.0	0.15	279.5	0.40	271.3
Large Islet	115.5000	-21.3000	Obs.	0.91	321.0	0.53	33.0	0.20	290.0	0.15	280.0	0.18	282.4
			Mod.	0.87	324.7	0.46	57.7	0.25	310.1	0.14	286.9	0.14	292.9
Learmonth	114.0833	-22.1833	Obs.	0.66	312.0	0.36	24.0	0.19	292.0	0.14	281.0	0.10	282.0
			Mod.	0.62	321.6	0.30	59.9	0.24	311.0	0.13	289.2	0.10	288.9
Lynher Bank	122.0167	-15.4667	Obs.	1.37	300.9	0.94	15.0	0.21	312.6	0.14	270.1	0.28	263.2
			Mod.	1.45	295.2	0.70	16.5	0.27	297.4	0.13	276.7	0.24	265.6
Monkey Mia	113.7167	-25.8000	Obs.	0.38	6.9	0.17	77.1	0.23	320.1	0.16	297.1	0.07	345.7
			Mod.	0.15	8.2	0.06	100.4	0.23	346.6	0.13	326.9	0.03	336.4
North Island	113.6000	-28.3000	Obs.	0.07	287.7	0.04	312.2	0.17	301.4	0.12	285.9	0.01	310.0
			Mod.	0.06	264.5	0.03	313.3	0.19	305.3	0.10	289.7	0.01	294.7
North Turtle Islet	118.9000	-19.9000	Obs.	1.80	295.0	1.10	5.0	0.20	292.0	0.20	270.0	0.35	257.5
			Mod.	1.91	311.9	0.99	41.4	0.28	303.9	0.14	282.4	0.30	281.7
North West Island	115.5167	-20.3667	Obs.	0.64	328.7	0.48	30.6	0.15	299.2	0.14	287.2	0.10	311.0
			Mod.	0.65	300.1	0.32	27.0	0.23	300.4	0.12	276.8	0.11	266.5
Onslow	115.1000	-21.6333	Obs.	0.59	301.8	0.32	12.8	0.21	293.9	0.13	276.2	0.11	273.2
			Mod.	0.56	302.4	0.28	32.7	0.23	302.7	0.12	281.6	0.10	268.6
Point Maud	113.7833	-23.1167	Obs.	0.28	275.2	0.08	341.6	0.20	286.8	0.12	270.9	0.05	244.9
			Mod.	0.25	275.2	0.11	8.1	0.20	296.1	0.11	276.9	0.05	241.5
Point Murat	114.1833	-21.8167	Obs.	0.49	314.0	0.27	26.5	0.18	302.0	0.13	281.0	0.09	295.0
			Mod.	0.45	309.7	0.21	44.2	0.22	305.4	0.12	283.3	0.08	275.4
Port Hedland	118.5833	-20.3000	Obs.	1.70	305.6	1.04	14.6	0.24	293.1	0.15	273.1	0.30	275.7
			Mod.	1.90	315.6	0.99	45.8	0.28	306.3	0.15	284.6	0.30	285.5
Port Walcott	117.1833	-20.5833	Obs.	1.38	306.1	0.82	15.3	0.24	293.0	0.15	272.4	0.24	274.4
			Mod.	1.52	312.7	0.78	41.5	0.27	304.8	0.14	282.5	0.25	281.4
Red Bluff	122.3167	-17.0667	Obs.	1.90	311.4	1.33	15.4	0.20	290.8	0.19	249.3	0.20	287.4
			Mod.	2.15	300.3	1.11	24.9	0.28	299.6	0.14	279.6	0.34	272.1
Serrurier Island	114.6833	-21.6000	Obs.	0.48	290.0	0.26	5.0	0.18	288.0	0.12	269.0	0.09	249.8
			Mod.	0.44	290.3	0.22	19.2	0.22	298.3	0.11	277.6	0.08	255.8
Serrurier Island	114.6833	-21.6000	Obs.	0.48	290.0	0.26	5.0	0.18	288.0	0.12	269.0	0.09	249.8
			Mod.	0.44	290.3	0.22	19.2	0.22	298.3	0.11	277.6	0.08	255.8
Shark Bay (INR BCN)	113.3833	-25.9667	Obs.	0.15	9.6	0.07	73.8	0.21	333.1	0.15	316.6	0.03	343.8
			Mod.	0.18	347.7	0.06	91.1	0.23	317.3	0.13	297.4	0.04	322.2
Steamboat Island	116.0667	-20.8167	Obs.	1.04	305.3	0.67	15.4	0.29	300.4	0.14	264.0	0.14	258.9
			Mod.	1.10	309.8	0.57	38.2	0.26	303.2	0.13	280.8	0.18	277.4
Tantabiddi	113.9833	-21.9167	Obs.	0.34	286.9	0.17	355.8	0.19	289.3	0.13	271.6	0.06	258.4
			Mod.	0.30	281.5	0.14	12.4	0.21	296.9	0.11	277.4	0.06	247.0
Trimouille Island	115.5500	-20.3833	Obs.	0.75	308.0	0.45	19.0	0.20	280.0	0.14	280.0	0.14	274.0
			Mod.	0.91	315.8	0.46	45.7	0.25	307.4	0.13	284.0	0.15	283.8
Useless Loop	113.4167	-26.1333	Obs.	0.13	35.3	0.05	100.5	0.23	344.9	0.15	326.0	0.02	10.9
			Mod.	0.26	14.2	0.10	122.7	0.24	327.9	0.14	307.1	0.05	350.6
Withnell Point	113.0167	-25.5833	Obs.	0.18	324.0	0.08	26.0	0.19	306.0	0.13	291.0	0.04	303.0
			Mod.	0.14	311.7	0.06	45.5	0.21	311.4	0.12	292.1	0.03	285.1

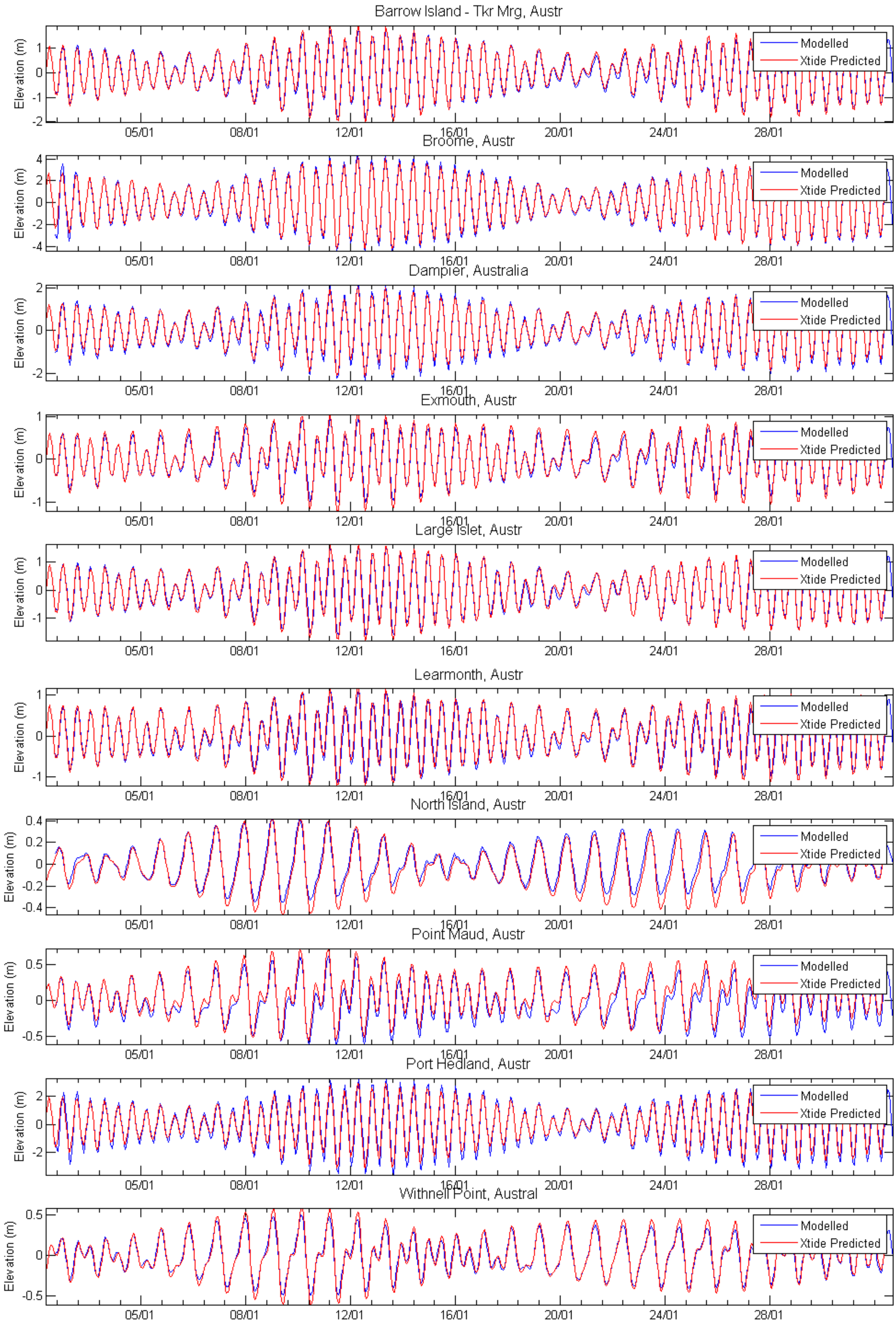


Figure 2-5: Comparison between the predicted (blue line) and observed (red line) surface elevation variations 10 coastal locations in the model domain for January, 2005.

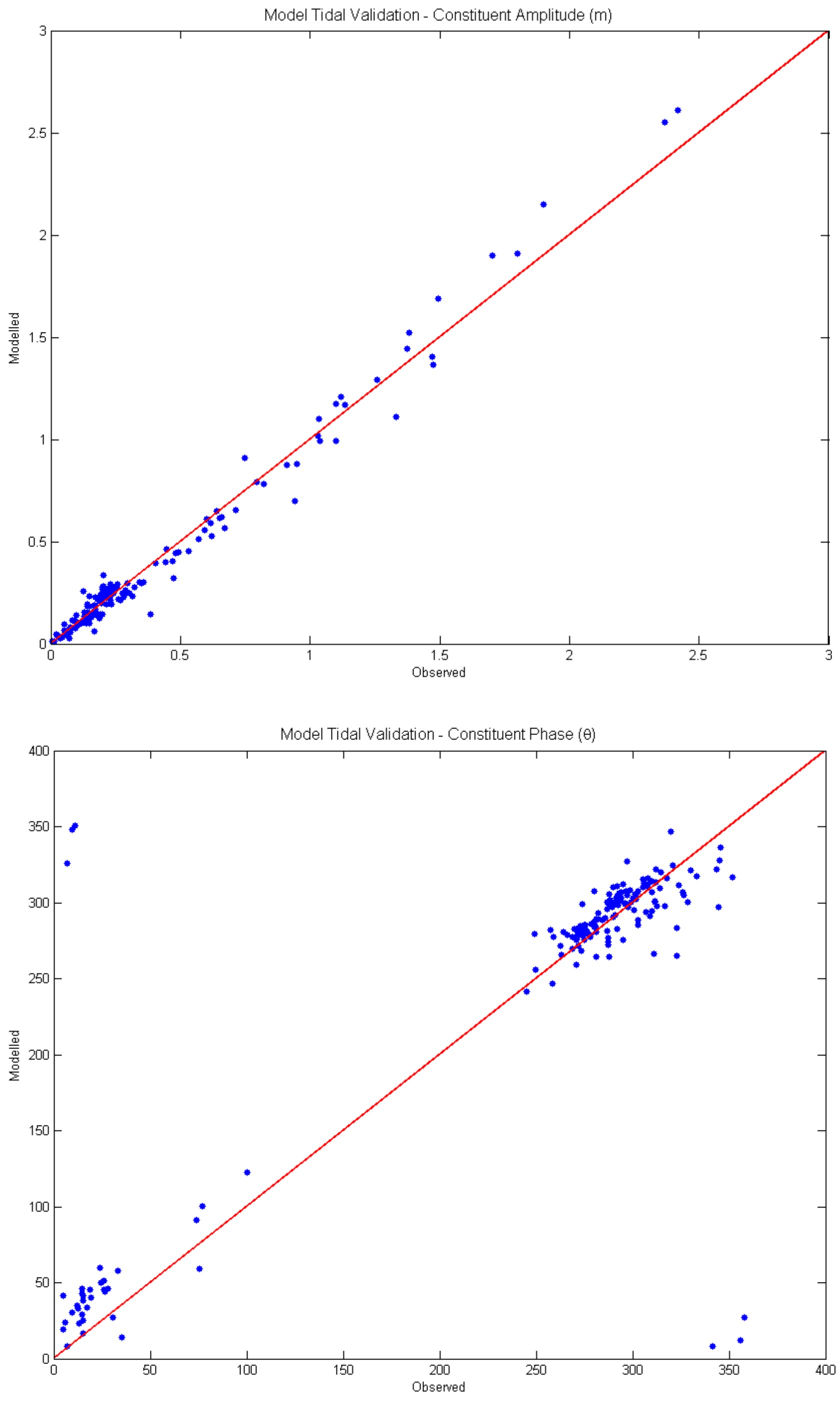
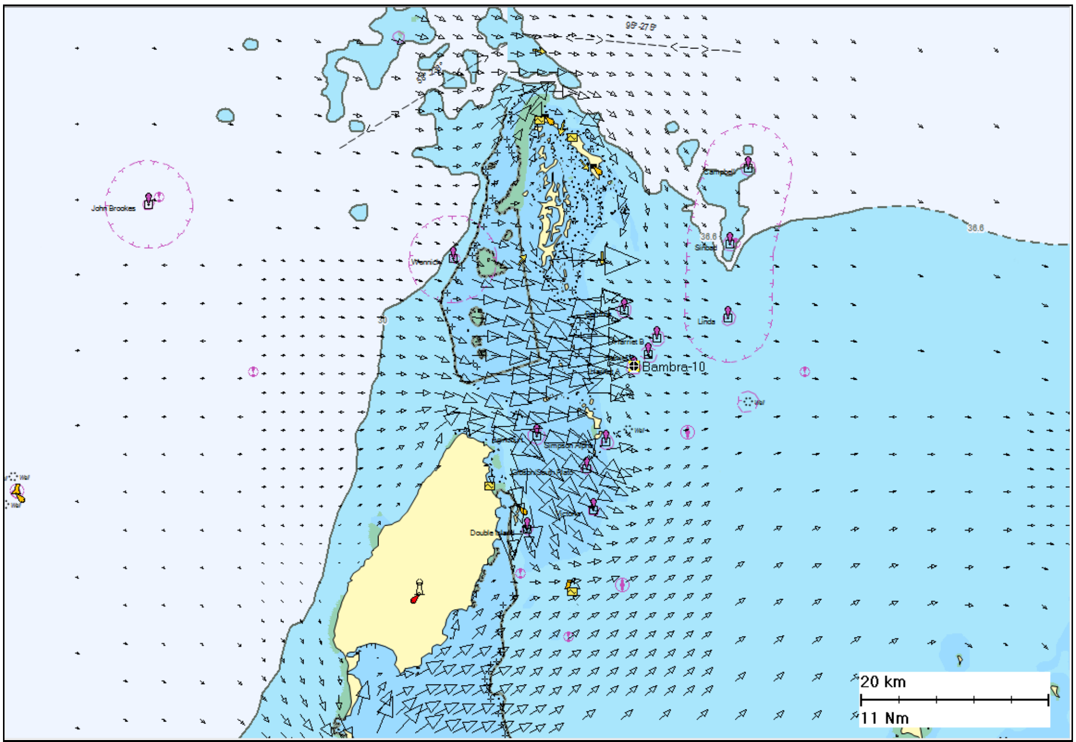


Figure 2-6 Comparison between modelled and observed tidal constituent amplitudes (top) and phases (bottom) at relevant stations.

Figure *2-7* shows examples of the tidal current regime around Barrow Island and the Lowendal and Montebello Island groups during a flooding and ebbing tide. Note that the tidal currents speed up and are significantly steered passing over the shallow ground among the island chains.



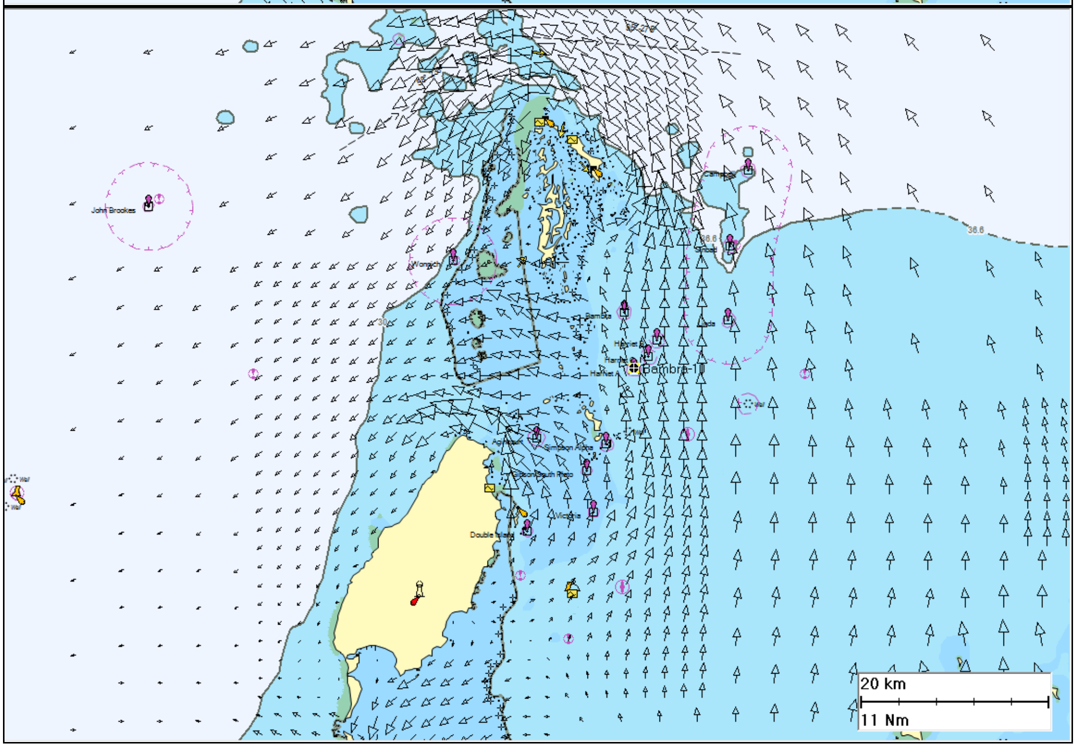


Figure 2-7: Examples of the tidal current regime around Barrow Island and the Lowendal and Montebello Island groups during flooding (top) and ebbing (bottom) tide. The relative magnitude of the current is reflected by the size of the arrow, which points to where the current is locally going.

2.2.2 Wind Data

To account for the influence of the wind on surface oil slicks, representation of the wind conditions were provided by spatial wind fields sourced from the National Center for Environmental Predictions (NCEP), NOAA-CIRES Climate Diagnostics Center in Boulder, Colorado. The NCEP wind data are hindcasts generated by integration of extensive historic and observed atmospheric data using a state-of-the-art atmospheric model with global coverage. An important advantage of applying this data is that it provides estimates of the spatial variation over the study region. This data is also an input to the HYCOM model, providing consistency with the HYCOM data.

NCEP wind data for the same spatial and temporal coverage as the current data (2005 to 2009 inclusive) were extracted for the nearest model nodes (Figure 2-8). The data were assumed to be a suitably representative sample of the wind conditions over the study area for future years.

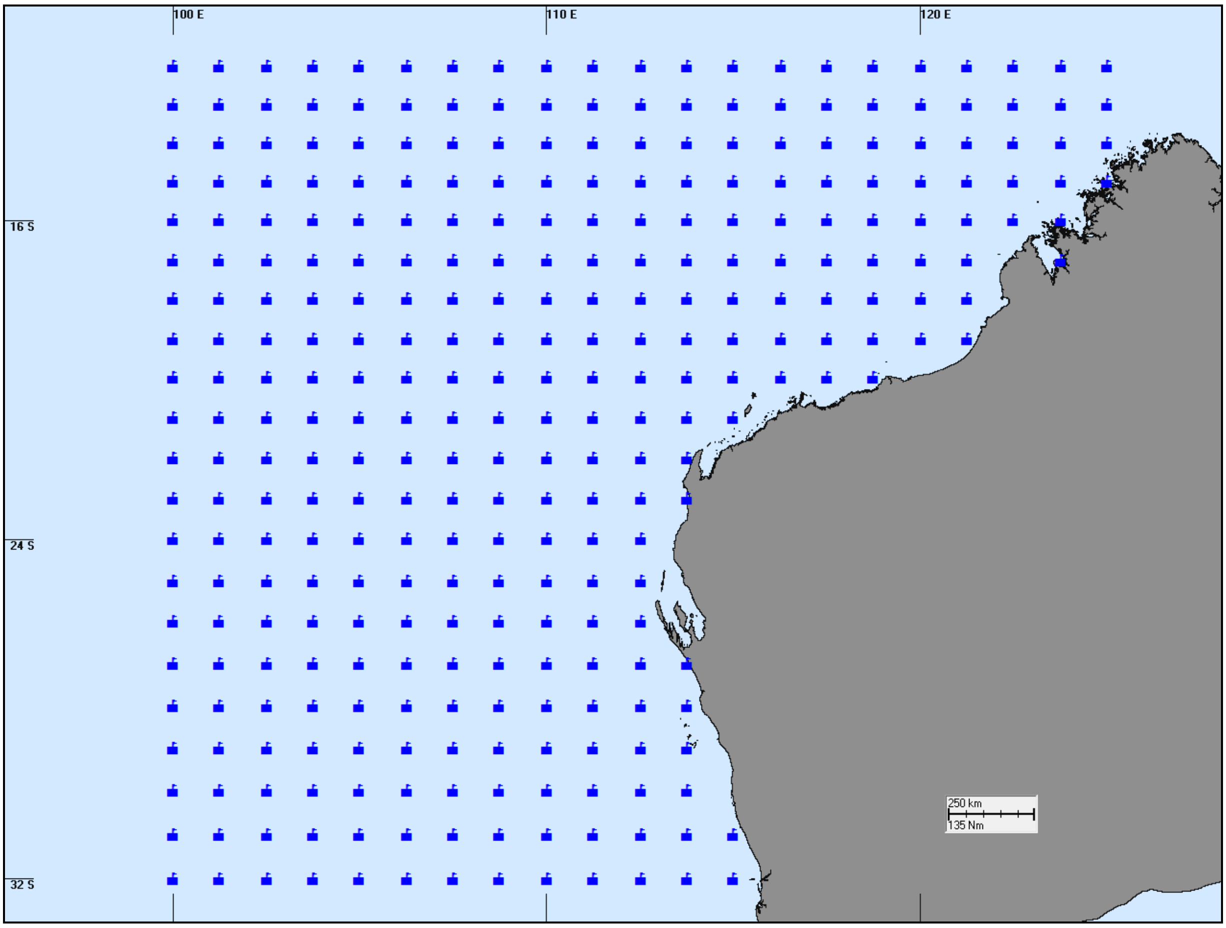


Figure 2-8: Location of the NCEP wind data nodes from which data were extracted for use in the spill model.

Figure 2-9 shows the seasonal wind rose distributions for the closest NCEP wind station to the modelled spill locations (coordinates 20° S, 115° E). Note that the convention for defining wind direction is the direction the wind blows from (opposite convention to ocean currents).

The wind direction is most commonly from the south-southwest to southwest during the summer and transitional spring months, and the wind direction is rarely from the north-west or north. During early-mid winter, winds typically prevail from the easterly to south-easterly direction, tending south-westerly late winter. During the transitional autumn month, the winds swing between the summer and winter patterns and southerly winds are quite common.

The wind data suggests that, in the absence of any current effects, the wind acting on surface slicks would tend to result in trajectories that will most frequently be towards the northeast to north-northeast during summer and transitional spring, west to north-west during winter and north during transitional autumn. Note that the actual trajectories of surface slicks will be the net result of a combination of the prevailing wind and current vectors acting in a given location.

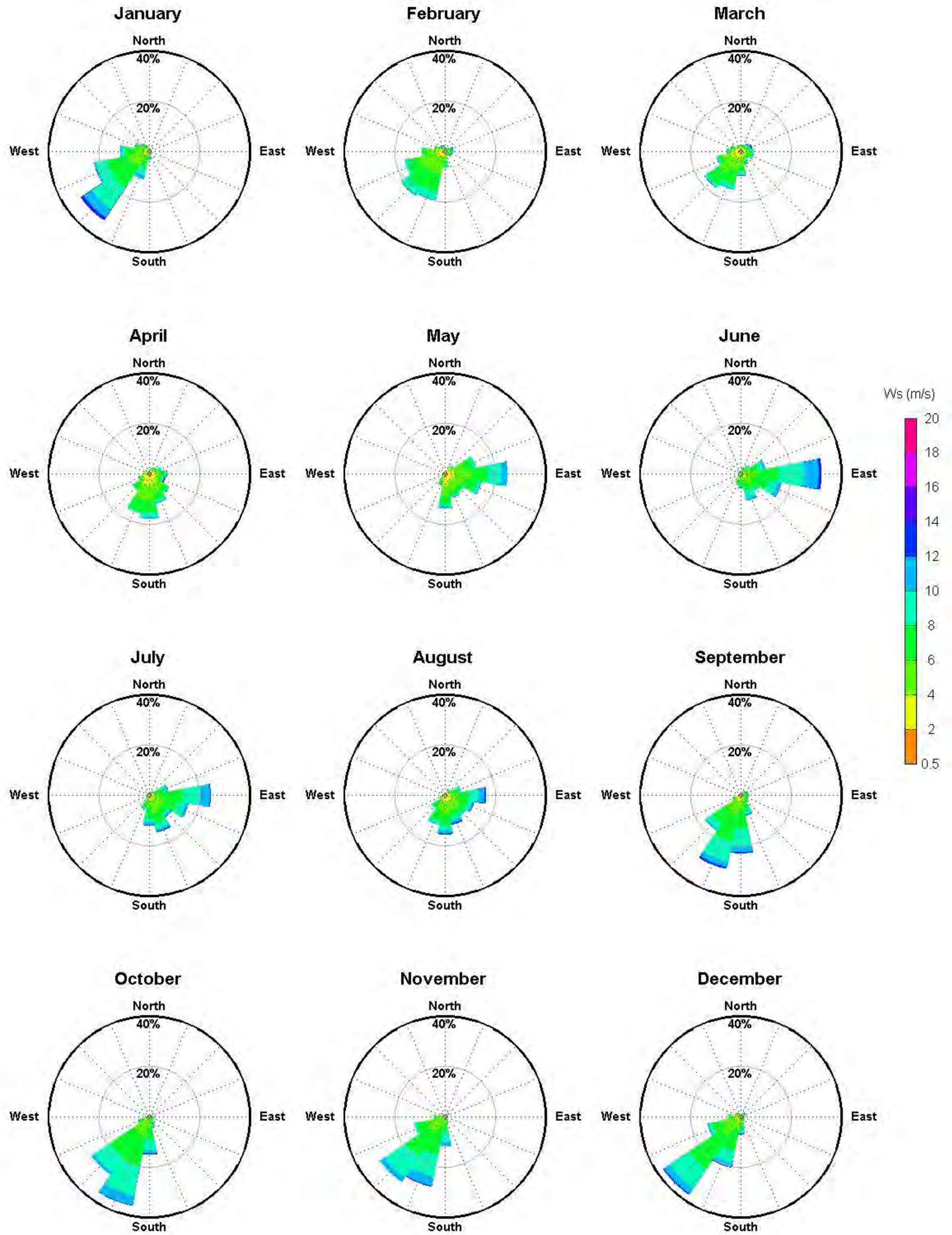


Figure 2-9: Monthly wind distribution (2005 - 2009) for NCEP data location (20° S, 115° E). The colour key shows the current magnitude, the compass direction provides the direction FROM and the length of the wedge gives the percentage of the record.

2.2.3 Water temperature and salinity settings

Sea surface temperatures vary seasonally within the monthly-averaged limits of 24°C (winter and early spring) to 27°C (summer), while water salinity is almost constant and close to 36 parts per thousand (ppt) throughout the seasons (Levitus World Oceanographic database). These data were applied to all the spill simulations.

2.2.4 Replication

Separate stochastic simulations were undertaken for each spill scenario and starting season, as outlined in Table 1-2. For the instantaneous spill (scenario 1, which was tracked for 7 days during each simulation) and the short duration spills (scenarios 2, 3 and 4, which were tracked for 14 days during each simulation) a total of 100 simulations were completed for each of the scenario and season combinations, to sample variation in the current and wind conditions that could occur. For the long simulation of the blowout (scenario 5), where each simulation would sample a large period of time (3 months), and hence greater variation in wind and current patterns, replication was reduced to 30 per season.

2.2.5 Dispersion

A horizontal dispersion coefficient of 5 m^2/s was used to account for dispersive processes acting at the surface that are below the scale of resolution of the input current field, based on typical values for open waters (Okubo 1971). Dispersion rates within the water column (applicable for entrained and dissolved plumes of hydrocarbons) were specified at 1 m^2/s, based on empirical data for the dispersion of hydrocarbon plumes over the North West Shelf (King & McAllister, 1998).

2.2.6 Contact Thresholds

The SIMAP model will track oil concentrations to very low levels. Hence, it is usual to define threshold concentrations for the recording of contact and determining the probability of exposure at a location (calculated from the number of repeat simulations in which this contact occurred) which are at meaningful levels.

The judgement of meaningful levels is complicated and will depend upon the sensitivity of biota contacted, the duration of the contact and the particular toxicity of the oil mixture that is involved in the contact. The latter factor is further complicated by the change in the composition of an oil type over time due to weathering processes. Such considerations are beyond the scope of this investigation. Hence, a conservative approach was followed whereby contact was judged for a number of thresholds, commencing at levels expected to be conservatively low.

Surface oil concentrations (g/m^2) are relevant to describing the risks of oil coating emergent reefs, vegetation in the littoral zone and shoreline habitats as well as the risk to wildlife found on the water surface, such as marine mammals, reptiles and birds. Thresholds for registering contact by surface slicks onto surface waters were assessed at indicative concentrations, based on the relationship between slick thickness and visible appearance (Bonn Agreement 2004) as indicated in Table 2-2 (see also Figure 2-10).

Table 2-2: The Bonn Agreement Oil Appearance Code.

Appearance (following Bonn visibility descriptors)	**Mass per area ($g\ m^{-2}$)**	**Thickness (µm)**	**Volume per area ($L\ km^{-2}$)**
Discontinuous true oil colours	50 to 200	50 to 200	50,000 to 200,000
Dull metallic colours	5 to 50	5 to 50	5,000 to 50,000
Rainbow sheen	0.30 to 5.0	0.30 to 5.0	300 to 5,000
Silver sheen	0.04 to 0.30	0.04 to 0.30	40-300

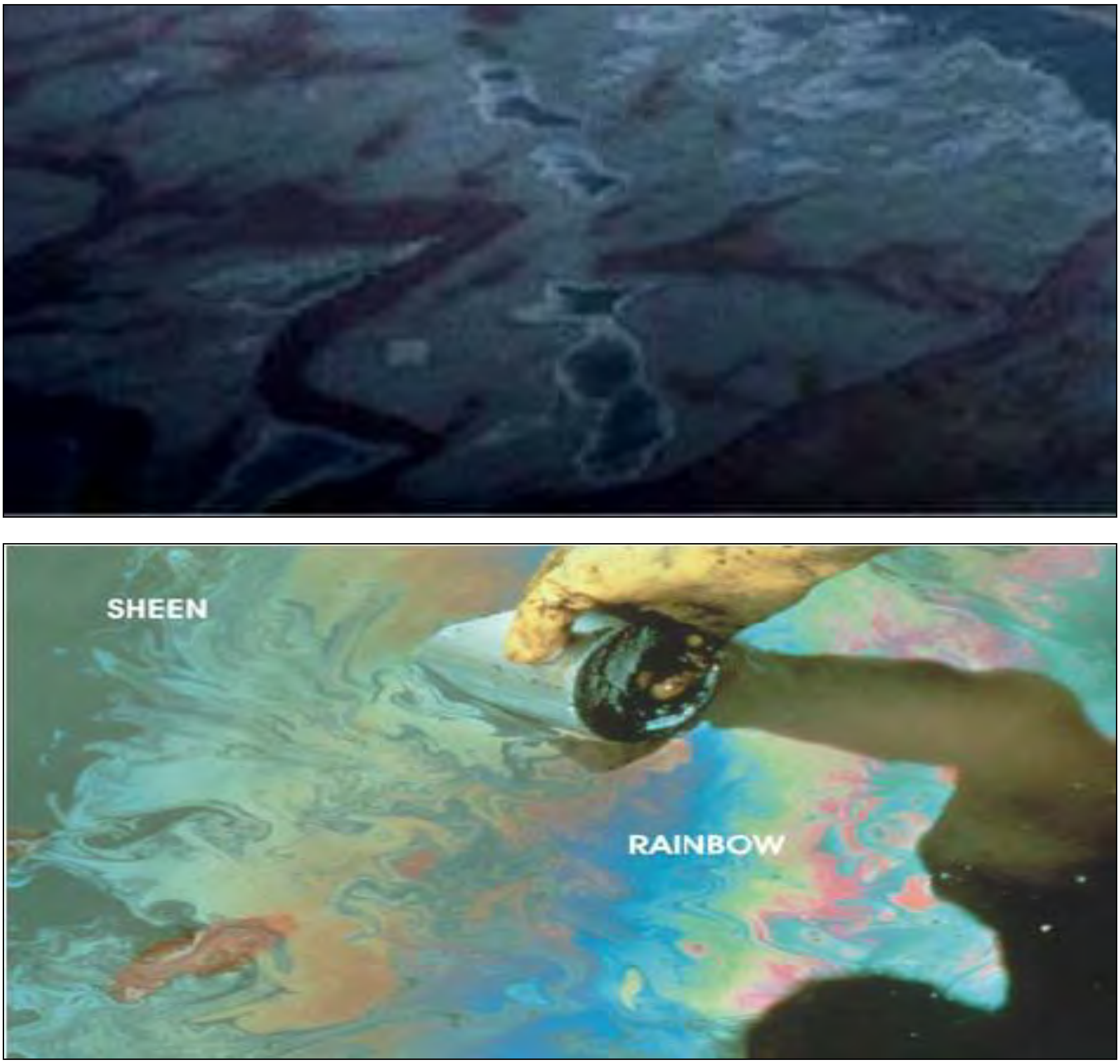


Figure 2-10: Photographs of oil film appearance on the water surface. Top panel indicates bands of dull metallic colour surrounded by rainbow and silver sheen. Lower panel indicates Rainbow sheen thinning to silver sheen (Source: "Oil on water sheens" – Ron Goodman Innovative Ventures Ltd).

It is important to note that real spill events generate surface slicks that break up into multiple patches separated by areas of open water. Therefore, calculation of concentrations requires careful definition.

For assessing the potential for ecological effect, the most relevant concentration will be the local concentration of oil within the oil patches. This is particularly true when the results are being compared to studies that have tested the direct impact of oil on biota, based on some defined concentration. It should be understood that calculating an aerial average concentration over a relatively large area of water surface (tens to hundreds of thousands of square metres or larger) that is occupied by patches of oil interspersed by areas of oil-free water will dilute the concentration estimate substantially. Similarly, calculating the average concentration by averaging the oil volume or mass within a large model grid cell (typically of the order of square kilometres to 10"s of square kilometres) will be misleading for the local concentrations within slick patches.

For this assessment, water surface concentrations have been tested in terms of the local patch concentrations. These patches are represented in the model simulations by many (tens of thousands) of independent “spillets”. The location of each spillet at a time-step represents the centre-point of a patch, while the volume to area ratio (volume/area) calculated for the spillet at a time-step defines the concentration of oil within the patch. This concentration evolves over time independently for each patch due to spreading, turbulent diffusion and weathering processes relevant to the location, state of weathering and surface area of the slick.

To help indicate the potential for exposure to oil concentrations of varying magnitude, probability contours for surface slicks were produced for patch concentrations of 1 g/m^2, indicative of light oiling at the surface, and 10 g/m^2 indicative of moderate oiling at the surface (Table 2-3). As an indication of the relevance of these concentrations, a patch of oil with a concentration of 10 g/m^2 (10 μm thickness) would likely appear as a thin film with a dull metallic colour. A concentration of 1 g/m^2 (1 μm thickness) would likely appear as a thin sheen with bright rainbow colour. For oil types that have a persistent wax component, the lower concentration would also be indicative of the occurrence of wax balls or sheets that will form after the loss of volatile components. Note that these concentrations are nominal and do not directly imply environmental impact. Assessment of environmental impact requires a consideration of the mechanisms of harm (e.g. smothering, ingestion, contact toxicity, interference with thermoregulation of seabirds etc.), the state of weathering of the oil and the specific chemical composition and physical properties of the oil in question.

Surface films can exert harm to organisms either at the water surface, or occupying surfaces emerging from the water surface (shorelines and emergent reefs) through direct contact, smothering, or interference with survival functions. For example, estimates for the minimal thickness of oil that will result in harm to seabirds through ingestion from preening of contaminated feathers, or the loss of thermal protection of their feathers, has been estimated by different researchers at approximately 10 g/m^2 (French 2000) to 25 g/m^2 (Kroops *et al*. 2004), allowing for the tendency for birds feathers to accumulate oil if they move within the film. Hence, the 10 g/m^2 threshold is considered a conservative indicator for potential harm to fauna that is at the sea-surface, such as seabirds. The 1 g/m^2 threshold is likely to be conservative in terms of environmental harm for effects on seabirds and other fauna at the surface. However, because this concentration will be highly visible, we report this threshold to indicate the perceived area of effect of the defined spill scenarios, which may trigger economic impacts, such as the temporary closure of local fisheries as a precautionary measure, or negative public and government reaction. The perceived area of effect also provides guidance on the area over which it may be necessary to determine whether any negative impacts have occurred if the spill scenario were to occur.

Thresholds for concentrations of entrained oil that may be of concern are more difficult to define because dispersed oil will be present in combination with dissolved, colloidal and particle-attached forms. Hence, it is difficult to separate the effects of each phase with very few studies addressing the effect of direct exposure to entrained oil, as opposed to the effects of hydrocarbons in mixed form or dissolved into solution from entrained oil (National Research Council, 2005). Moreover, the specific effects of exposure to entrained droplets of Chandon condensate have not been tested. Thus it was necessary to develop indicative thresholds based on the scientific literature.

Most crude oils will contain aromatic hydrocarbons in the form of mono-aromatic (MAH), di-aromatic (DAH) and poly-aromatic hydrocarbons (PAH; Oil droplets entrained within the water column will undergo weathering through the selective dissolution of the lower molecular-weight aromatic and aliphatic hydrocarbons into the water column, with the mono-aromatic compounds (including benzene, toluene, xylene and ethyl benzene) dissolving rapidly and flashing off if at the surface. This results in the relative enrichment (i.e. increased relative concentration) of the entrained oil by the larger molecular weight PAHs over time (Neff *et al* 2000, National Research Council, 2005). PAH compounds cause toxicity through the mode of narcosis (or anaesthesis). The entrained oil is therefore a vehicle for generating toxic effects directly. Direct effects that have been demonstrated for PAH transfer from dispersed oil include uptake of PAH through filtering of entrained oil by fish gills, ingestion by suspension-feeding zooplankton species, such as copepods, and filter-feeding organisms, such as oysters and mussels, as well as the contamination of food chains through the accumulation of PAH in organisms at sub-acute concentrations (National Research Council, 2005). Acute tests for the toxicity of dispersed oil has indicated a wide range of concentrations for different species, oil types and conditions, with LC_{50} concentrations reported from exposure to physically dispersed oil in laboratory studies over the range 0.45 mg/l to over 258,000 mg/l (~ 45 ppb – 258,000 ppm) varying with species, life stage, oil composition and exposure pattern, with most acute tests on larval mortality for fish and invertebrates in the range 0.150 to 1.000 mg/l (~ 150 – 1000 ppb) for 24 hr treatment (National Research Council, 2005). Allowing for one order of magnitude lower concentrations as a safety margin indicates that concentrations of 15 ppb – 100 ppb could be conservative low effect thresholds for exposure over a day.

In lieu of well-defined information, conservative thresholds were used to indicate possible effect areas for dispersed oil. The lowest threshold concentration was set at 10 ppb (Table 2-3), which also corresponds generally with the lowest trigger levels for total hydrocarbons in water recommended in the ANZECC (2000) water quality guidelines for Australia. This threshold is treated as a low trigger value for potential sub-acute effects. Because of the requirement for relatively long exposure (1 day or more) times for these concentrations to be significant, they are likely to be more meaningful for juvenile fish, larvae and planktonic organisms that might be entrained (or otherwise moving) within the entrained oil plumes, or when entrained oil adheres to organisms or is trapped against a shoreline for periods of several hours or more. To indicate areas that could be affected by higher concentrations, which may be considered as low thresholds with increasing potential for impact, additional thresholds were set one order of magnitude higher (100 ppb) and 50 times higher (500 ppb). The latter threshold was relevant to the blowout scenarios only.

The specific toxicity of the water-soluble fractions of Chandon Condensate was not available to this study. Hence, it was necessary to set relatively conservative thresholds based on tests for other oils. A large body of evidence exists for the effect of the soluble compounds of oil on marine organisms (e.g. Neff & Anderson 1981, French 2000) as standard test formats have been developed to test the toxicity of the water soluble fraction and many oils have been tested using these procedures, with highly variable results. Among the many factors known to affect these results are the composition of the oil mixture, how the test solution was prepared, the species and life-stage that are used in the tests, the water temperatures used in the test and the exposure period.

These tests rely upon extracting soluble hydrocarbons from an oil sample by either shaking a sample of oil in a volume of water within an enclosed chamber or stirring a sample of oil in a volume of water in an open chamber. Test organisms are then exposed to the water solution that has been prepared (with non-dissolved oil removed) after dilution to different levels. Because the more soluble compounds are also the most volatile (i.e. evaporation and dissolution are competing processes), these different preparation methods will result in different mixtures, hence different toxicity, from the same oil type, because the closed chamber method limits the loss of soluble compounds, which go into solution instead. Consequently, the closed chamber method is more indicative of the outcome of a turbulent release in deep water, while the open chamber method is more realistic for a surface spill due to the rapid evaporation of the highly volatile compounds (French 2000). For testing the effect of weathering on the toxicity of oil, these water preparations are made after the oil sample has been heated or exposed to the atmosphere for a period of time, resulting in selective evaporation of the more volatile compounds. Hence, they are unavailable to go into the test solution.

Many studies have concluded that the toxicity of the water solutions generated from oil samples (taken as indicative of the relative toxicity of the oil itself) can be largely, but not always, predicted by the concentration of aromatic hydrocarbons in the oil (e.g. Neff and Anderson 1981, Neff *et al* 2000, French 2000) because the aromatic hydrocarbons are the most bioavailable (absorbable into tissue of organisms) and have the greatest effect on biological processes.

French (2000) reviewed the body of toxicity data available for tests of water-soluble fractions on marine organisms and dissolved aromatic compounds, accounting for the method used to prepare the test solutions and concluded that a no observable effect concentration for species/life stages of high sensitivity, exposed to the most toxic mixtures, could be as low as 0.3 ppb, given exposure long enough for saturation of tissues. This NOEC was calculated assuming a 200 times reduction on the lowest calculated LC_{50} concentration (64 ppb for 96 hr exposure). We therefore adopted 5 ppb as the most conservative threshold for calculating limits likely to be safe for exposure to dissolved aromatic hydrocarbons. However, as described by Pace *et al* (1999) and French (2000), organisms can tolerate exponentially higher concentrations of aromatic hydrocarbons for shorter exposure times and exposure to dissolved aromatics due to a spill will frequently be very short (minutes to a few hours) due to movements of dissolved oil plumes. This indicates that concentrations of the order of 500 ppb would be indicative of possible effects over short duration (1 hr) exposure and 50 ppb would be indicative of moderate periods of exposure (~10 hours; Table 2-3), following

Table 2-3: Summary of thresholds applied in this modelling study.

	Surface Oil (g/m^2)	Entrained oil (ppb)	Dissolved aromatic (ppb)
Thresholds used	1 g/m^2 (Rainbow Sheen)	10 ppb	5 ppb - long duration (~96 hrs)
	10 g/m^2 (Dull Metallic Colours)	100 ppb	50 ppb - moderate duration (~10 hrs)
		500 ppb (blowouts only)	500 ppb - short duration (~1 hr)

2.2.7 Oil Properties and Weathering Characteristics

Characteristics for diesel oil were extracted from the ASA oil database for similar operational temperatures. Diesel is a mixture of volatile and persistent hydrocarbons (see Table 2-4), with approximately 40-50% by mass predicted to evaporate over the first two days, depending upon the prevailing conditions, with further evaporation slowing over time. The heavier components of diesel have a strong tendency to entrain into the upper water column due to wind-generated waves, but can subsequently resurface if wind waves abate. Predictions for the weathering of a marine diesel spill under representative ambient conditions are shown in Figure 2-11 (2.5 m^3 surface spill) and Figure 2-12 (80 m^3 surface spill).

Table 2-4: Characteristics of the diesel used in this study

Oil type	Initial density (kg/m^3) at 25 ^{o}C	Viscosity (cP) (25 ^{o}C)	Component	Volatiles (%)	Semi-volatiles (%)	Low Volatility (%)	Residual (%)
			BP (^{o}C)	<180	180-265	265 - 380	>380
Diesel Fuel Oil (Southern USA, 1997)	829.1	4.0	**% of total**	6	34.6	54.4	5
				NON-PERSISTENT			PERSISTENT

Characteristics for the condensate were specified from assay reports on oil from the nearby wells. Characteristics assumed for this condensate are summarised in Table 2-6. Chandon Condensate has a low viscosity and approximately 90% of the oil could evaporate if exposed to the atmosphere, leaving persistent components (9.09%) that would have boiling points too high to evaporate under ambient conditions. This proportion of the oil could persist in the marine environment for extended periods of time, most likely as long carbon-chain compounds.

Atmospheric weathering requires the oil to be exposed to the atmosphere at the water surface. The surfacing rate of oil released underwater will be strongly dependent upon the size of the oil droplets that are generated at the release site. High pressure releases that involve mixed gas and condensate will tend to generate relatively small droplet sizes that have slow rise rates and may become trapped by density layers in the water column. The buoyancy of the gas cloud will entrain oil particles towards the surface and in the case of blowouts in relatively shallow water (< 200 m); the gas can lift the condensate to the surface. For deeper releases, this lift will tend to be lost before oil surfaces because the gas goes into solution or accelerates away from the oil droplets. These phenomena were explored for Chandon using a blowout model.

The blowout model input parameters and output parameters that were used as input into SIMAP are presented in Table 2-5. The input parameters are listed in the first section of the table.

The blowout simulation was modelled with OILMAP-DEEP for a case with methane-hydrate processes excluded, on the assumption that stable methane hydrates would not form due to the turbulence of the release. In the absence of methane-hydrate formation, the plume trapping height and radius forecasted by OILMAP-deep was approximately 480 m ASB, with a radius of approximately 158 m. Hence, the simulation indicated that oil droplets would need rise at least 720 m to reach the surface, with the rise generated by the positive buoyancy of the droplets but opposed by the viscosity of the water. The oil droplet sizes were forecasted to be in the range 40 to 183 µm.

Table 2-5 Near-field blowout model parameters

		Chandon
	Release Depth (m)	1200
	Oil Density (g/cm^3)	0.7361
	Oil Viscosity (cP)	1.044
	Oil temp (C°)	73
	GAS:OIL ratio (m^3/m^3)	31,275
	Oil Flow rate (bbl/day)	2,349
	Diameter of pipe (m)	0.194
	Plume radius (m)	158
	Plume height (m ASB)	480
Oil droplet size distribution	3.5% droplets of size (μm)	38.9
	14.9% droplets of size (μm)	65.2
	24.9% droplets of size (μm)	93.8
	26.5% droplets of size (μm)	115.4
	19.7% droplets of size (μm)	154.3
	10.5% droplets of size (μm)	183.2

Predictions for the weathering of a short term release of this condensate at the seabed due to a pipeline rupture under representative ambient conditions are shown in Figure 2-13. Less than 10% of the volume is likely to evaporate over the first two weeks. The forecast indicates that only a small proportion (~10%) of the condensate would reach the surface over a period of 14 days, with most of this proportion (consisting of the largest droplets) surfacing over the first 48 hours. Rapid evaporation of this widely spread volume would then maintain the surface volume at less than 5-6% at any time over the first 4 days. Subsequently, <2% would be at surface.

Predictions for the weathering of a long term release of this condensate at the seabed under representative ambient conditions are shown in Figure 2-14. This forecast indicated that, for a discharge of 28,7500 m3 over 11 weeks, the volume on the surface at any one time would not exceed ~1,200 m^3 (4% of the total) and 20 - 30% of the condensate may remain in the water column 2 weeks after the cessation of the blowout. Biological decay is forecasted to account for approximately 16% of the volume by 2 weeks after cessation.

Table 2-6: Characteristics of the condensate used in this study

Oil type	**Initial density (kg/m^3) at 15 °C**	**Viscosity (cP) (20 °C)**	**Component**	**Volatiles (%)**	**Semi-volatiles (%)**	**Low Volatility (%)**	**Residual (%)**
			BP (°C)	<180	180-265	265 - 380	>380
Chandon Condensate	736.1	0.566	**% of total**	73.25	10.18	7.47	9.09
				NON-PERSISTENT			PERSISTENT

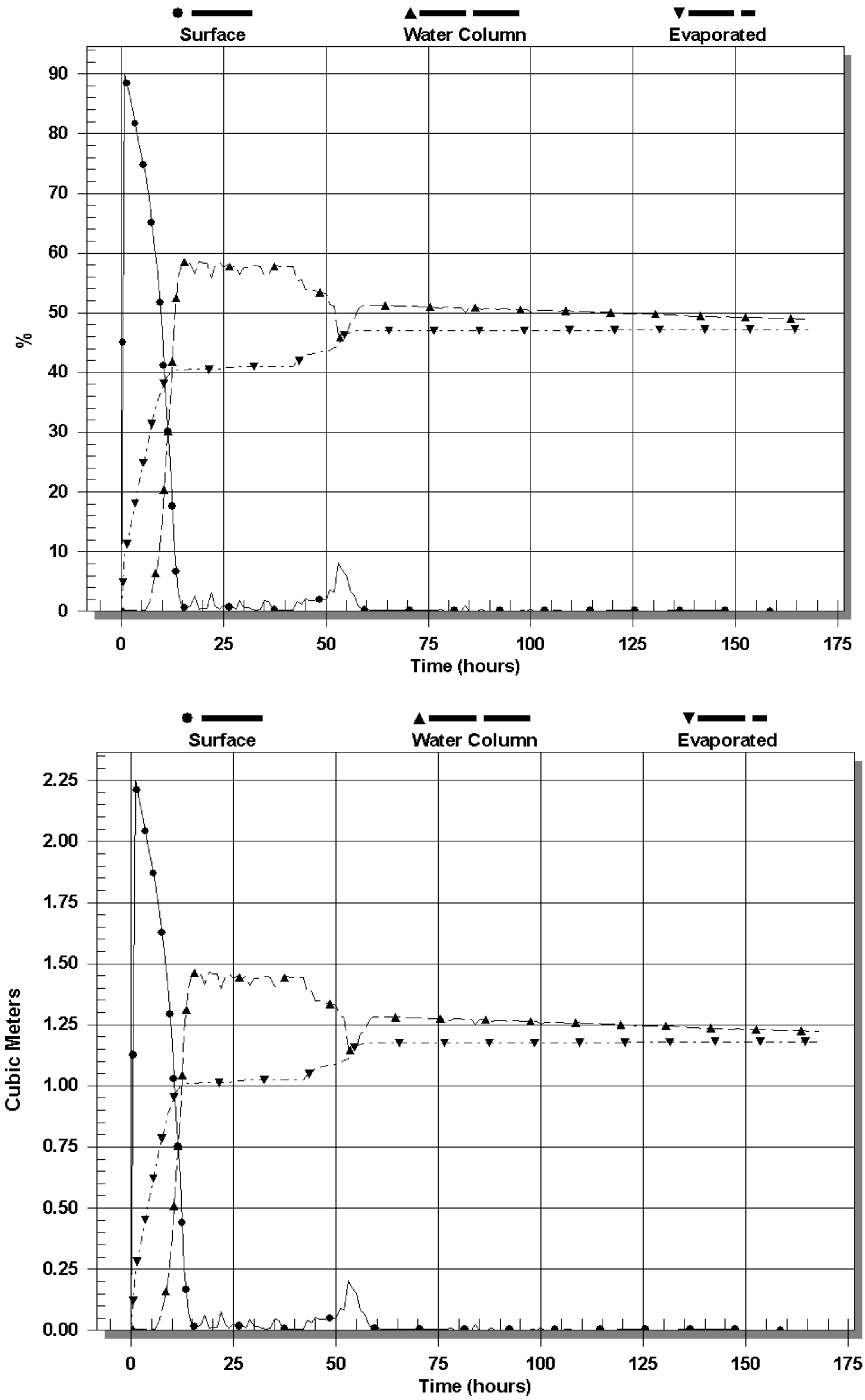


Figure 2-11: Predictions for the partitioning of oil mass over time through weathering processes for a 2.5 m³ surface spill of diesel as a % of the total mass released (top) and by volume (bottom). Predictions are based on examples of time-varying environmental conditions.

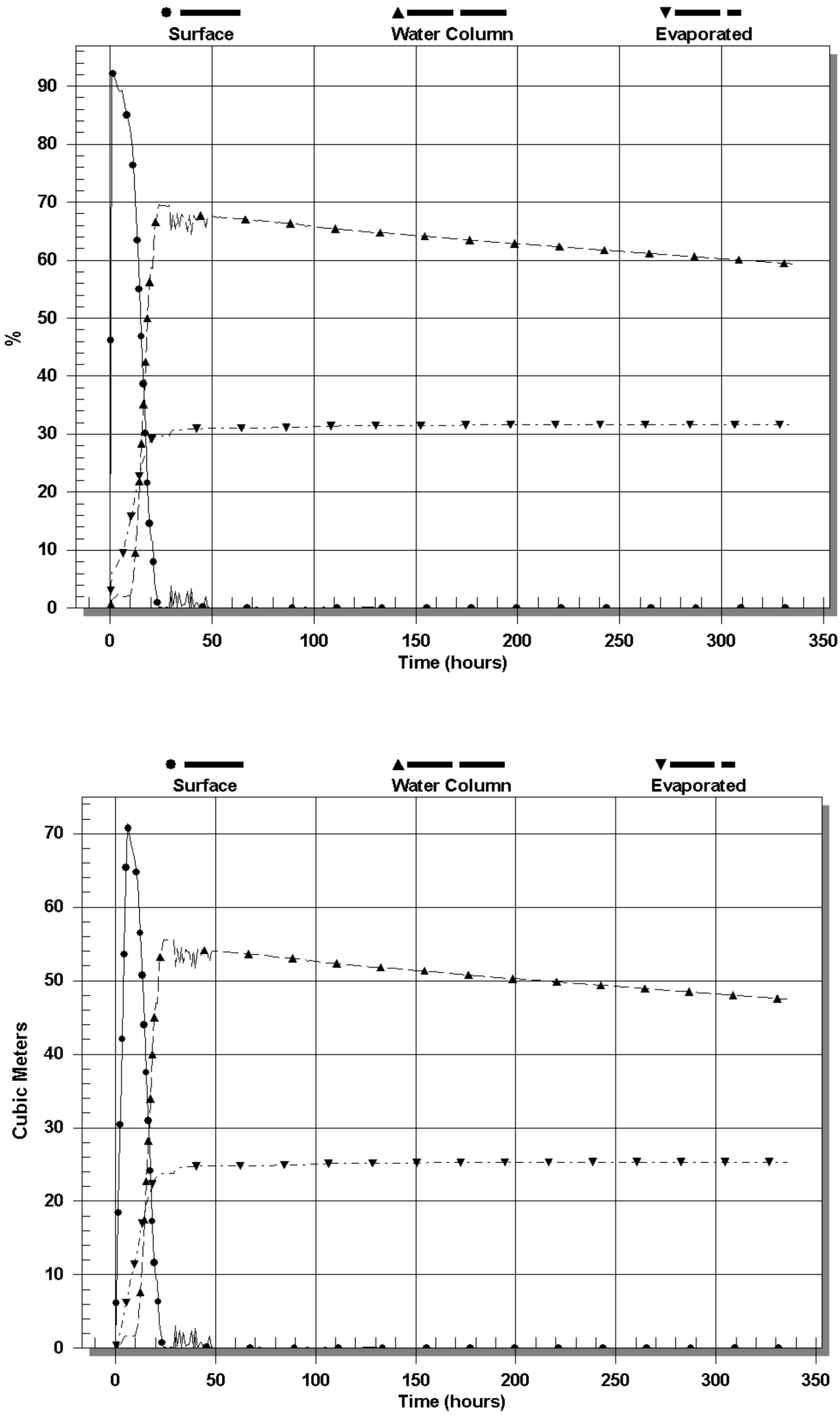
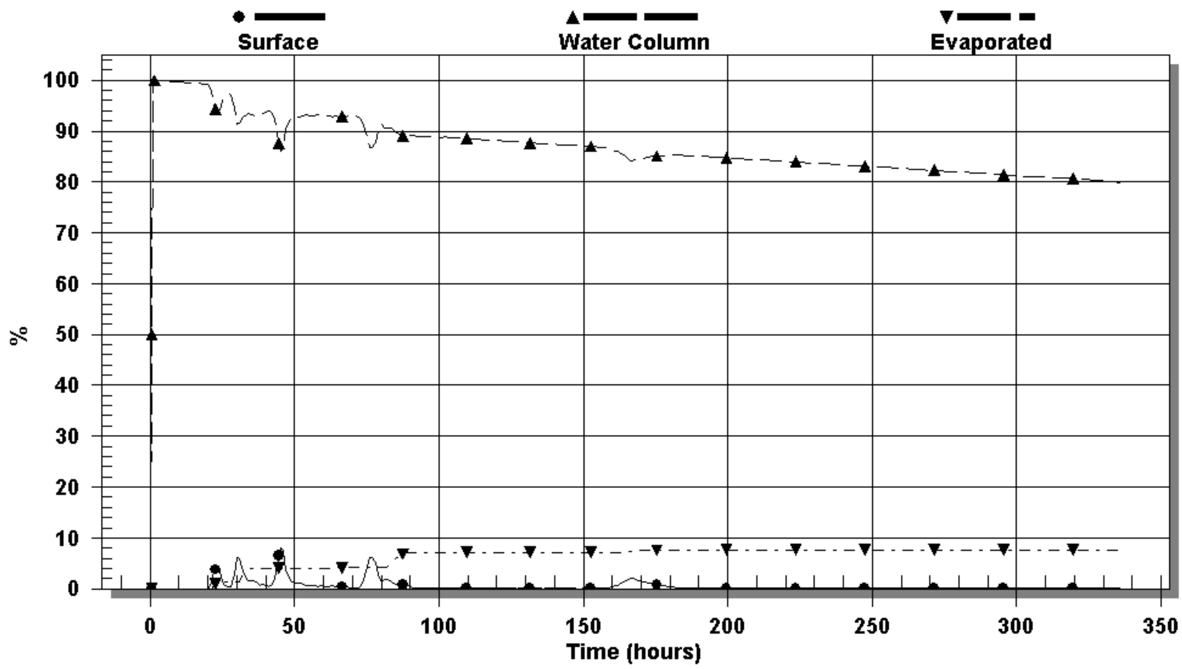


Figure 2-12: Predictions for the partitioning of oil mass over time through weathering processes for an 80 m³ surface spill of diesel as a % of the total mass released (top) and by volume (bottom). Predictions are based on examples of time-varying environmental conditions.



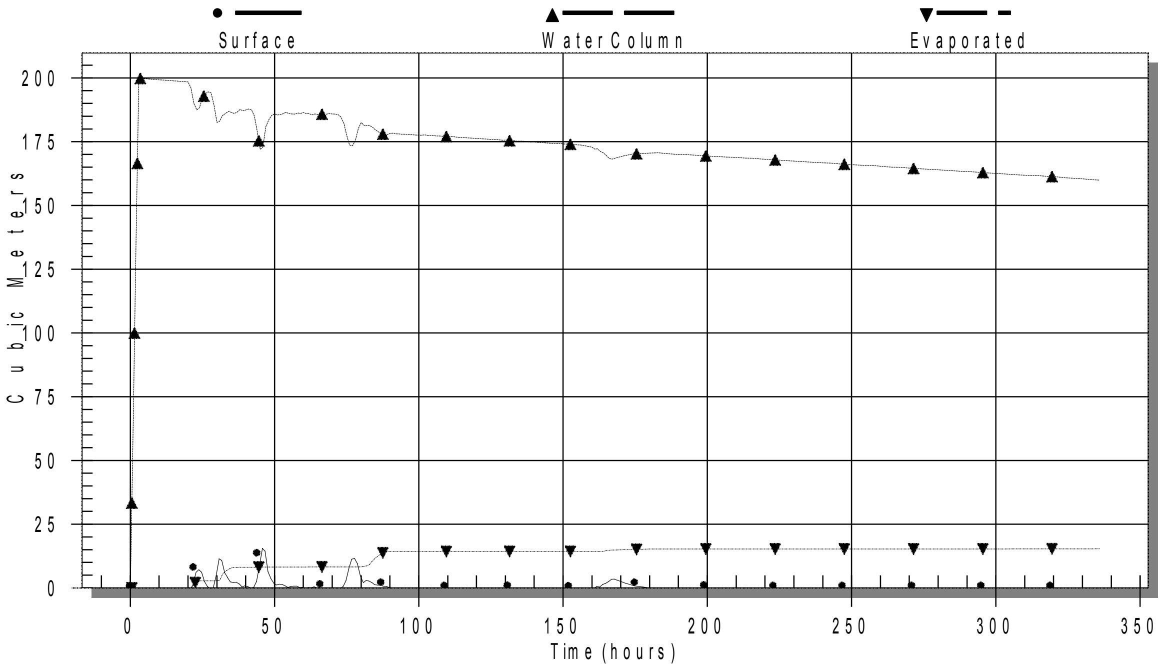
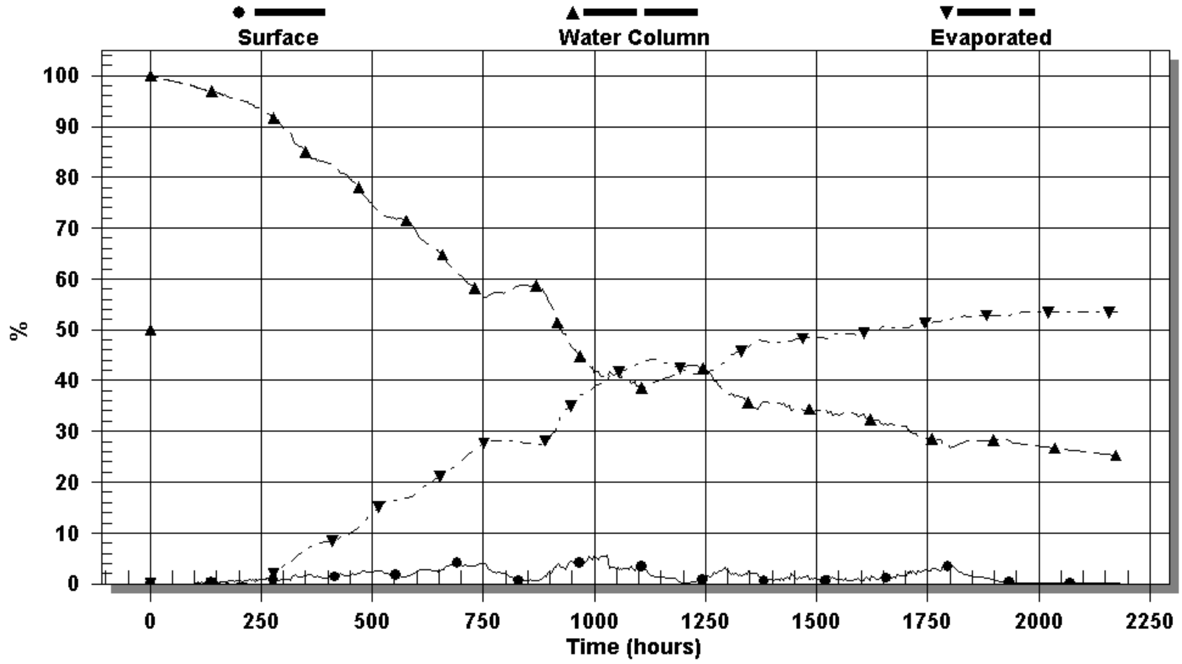


Figure 2-13: Predictions for the partitioning of oil mass over time through weathering processes for a 200 m³ subsea release of Chandon Condensate, as % of the total mass released (top) and by volume released (bottom). Predictions are based on examples of time-varying environmental conditions.



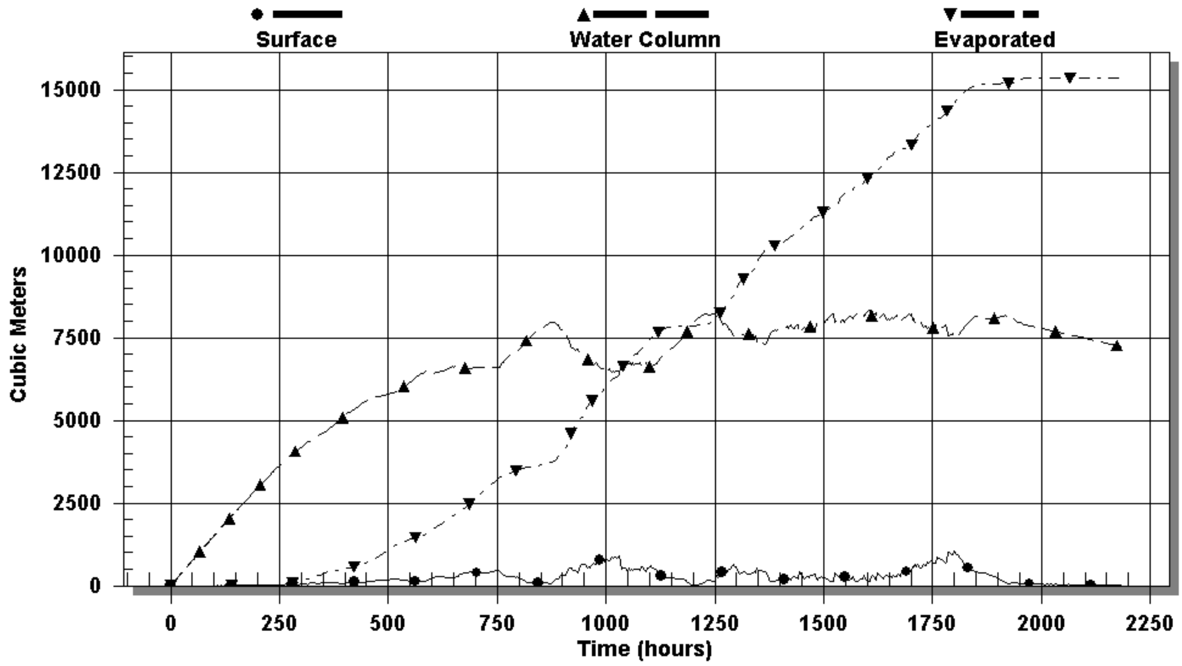


Figure 2-14: Predictions for the partitioning of oil mass over time through weathering processes for an 11 week, 180,873 bbl (28,756.5 m³) subsea blowout of Chandon Condensate, as a % of the total mass released (top) and by volume (bottom). Predictions are based on examples of time-varying environmental conditions.

3 RESULTS

Predictions for the probability of contact by oil concentrations exceeding defined thresholds are provided in the following sections to summarise the results of the stochastic modelling. Results are separately presented for releases that begin during each season. Readers should recall that the short term simulations have a span of up to 2 weeks and that the long term blowout simulations have a span of 13 weeks (including 2 weeks post-discharge). Consequently, releases commencing during one season may continue through different seasons. The trajectory of oil released during a long term blowout commencing at the end of one season may have a greater proportion of the release during a subsequent season, or seasons. Hence, the risk contours and summary tables will reflect these different possible conditions.

Results have been presented for oil at the surface, both on the water and onto shorelines, oil that is expected as entrained oil droplets in suspension and for the aromatic hydrocarbons that are expected to go into solution. Contour plots and tabled results for the probability of surface-bound oil arriving at shorelines are based on the defined minimum threshold concentrations (1 and 10 g/m^2). For example, the “Probability (%) of oil >1 g/m² at shorelines” in the tables of results for surface oil is for oil arriving at or above 1 g/m² at any coastline. The last two columns in the tables of results for surface oil give statistical estimates for the amount of oil that might accumulate onto shorelines during the course of a single spill event (of the defined scenario). These maxima are calculated by adding the mass that arrives at a section of shoreline (designated by a cell address) less any mass lost to evaporation while on shore.

Because the model calculates the accumulation of oil onto sections of shorelines over time that might be arriving at any concentration, it is possible for oil to arrive from concentrations below the thresholds applied to surface films. Therefore, accumulated oil concentrations on shorelines may exceed the thresholds applied to the oil on the water surface. Hence, where accumulation of oil on shorelines is reported but the probability of contact by surface films is below detection (NC = not contacted during any simulations), it may be understood that accumulation occurs from surface films with lower concentrations than 1 g/m^2.

The maximum is the highest recorded accumulation on any part of the shoreline within any replicate simulation, and therefore represents an extreme upper possible oil load. The “mean expected maximum” is the highest average, across replicates of the maxima on parts of the shoreline, and therefore represents a central tendency value accounting for variations among the replicate simulations.

Results tabulated for entrained oil and dissolved oil (aromatic hydrocarbon) concentrations in are based on concentrations recorded in model cells adjacent to shorelines. Hence, indicate risks of entrained or dissolved oil arriving within approximately 500 m of shoreline, with this buffer zone chosen to reflect a safety margin for arrival of these components within shallow coastal margins.

We do not report the distribution of evaporated oil in the atmosphere because this was beyond the scope of this study. Moreover, we do not present results for sedimentation because sedimentation was not forecasted for the oil types in the setting for any of the scenarios.

Figures are presented along with tabulation for any shoreline contact outcomes, summarised for all surrounding shorelines subdivided into 9 regions: Dampier Archipelago, Montebello Islands, Lowendal Islands, Barrow Islands, Muiron Islands, Ningaloo Coast, Southern Island Group, Middle Island Group and North Island Group (Figure 1-1, bottom). The region referred to as "Ningaloo Coast" covers the intertidal and shallow subtidal zone from North West Cape to Point Cloates. Given the larger area of possible exposure for the blowout scenarios, tabulation is presented for two additional regions: Bernier and Dorre Islands, and Abrolhos Islands (Figure 1-1, top).

These subdivisions were based on regional separation and serve to indicate which areas might be at greater or lesser risk for different scenario and season combinations and do not imply different importance to particular locations. Readers should assess this importance on other grounds.

As noted earlier in this report, it is important to note that the contour maps presented herein do not represent the predicted coverage of any one hydrocarbon slick or plume at any particular instant in time. Rather, the results are a composite of numerous theoretical slicks, integrated over the full duration of numerous replicates of each scenario, each of which was exposed to different wind and current conditions. Hence, a single event would only effect part of the area within the contour over the full duration of that event and only a subset of this area would be effected at any point in time during that single event.

The correct representation of the contours is that they show the probability that the defined threshold will occur at a given location at some point in time, given the defined spill scenario/season combination.

3.1 Simulation of 2.5 m³ surface diesel spill at the Chandon Well location

This scenario investigated the probability of exposure to surrounding regions by hydrocarbons due to a 2.5 m^3 surface spill of diesel fuel occurring „instantaneously" at the Chandon Well location. Result figures and tables are presented for each of the seasons in the following sections.

The probability contours at the two thresholds (1 and 10 g/m²) calculated for oil floating on the water surface indicate that surface slicks are most likely to drift towards the southwest during summer (Figure 3-1) and autumn (Figure 3-3). During winter and spring, surface slicks are most likely to drift to the southwest and to the north respectively (Figure 3-5, Figure 3-7). The model indicates that there would be no shoreline exposure during any of the seasons (Table 3-1, Table 3-3, Table 3-5, Table 3-7).

Low probabilities (≤ 5%) are predicted for oil to entrain in the water column at concentrations > 10 ppb during each of the seasons. For the summer scenario, entrained oil > 10 ppb is most likely (up to 5% probability) to drift to the northwest and northeast (Figure 3-2). During autumn and winter, trajectories towards the west and southwest are the most common (Figure 3-4, Figure 3-6) and during spring, drift is most likely to be towards the northeast, southeast and southwest (Figure 3-8). Entrained oil concentrations > 100 ppb are not predicted.

Similar to the surface oil results, entrained oil > 10 ppb is unlikely to be present immediately adjacent to any shorelines during any of the seasons (Table 3-2, Table 3-4, Table 3-6, Table 3-8). Modelling also indicated dissolved aromatic hydrocarbons are not forecast to be present in the water column at concentrations > 5ppb during any of the seasons, averaged at the scale of the model grid.

3.1.1 Summer

Surface Slicks and Films

Table 3-1: Summary of shoreline risks for different locations from a 2.5 m³ spill of diesel on the water surface at the Chandon Well commencing during summer months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m²)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m²)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

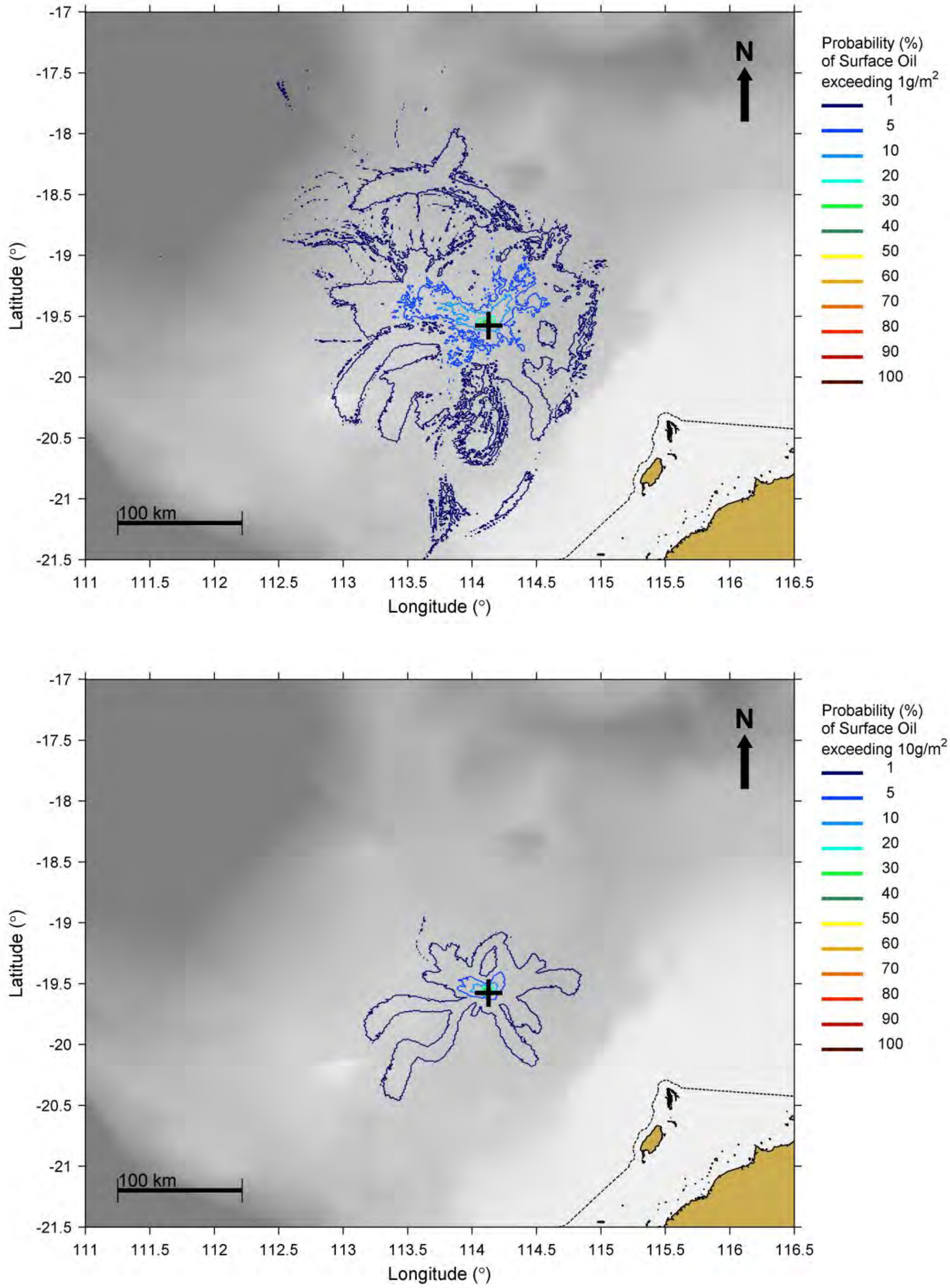


Figure 3-1: Predicted probability of sea surface contact to concentrations above 1 g/m^2 (top) and 10 g/m^2 (bottom) resulting from a 2.5 m³ spill of diesel on the water surface at the Chandon Well commencing during summer months. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-2: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from a 2.5 m³ spill of diesel on the water surface at the Chandon Well commencing during summer months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

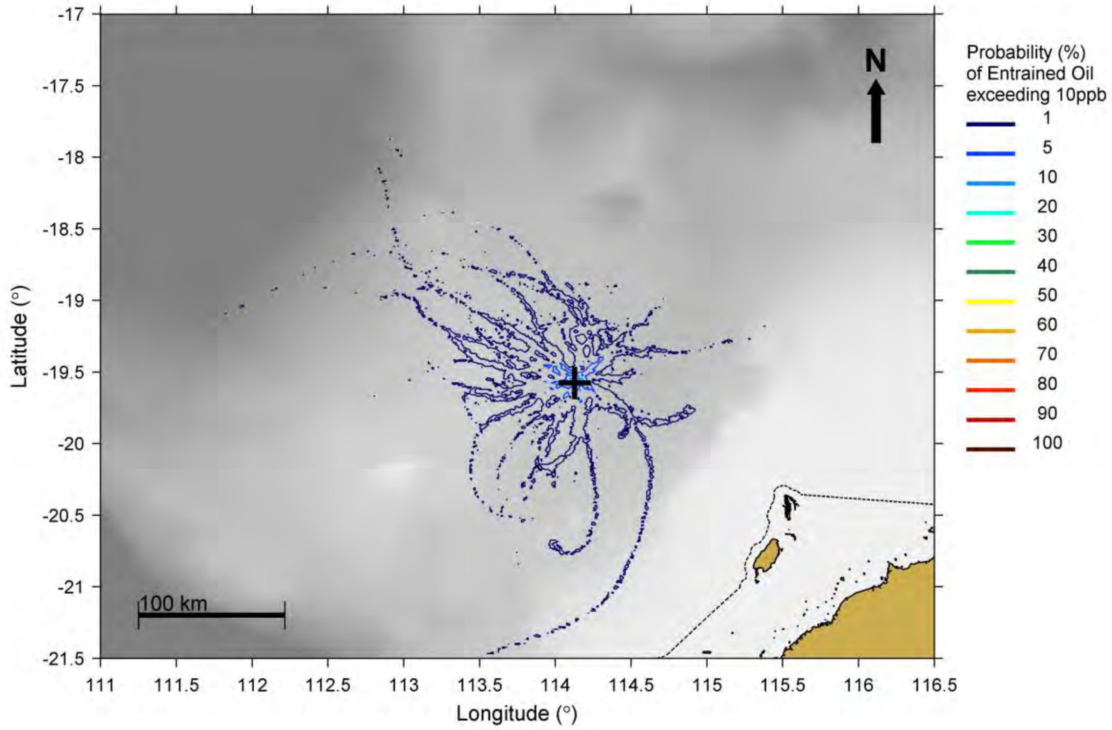


Figure 3-2: Predicted probability of entrained concentrations above 10 ppb resulting from a 2.5 m³ spill of diesel on the water surface at the Chandon Well commencing during summer months. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

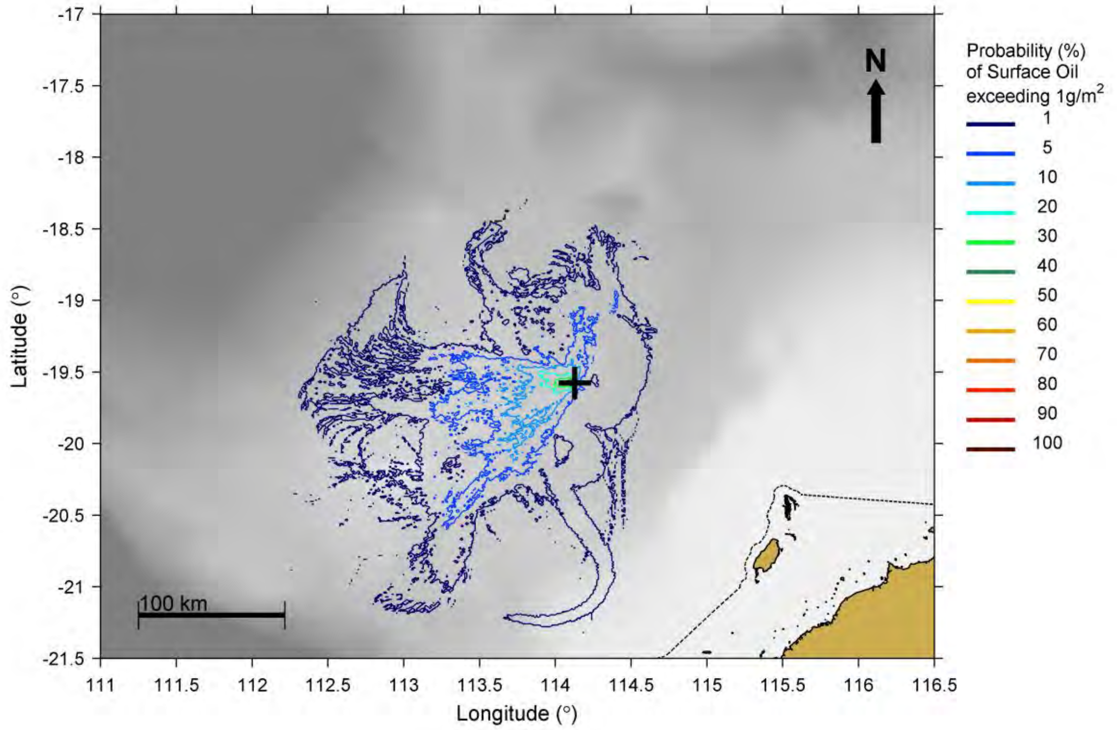
3.1.2 Autumn

Surface Slicks and Films

Table 3-3: Summary of shoreline risks for different locations from a 2.5 m³ spill of diesel on the water surface at the Chandon Well commencing during the autumn months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m²)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m²)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold



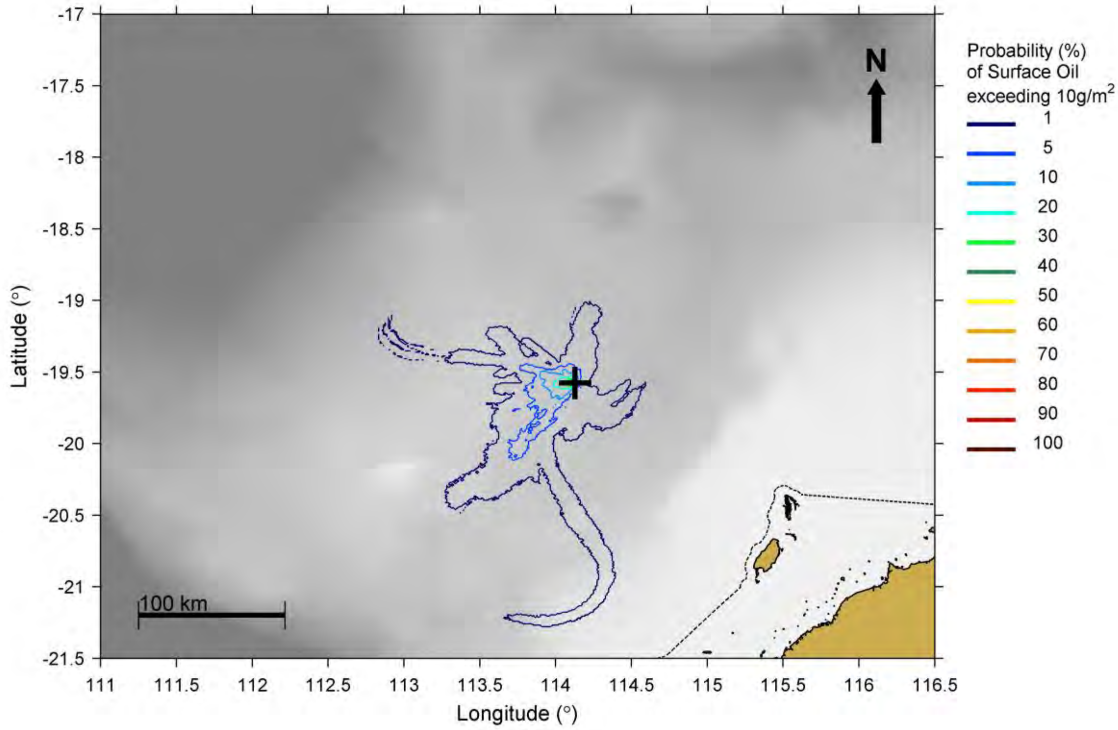


Figure 3-3: Predicted probability of sea surface contact to concentrations above 1 g/m^2 (top) and 10 g/m^2 (bottom) resulting from a 2.5 m^3 spill of diesel on the water surface at the Chandon Well commencing during the autumn months. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-4: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from a 2.5 m³ spill of diesel on the water surface at the Chandon Well commencing during the autumn months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

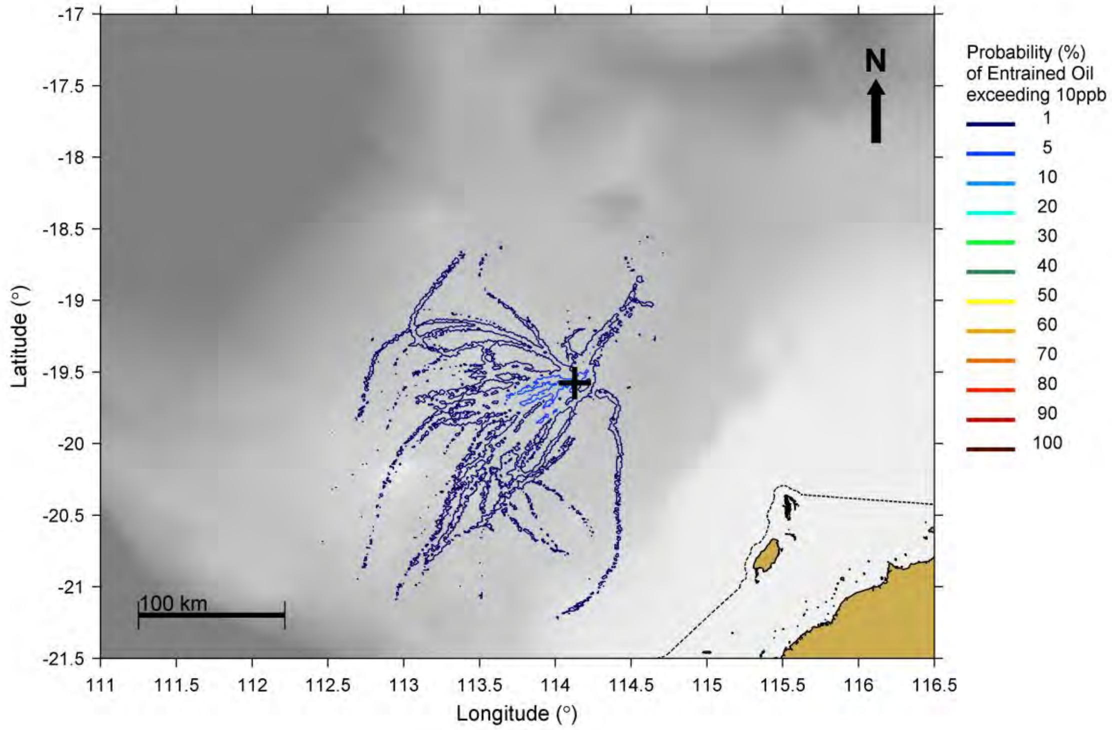


Figure 3-4: Predicted probability of entrained concentrations above 10 ppb resulting from a 2.5 m³ spill of diesel on the water surface at the Chandon Well commencing during autumn months. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

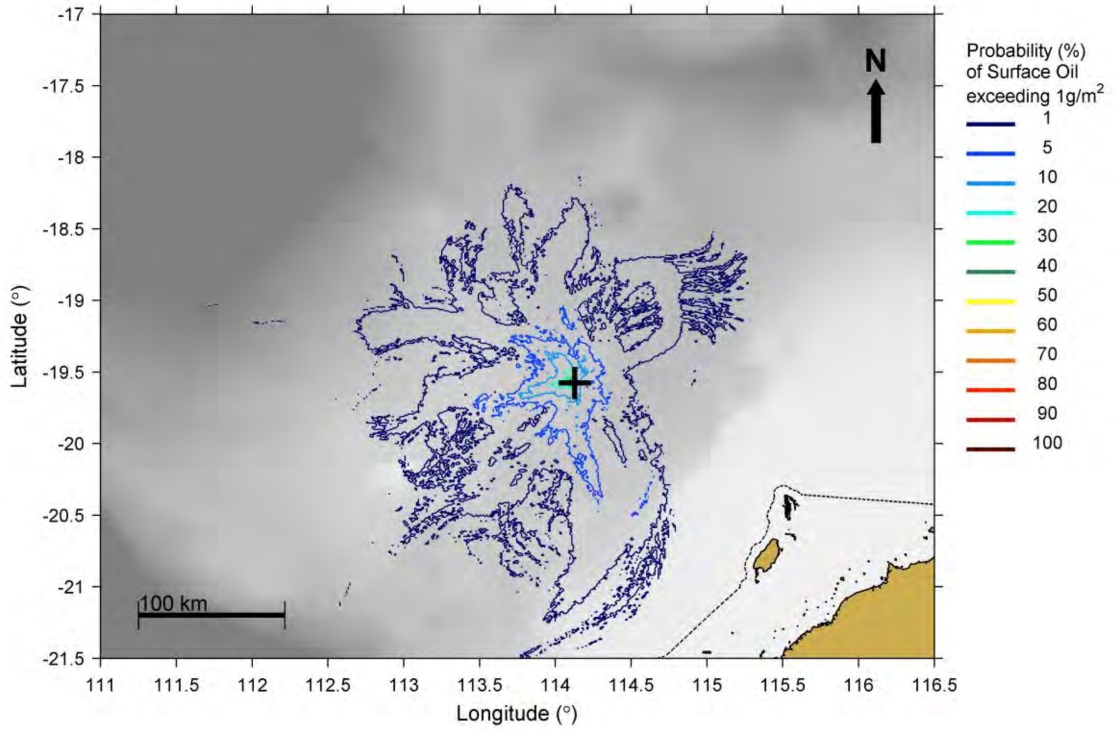
3.1.3 Winter

Surface Slicks and Films

Table 3-5: Summary of shoreline risks for different locations from a 2.5 m³ spill of diesel on the water surface at the Chandon Well commencing during winter months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m²)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m²)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold



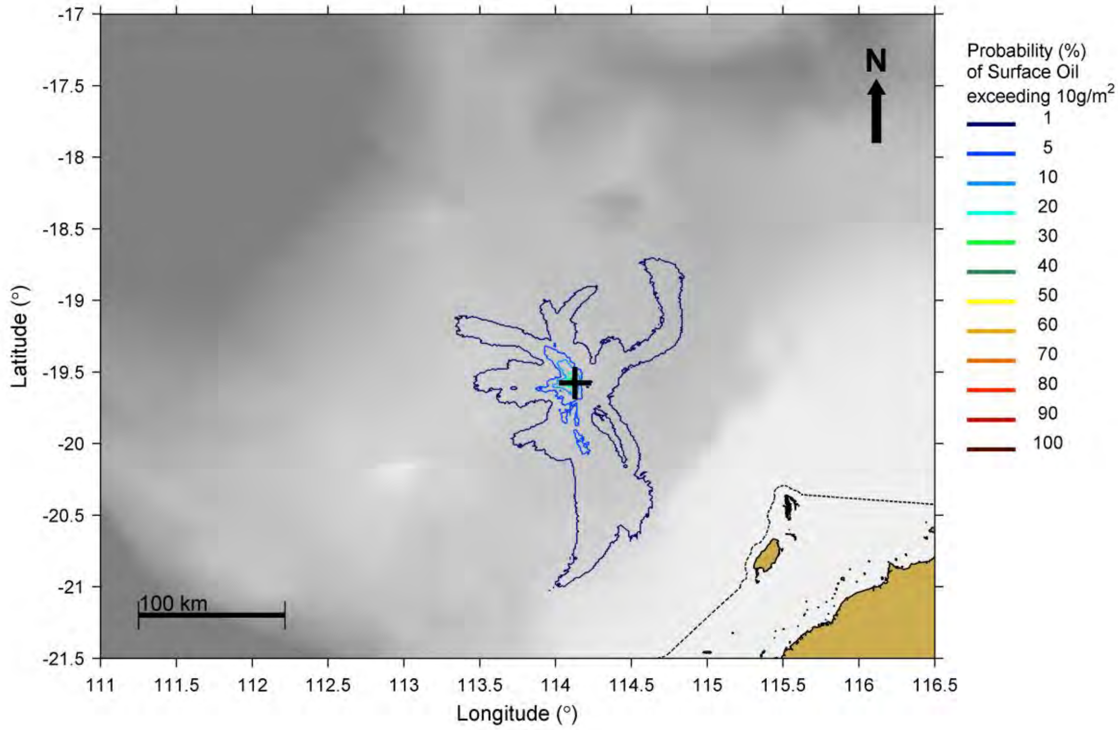


Figure 3-5: Predicted probability of sea surface contact to concentrations above 1 g/m^2 (top) and 10 g/m^2 (bottom) resulting from a 2.5 m^3 spill of diesel on the water surface at the Chandon Well commencing during winter months. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-6: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from a 2.5 m³ spill of diesel on the water surface at the Chandon Well commencing during winter months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

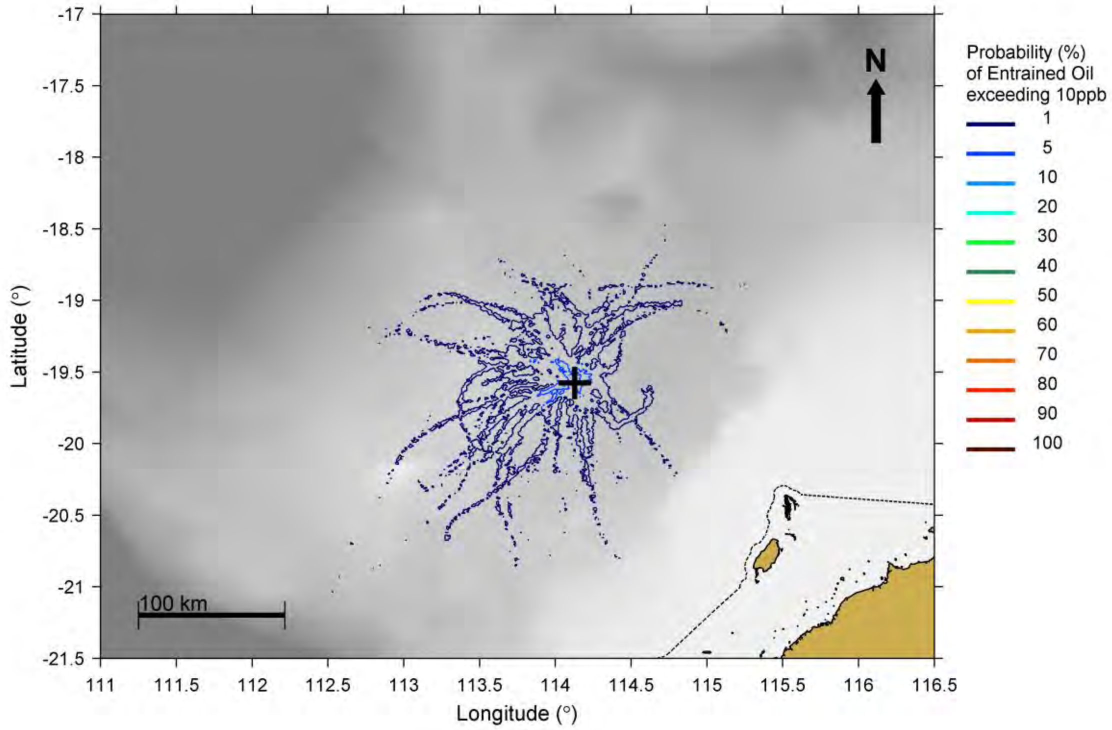


Figure 3-6: Predicted probability of entrained concentrations above 10 ppb resulting from a 2.5 m³ spill of diesel on the water surface at the Chandon Well commencing during winter months. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

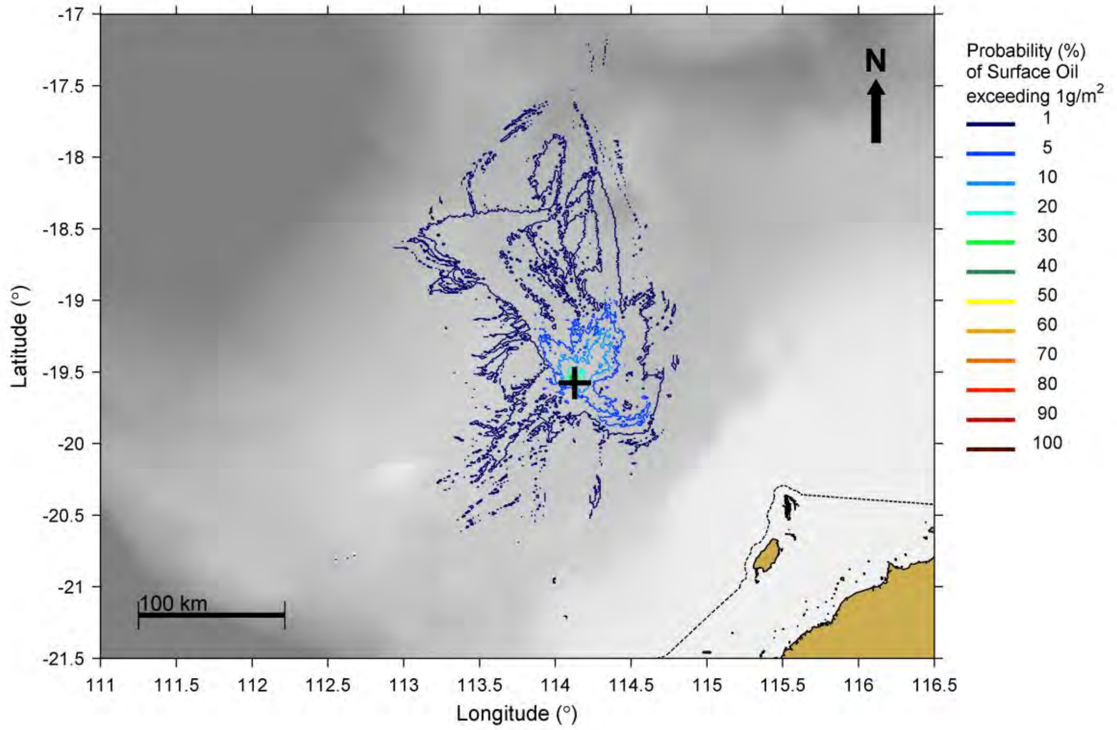
3.1.4 Spring

Surface Slicks and Films

Table 3-7: Summary of shoreline risks for different locations from a 2.5 m³ spill of diesel on the water surface at the Chandon Well commencing during the spring month. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m²)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m²)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold



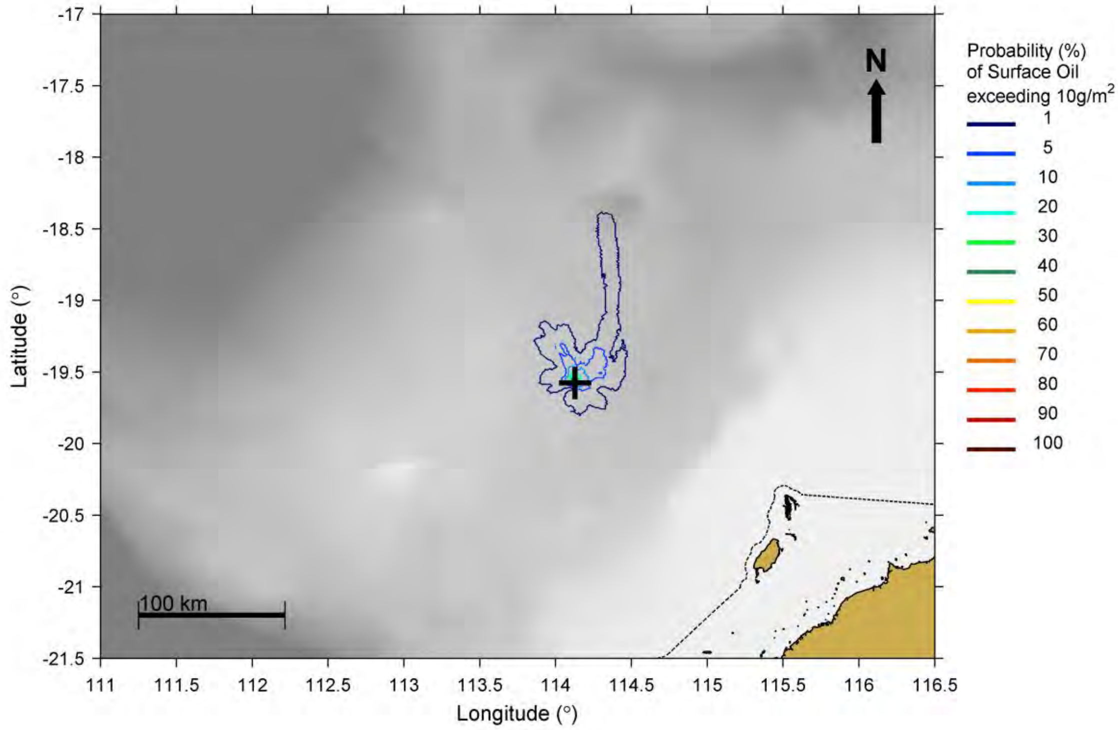


Figure 3-7: Predicted probability of sea surface contact to concentrations above 1 g/m² (top) and 10 g/m² (bottom) resulting from a 2.5 m³ spill of diesel on the water surface at the Chandon Well commencing during the spring months. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-8: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from a 2.5 m³ spill of diesel on the water surface at the Chandon Well commencing during the spring months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

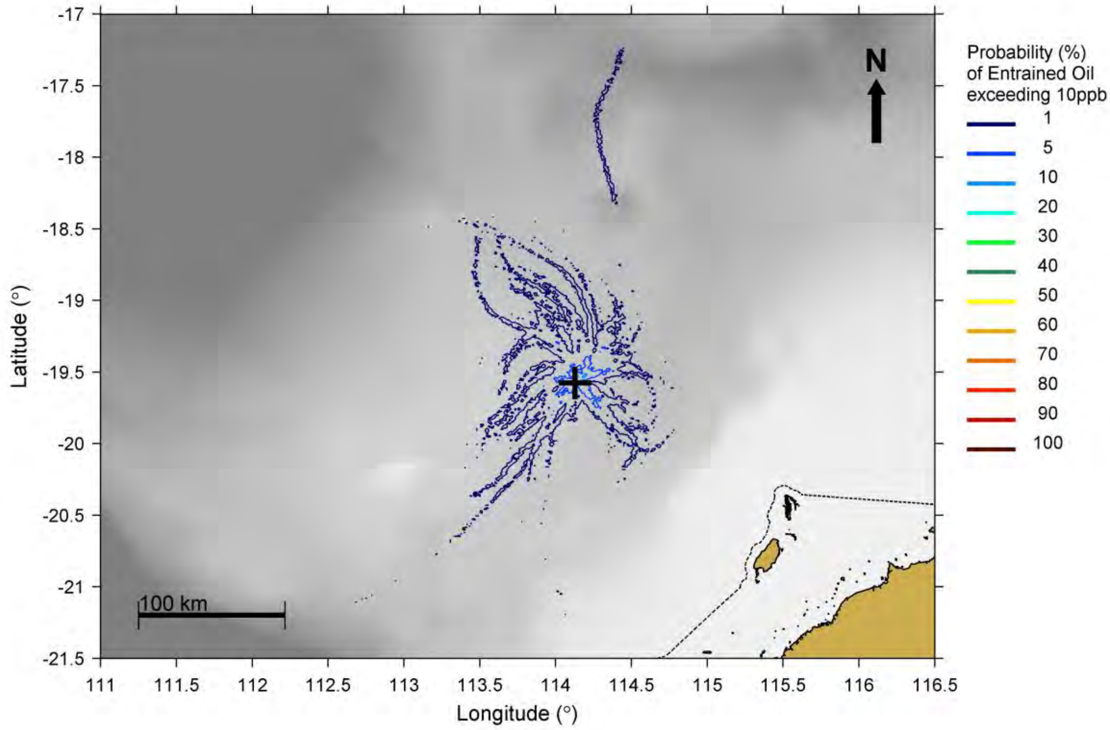


Figure 3-8: Predicted probability of entrained concentrations above 10 ppb (top) resulting from a 2.5 m^3 spill of diesel on the water surface at the Chandon Well commencing during spring months. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

3.2 Simulation of 80 m^3 surface diesel spill at the Chandon Well

This scenario investigated the probability of exposure to surrounding regions by oil due to an 80 m^3 surface spill of diesel over 6 hours at the Chandon Well location. Result figures and tables are presented for each of the seasons in the following sections.

As expected, surface oil was predicted to drift in similar directions to those predicted for the 2.5 m^3 diesel scenario. Highest probabilities are for drift to the west-northwest during summer (Figure 3-9, Figure 3-10), west and southwest during autumn (Figure 3-13, Figure 3-14), west and northwest during winter (Figure 3-17, Figure 3-18) and north-northwest during spring (Figure 3-21, Figure 3-22). Surface oil > 1 g/m² is unlikely (< 1% probability) to contact any shorelines during each of the seasons (Table 3-9, Table 3-11, Table 3-13, and Table 3-15). Low probabilities (≤ 1%) are predicted for oil > 10 g/m² to occur on the water surface within 100 km of the spill site.

Entrained oil > 10 ppb is forecast to occur in waters over a larger region than surface oil > 1 g/m², during each of the seasons. Low to moderate probabilities for drift towards the south-southwest to southwest are indicated during each season, with drift towards the west-northwest also likely during summer (Figure 3-11, Figure 3-12). Trajectories in the north to north-northeast direction are also indicated for the autumn (Figure 3-15, Figure 3-16), winter (Figure 3-19, Figure 3-20) and spring (Figure 3-23, Figure 3-24) scenarios.

If an 80 m^3 spill of diesel were to occur during the spring month, modelling predicts a 1% chance of entrained oil > 10 ppb and 100 ppb contacting waters bordering the Ningaloo Coast, with a minimum time to shoreline of approximately 12 days (Table 3-16). A maximum short-term concentration of 120 ppb is also forecast for this shoreline. Entrained oil > 10 ppb is unlikely (< 1% chance) to be present in waters bordering any other shoreline during each of the seasons (Table 3-10, Table 3-12, Table 3-14).

Aromatic hydrocarbon concentrations > 5 ppb are not forecast to occur > 100km from the spill site, and consequently no shoreline contact was predicted above 5 ppb during any of the seasons. Dissolved aromatic concentrations were not predicted to exceed 50 ppb, averaged at the scale of the model grid.

3.2.1 Summer

Surface Slicks and Films

Table 3-9: Summary of shoreline risks for different locations from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during summer months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m²)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m²)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

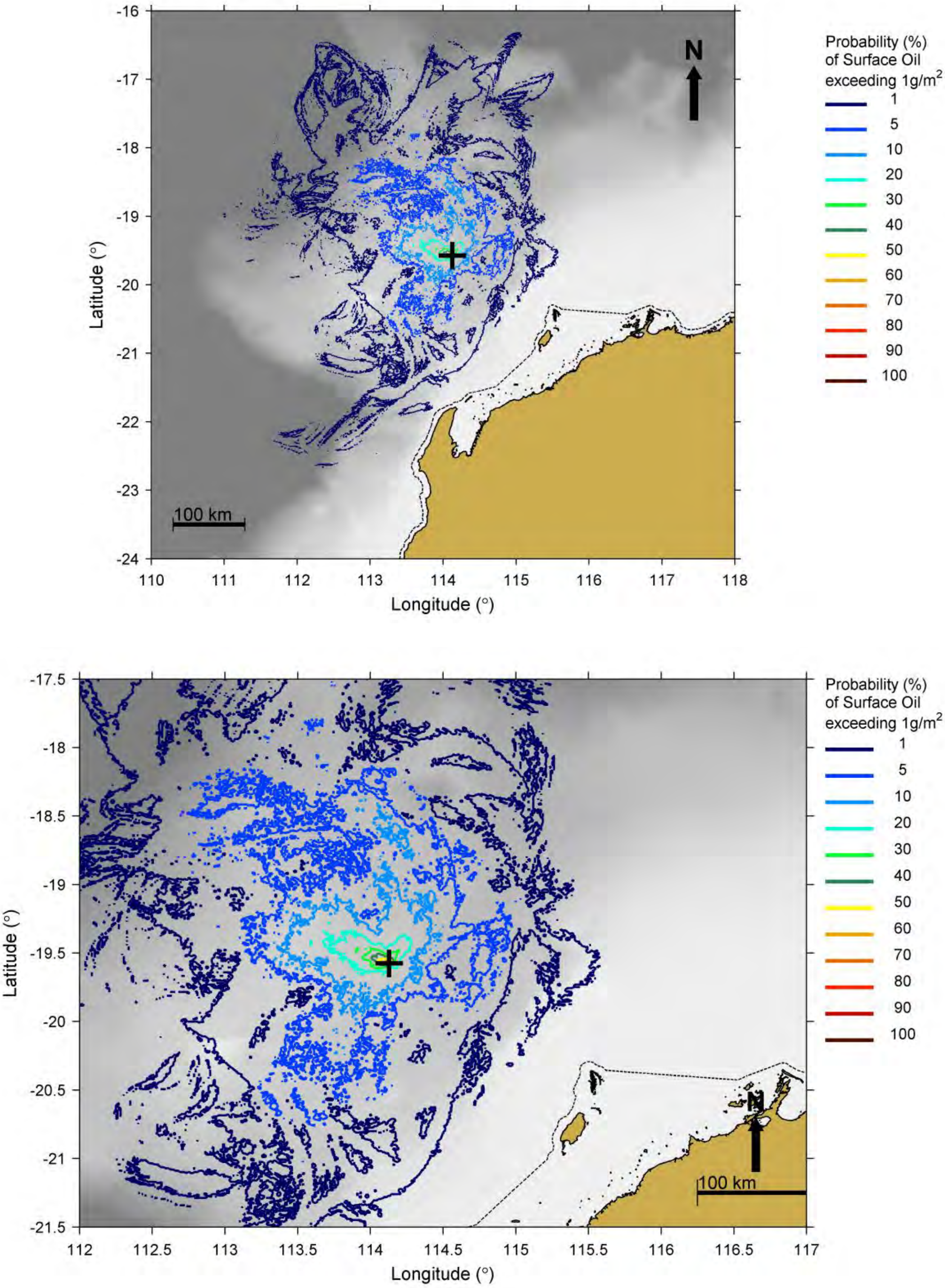


Figure 3-9: Predicted probability of sea surface contact to concentrations above 1 g/m^2 resulting from an 80 m^3 spill of diesel on the water surface at the Chandon Well commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

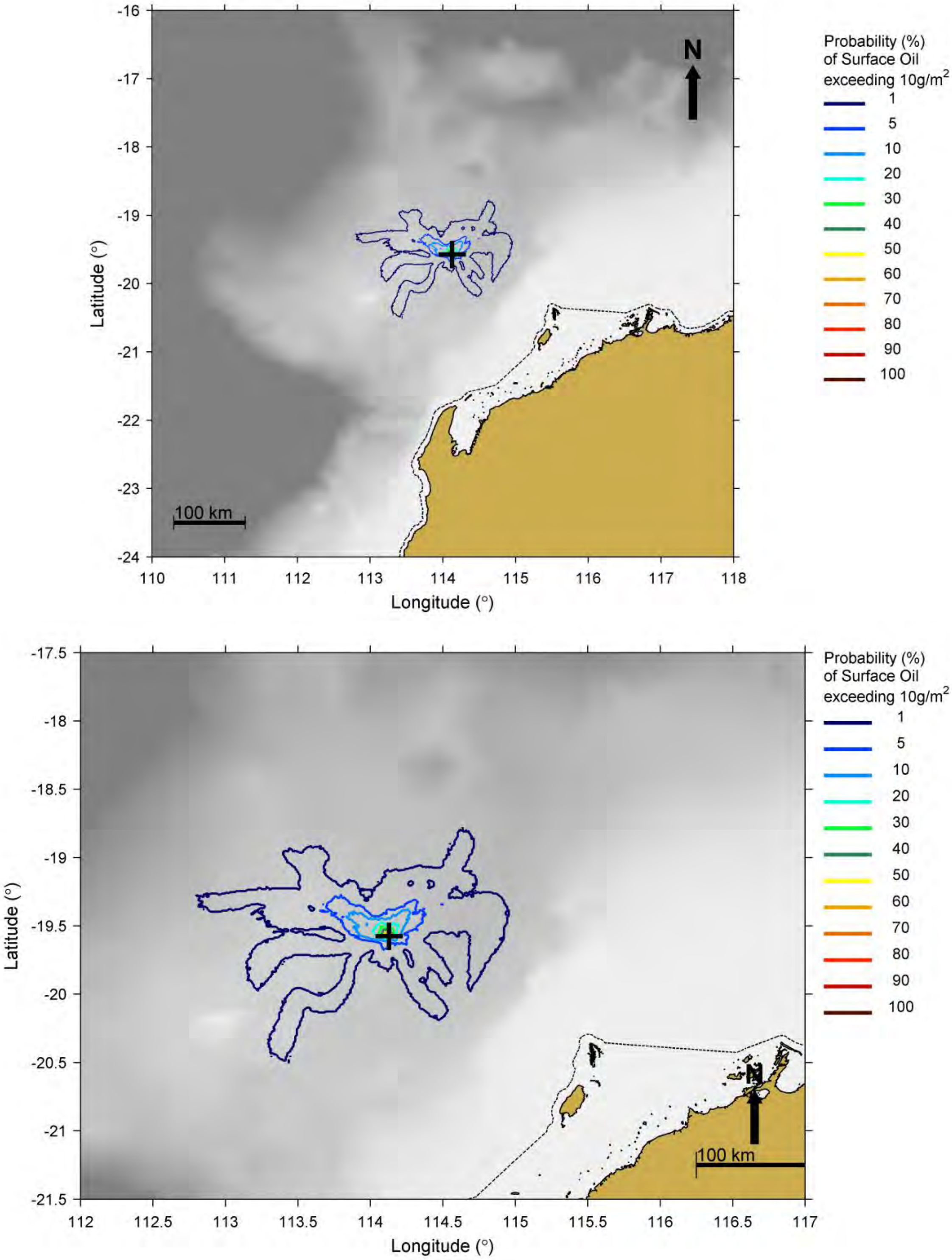


Figure 3-10: Predicted probability of sea surface contact to concentrations above 10 g/m² resulting from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-10: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during summer months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

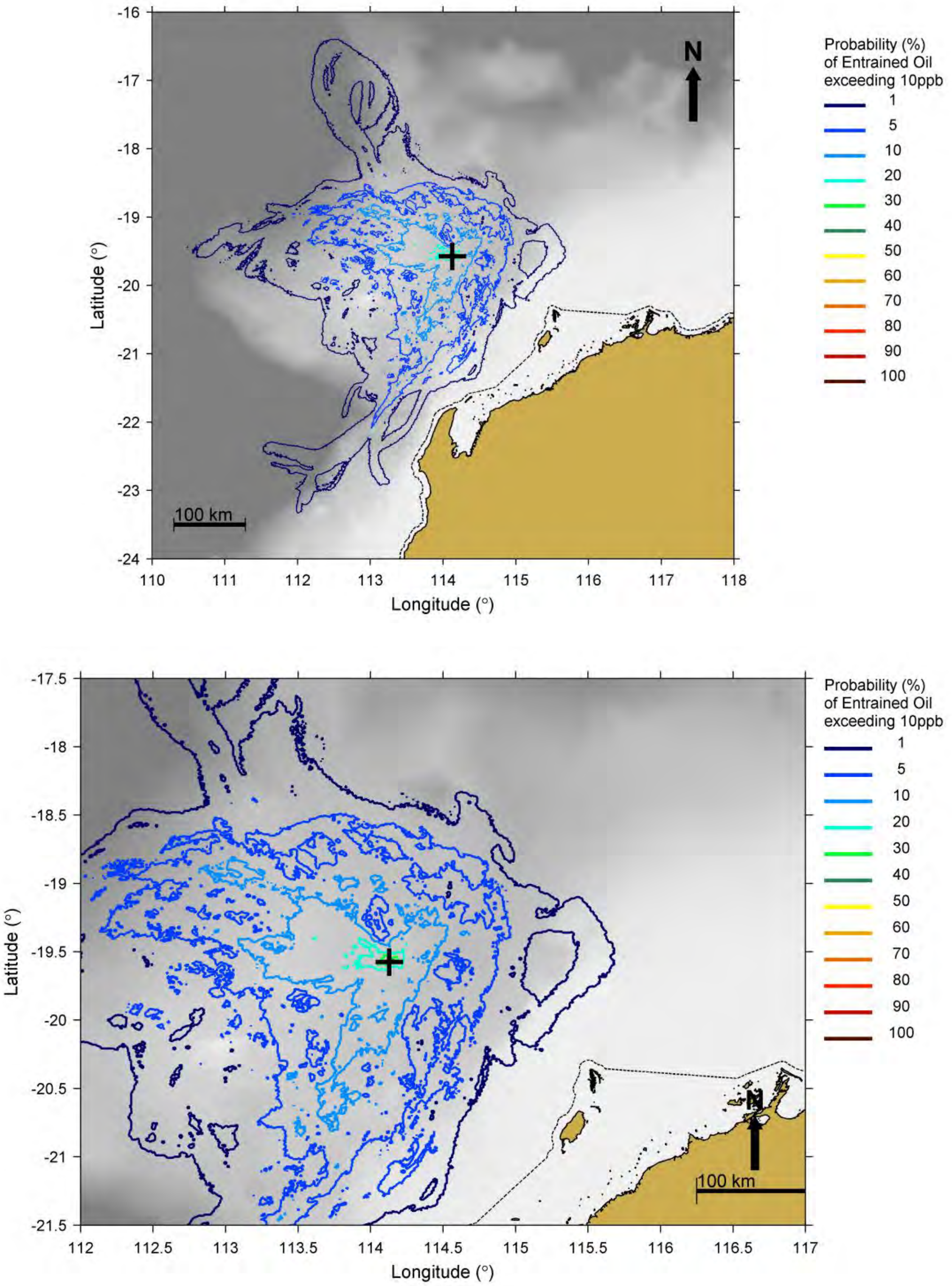


Figure 3-11: Predicted probability of entrained concentrations above 10 ppb resulting from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

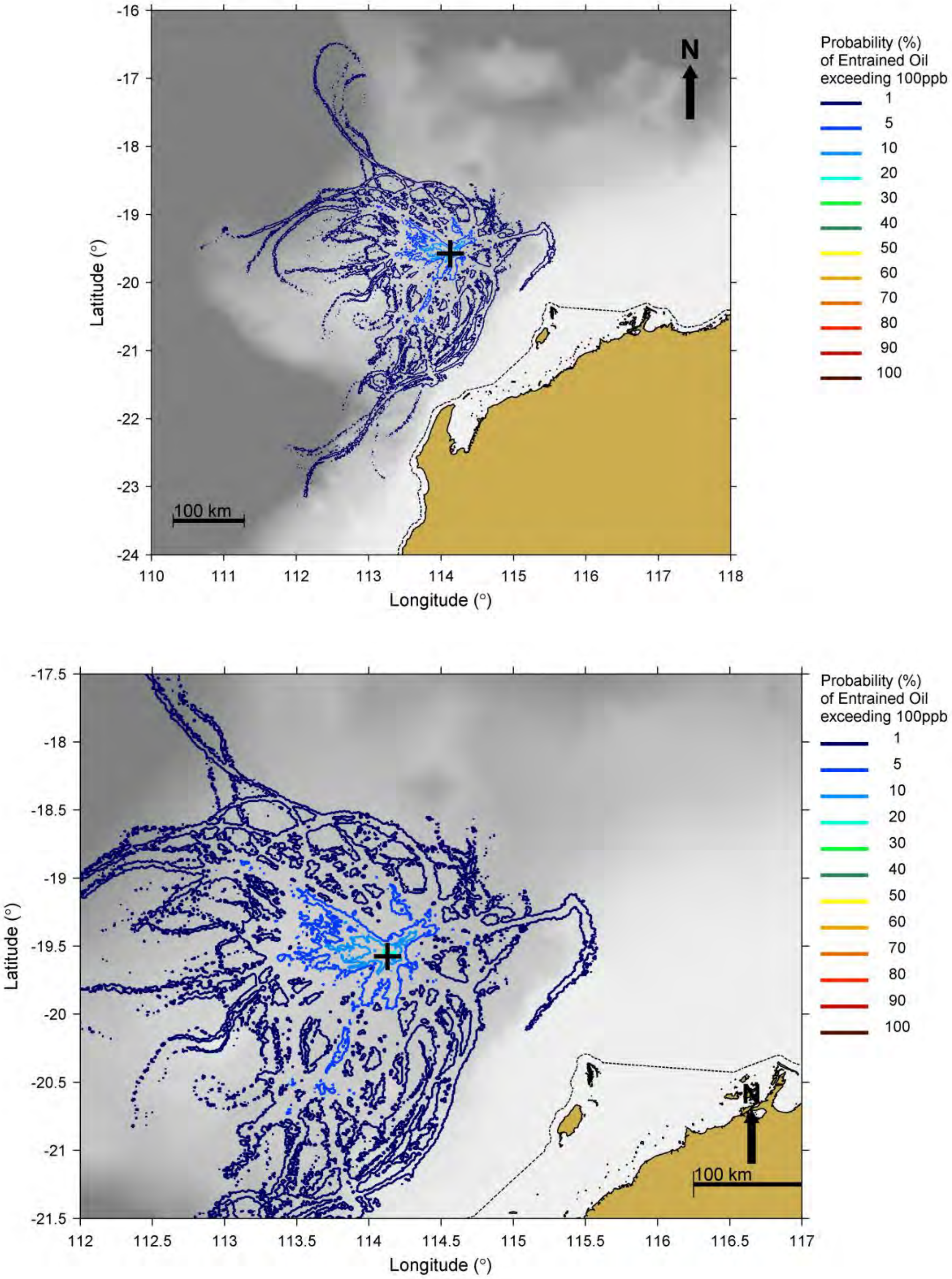


Figure 3-12: Predicted probability of entrained concentrations above 100 ppb resulting from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

3.2.2 Autumn

Surface Slicks and Films

Table 3-11: Summary of shoreline risks for different locations from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during autumn months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m²)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m²)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

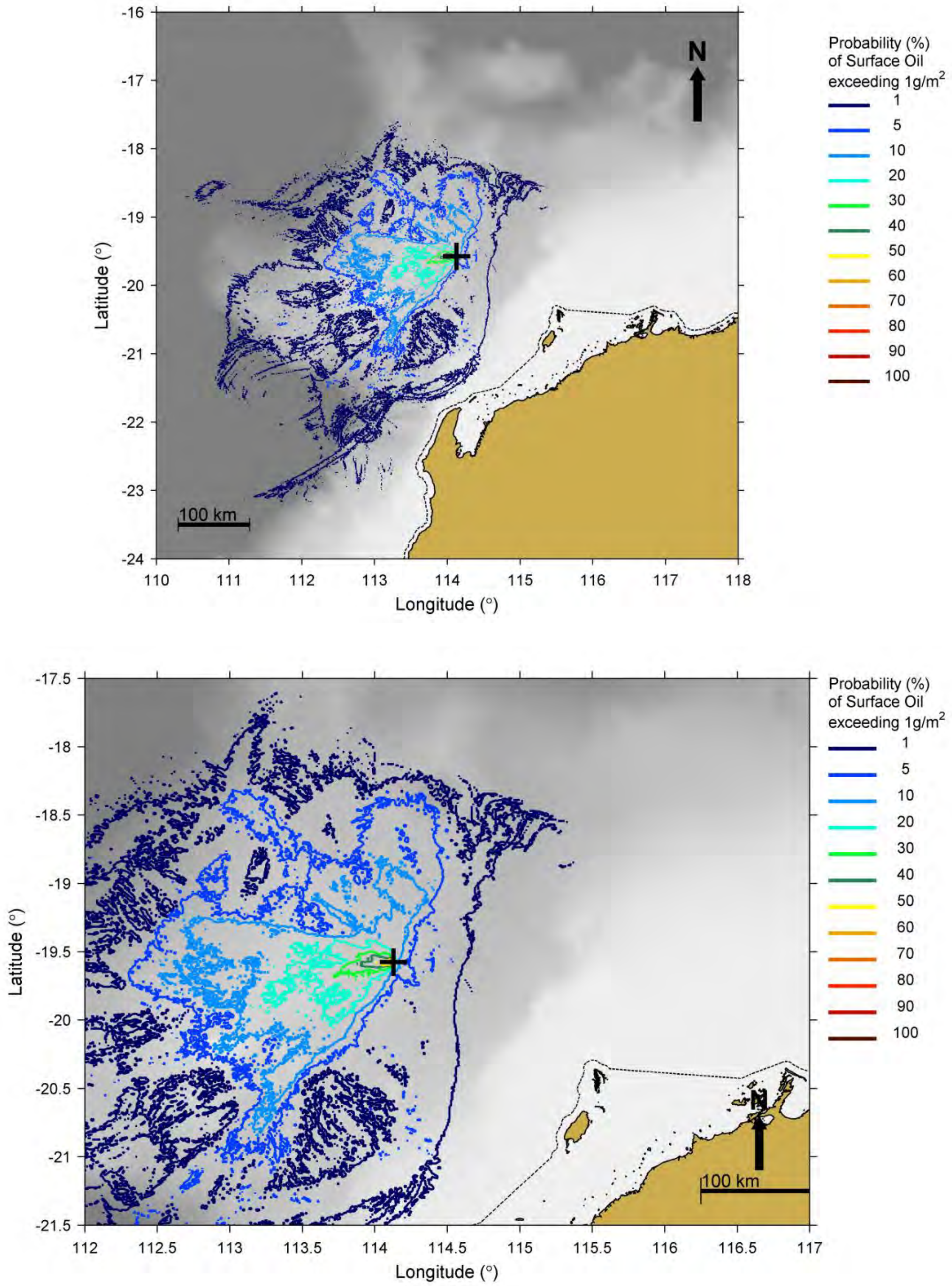
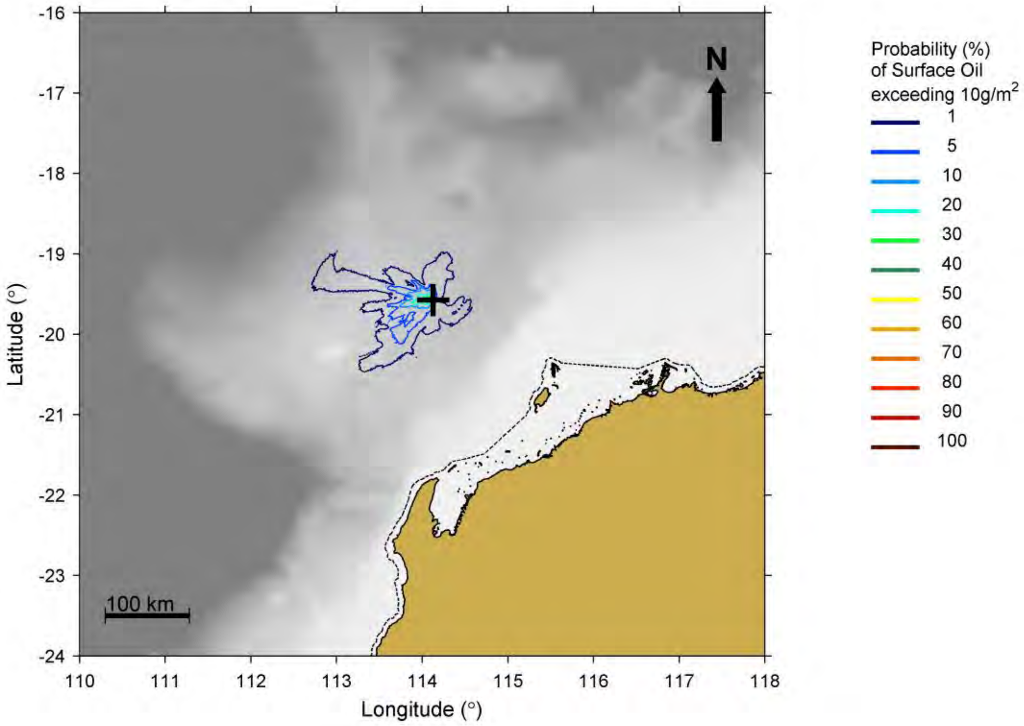


Figure 3-13: Predicted probability of sea surface contact to concentrations above 1 g/m² resulting from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.



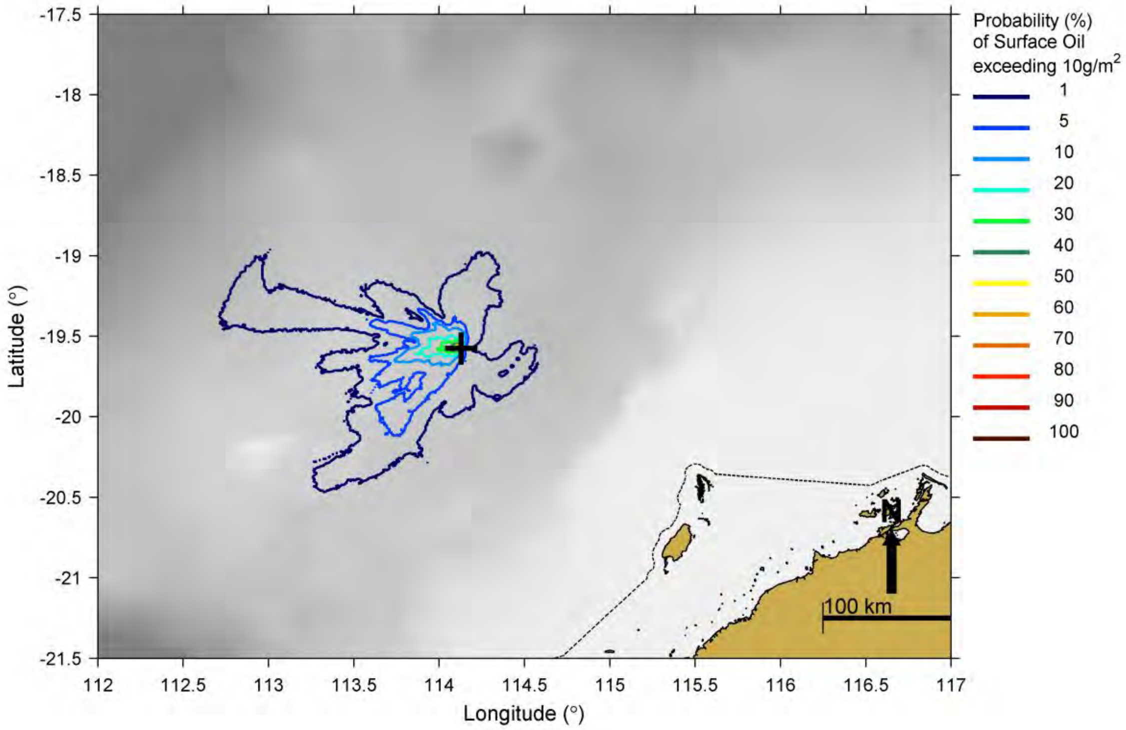


Figure 3-14: Predicted probability of sea surface contact to concentrations above 10 g/m^2 resulting from an 80 m^3 spill of diesel on the water surface at the Chandon Well commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-12: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during the autumn months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

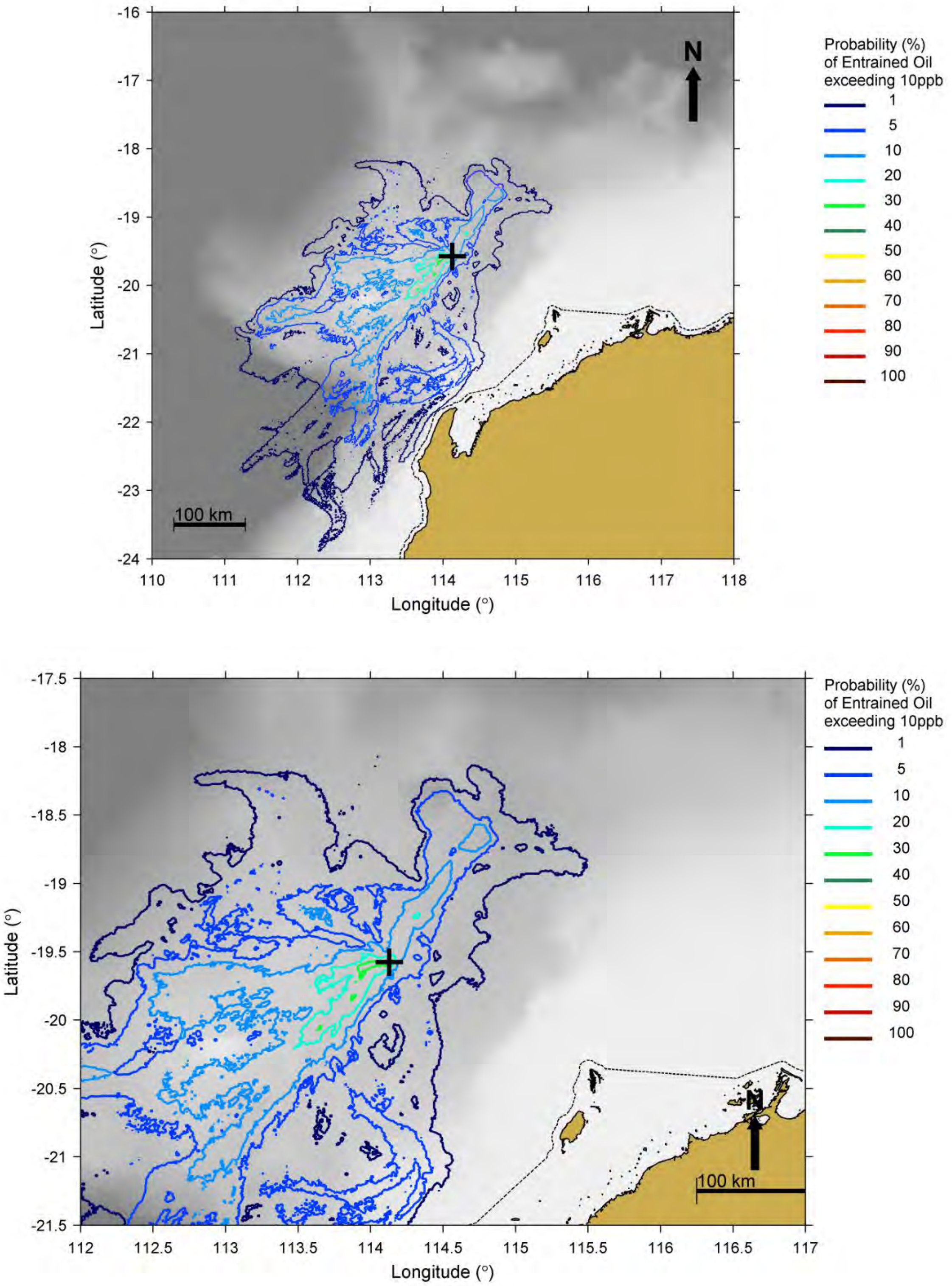


Figure 3-15: Predicted probability of entrained concentrations above 10 ppb resulting from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

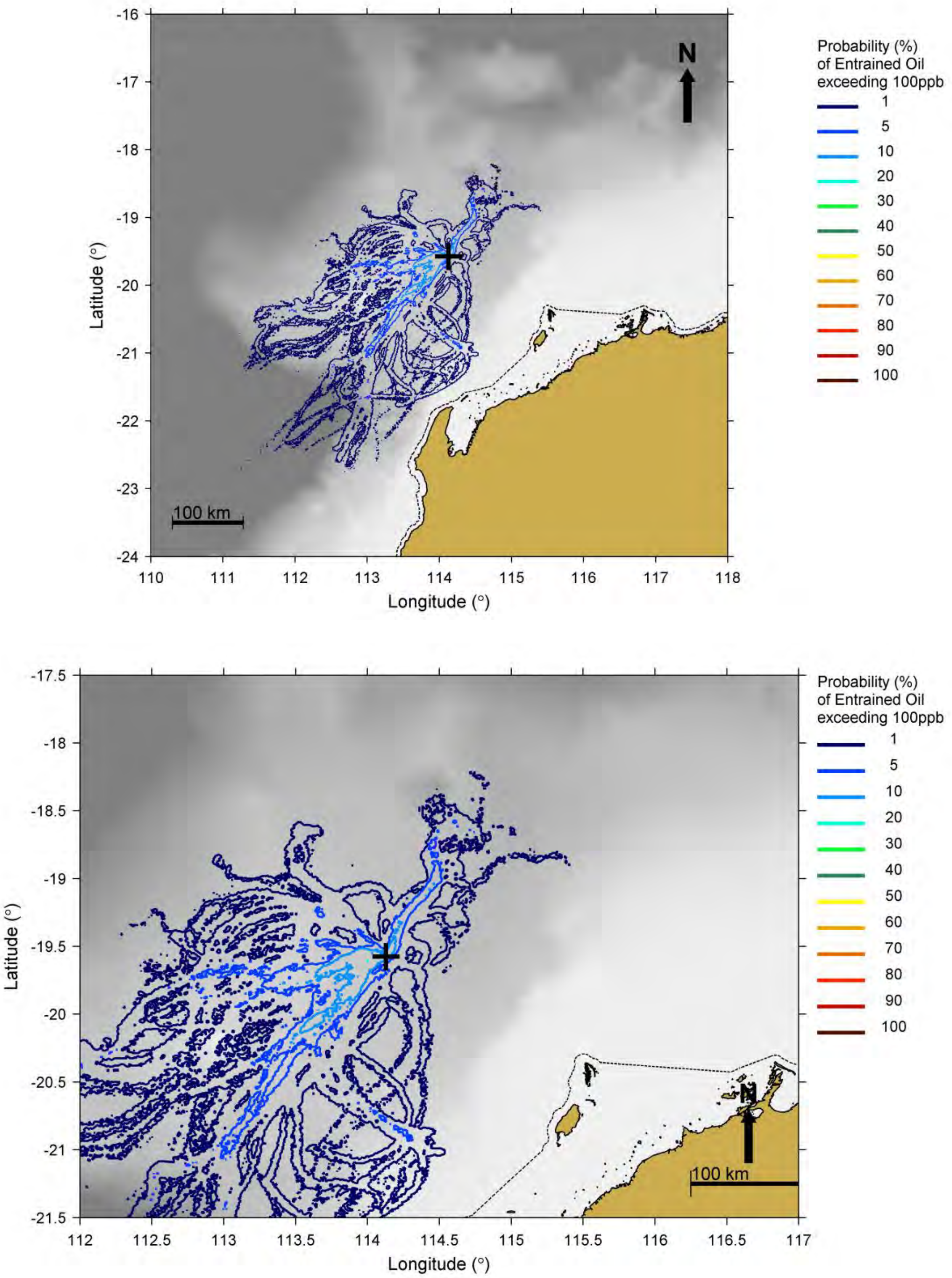


Figure 3-16: Predicted probability of entrained concentrations above 100 ppb resulting from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

3.2.3 Winter

Surface Slicks and Films

Table 3-13: Summary of shoreline risks for different locations from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during winter months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

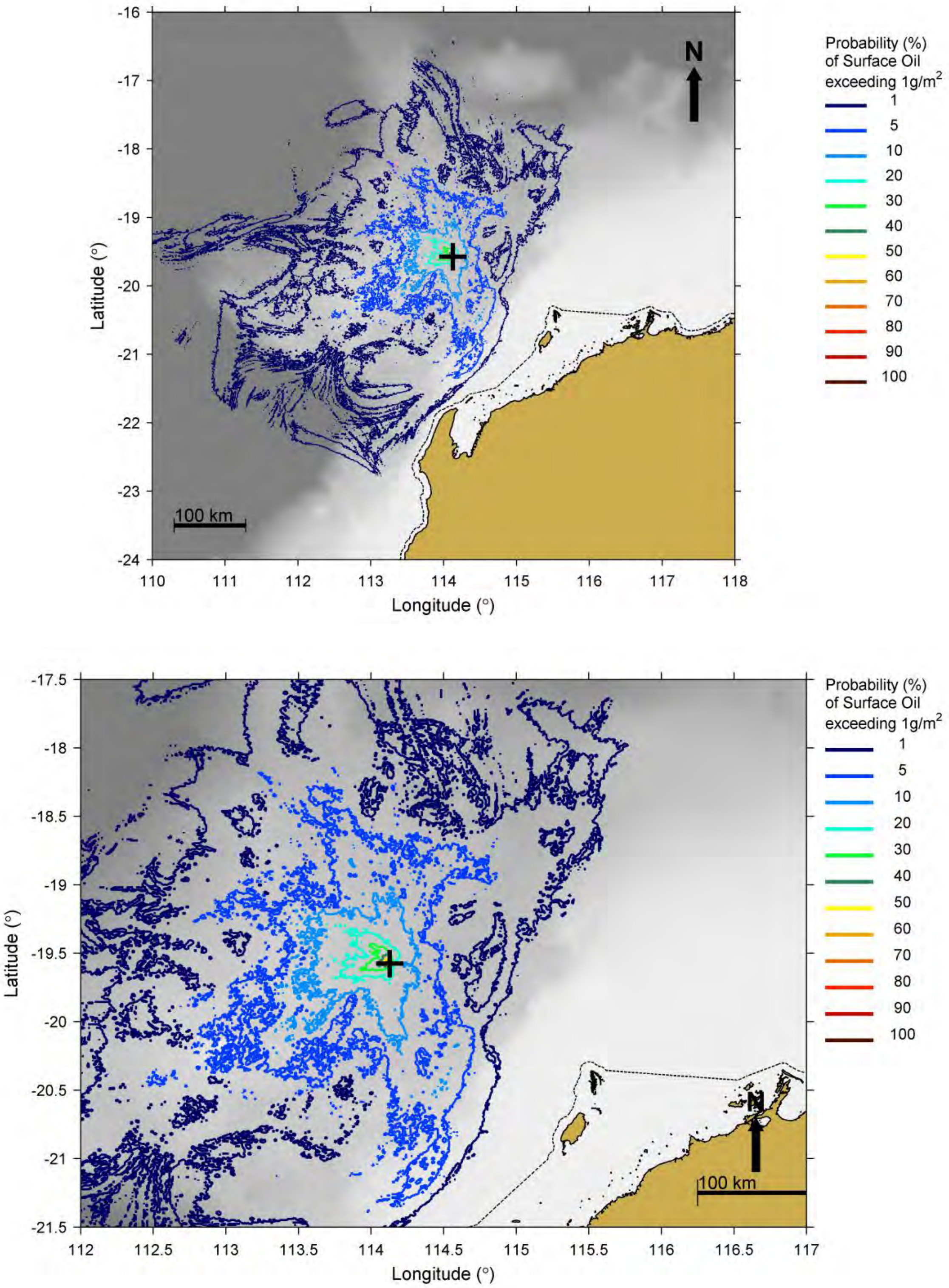


Figure 3-17: Predicted probability of sea surface contact to concentrations above 1 g/m^2 resulting from an 80 m^3 spill of diesel on the water surface at the Chandon Well commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

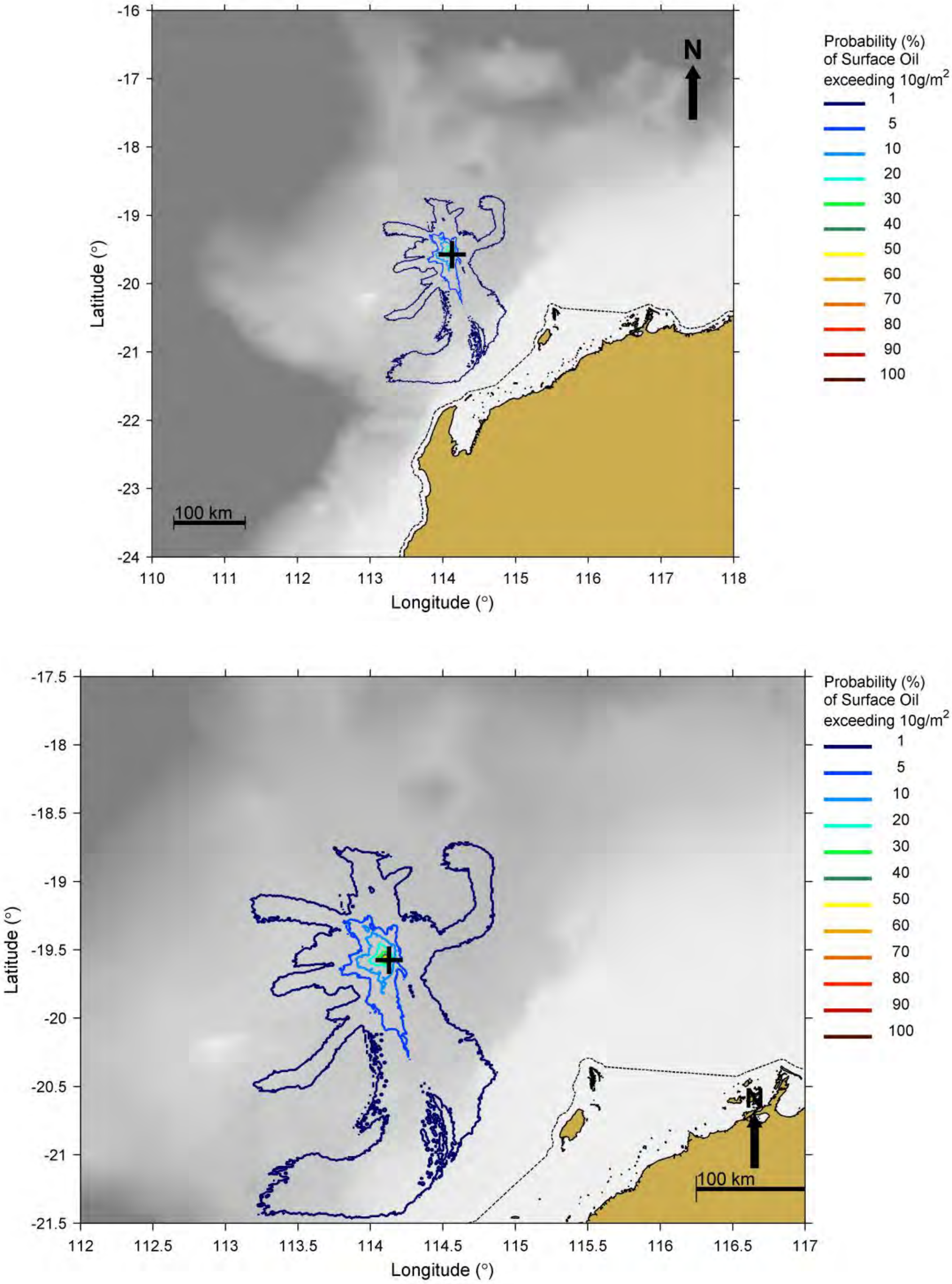


Figure 3-18: Predicted probability of sea surface contact to concentrations above 1 g/m² (top) and 10 g/m² (bottom) resulting from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-14: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during winter months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

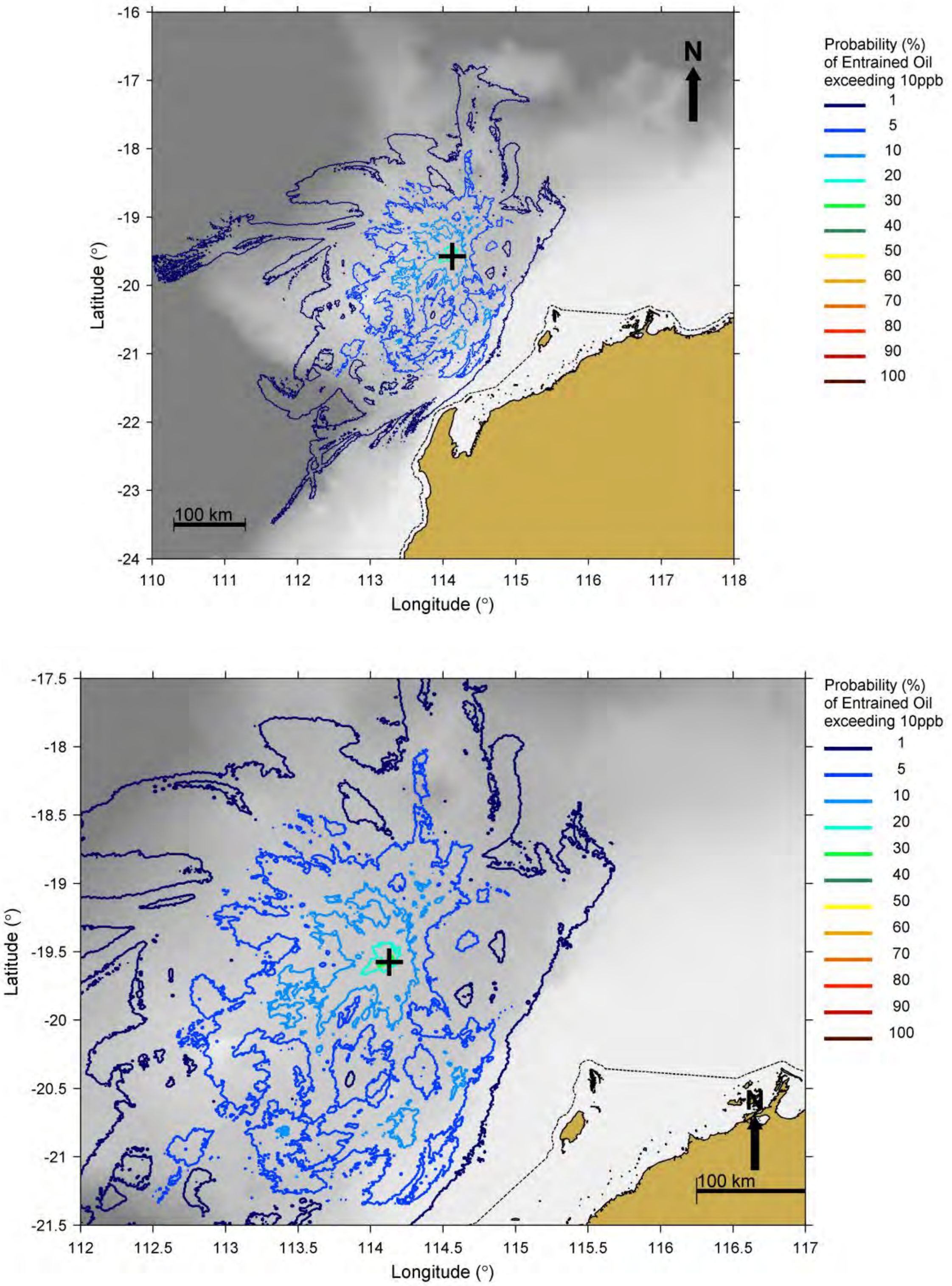


Figure 3-19: Predicted probability of entrained concentrations above 10 ppb resulting from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

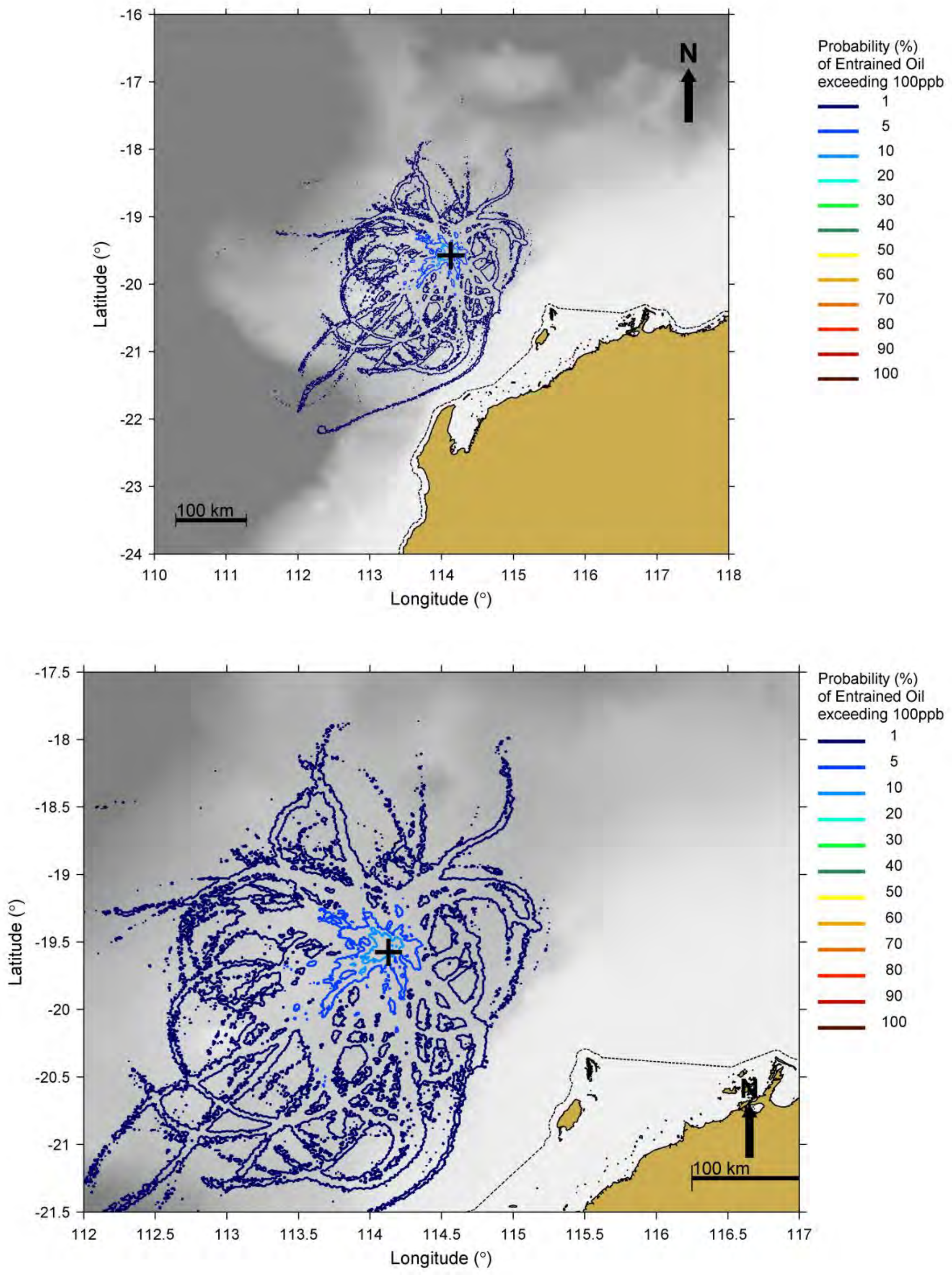


Figure 3-20: Predicted probability of entrained concentrations above 100 ppb resulting from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

3.2.4 Spring

Surface Slicks and Films

Table 3-15: Summary of shoreline risks for different locations from an 80 m^3 spill of diesel on the water surface at the Chandon Well commencing during spring months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m^2 at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m^2 at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m^2	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m^2	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

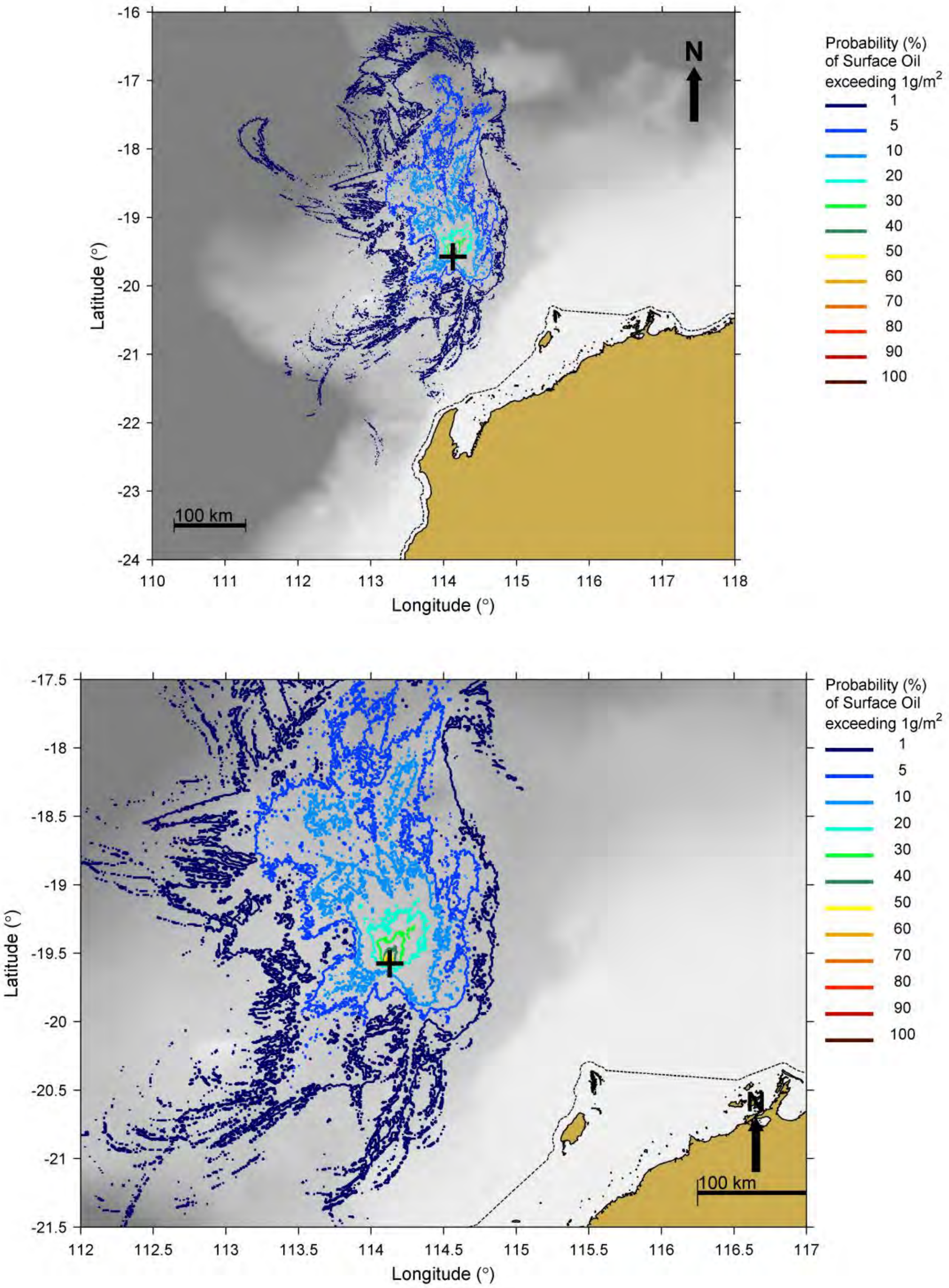


Figure 3-21: Predicted probability of sea surface contact to concentrations above 1 g/m² resulting from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

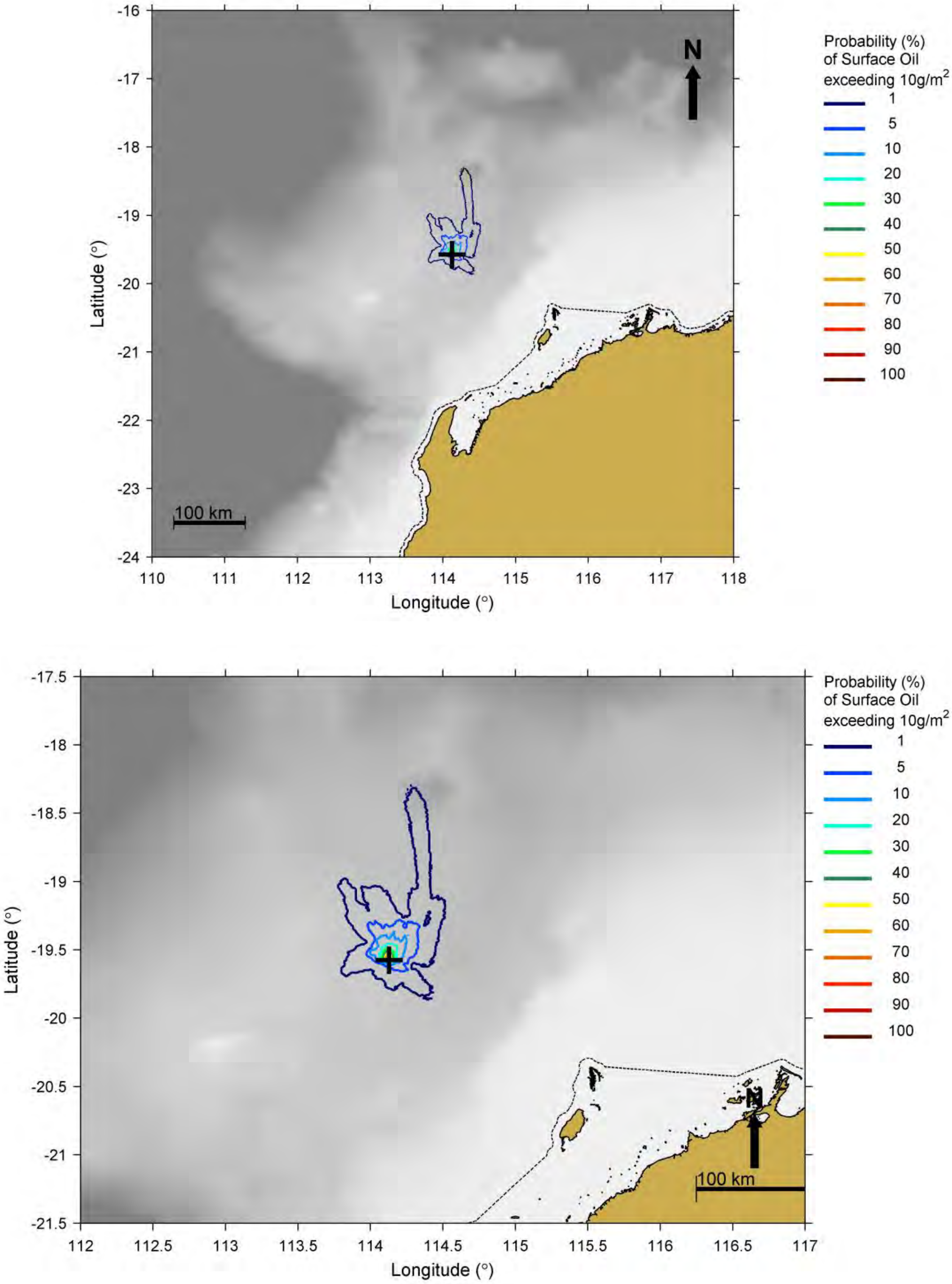


Figure 3-22: Predicted probability of sea surface contact to concentrations above 1 g/m^2 (top) and 10 g/m^2 (bottom) resulting from an 80 m^3 spill of diesel on the water surface at the Chandon Well commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-16: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during spring months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	1	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	1	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	12	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	14	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	< 10	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	120	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

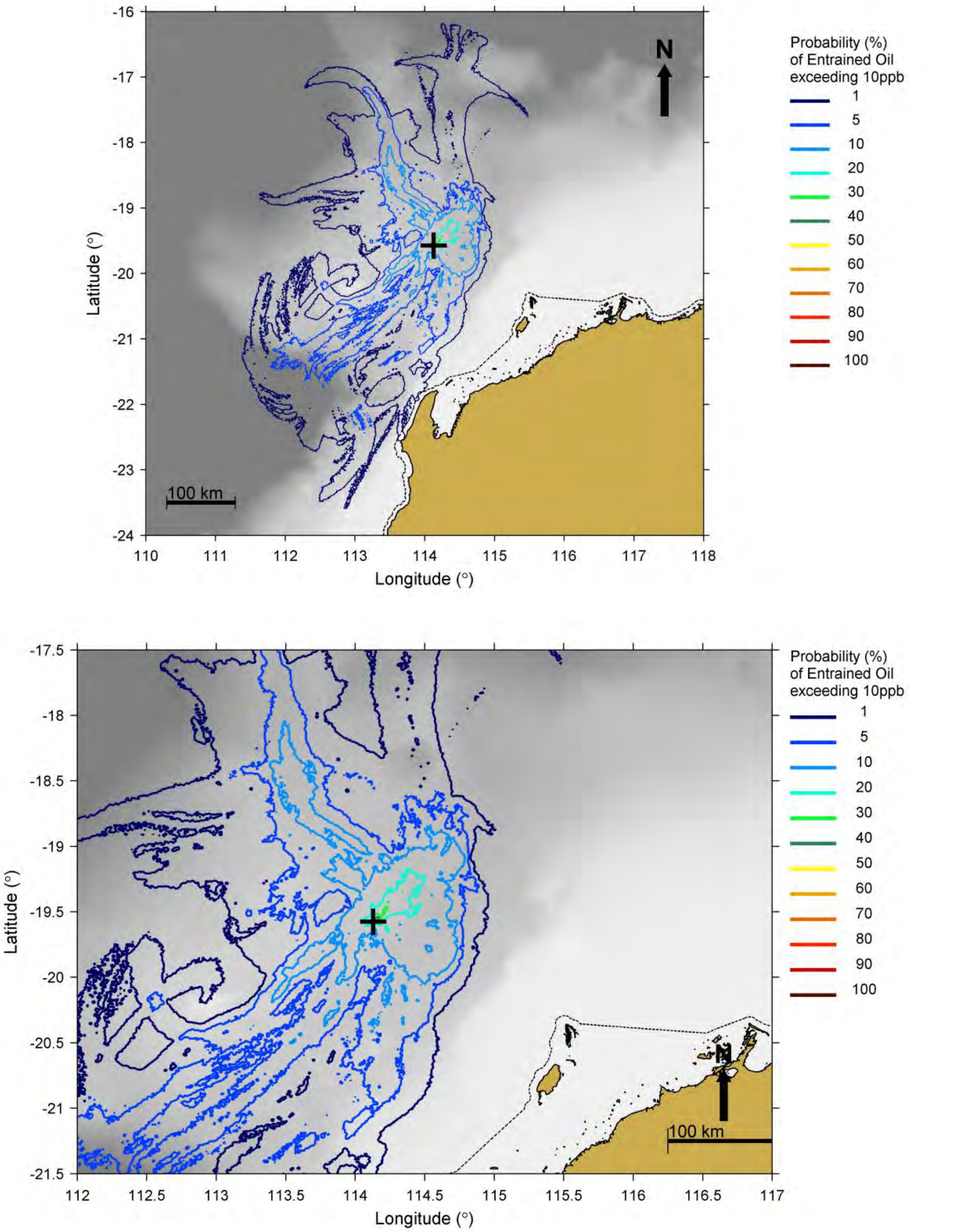


Figure 3-23: Predicted probability of entrained concentrations above 10 ppb resulting from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

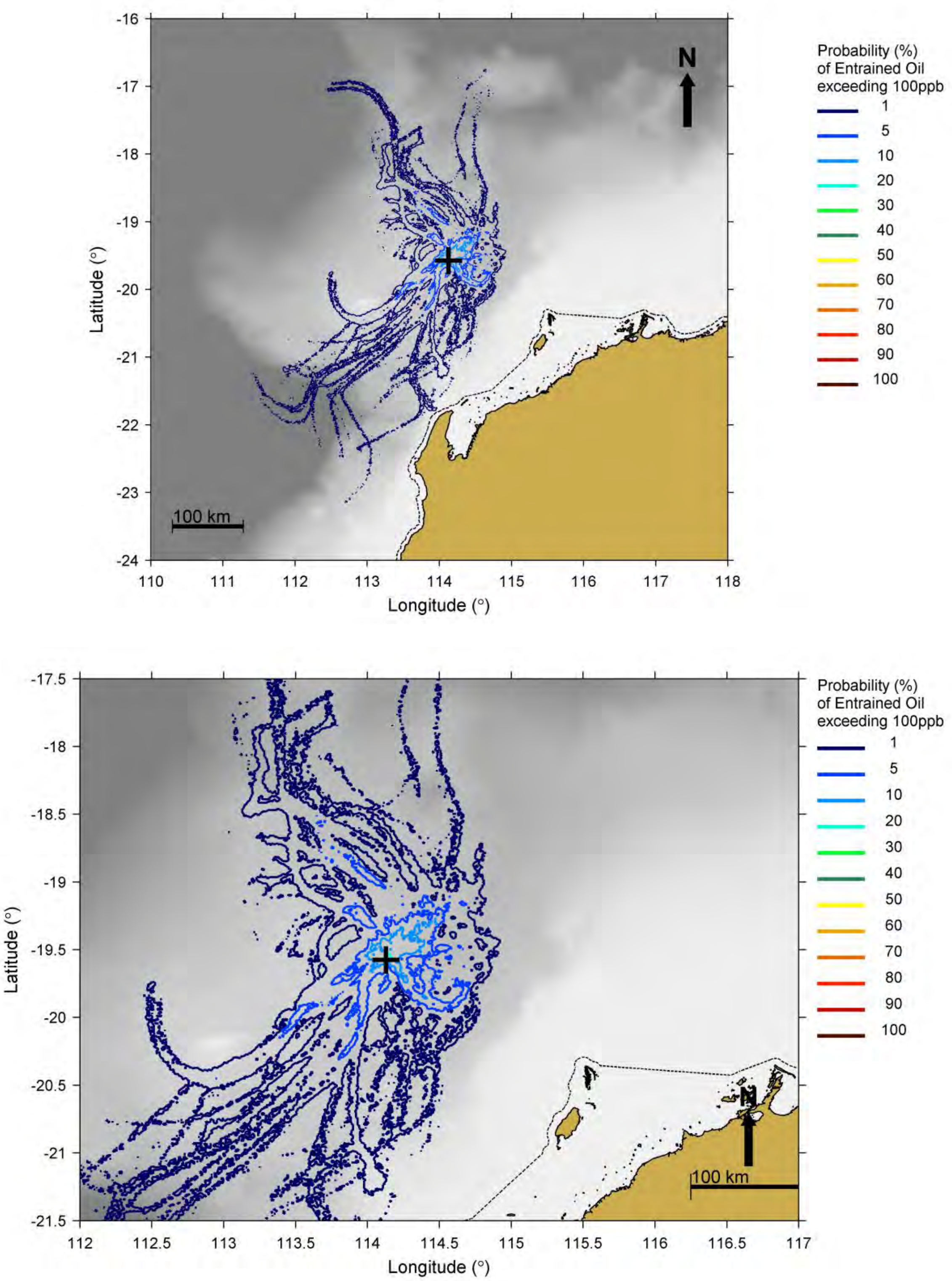


Figure 3-24: Predicted probability of entrained concentrations above 100 ppb resulting from an 80 m³ spill of diesel on the water surface at the Chandon Well commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

3.3 Simulation of pipeline rupture at seabed at the Chandon Manifold

This scenario investigated the probability of exposure to the surrounding regions by oil due to a short-term pipeline rupture at the seabed (1,200 m depth), at the Chandon Manifold. The Manifold is at the same location as the Chandon Well. Figures and tables of results are presented for each of the seasons in the following sections.

Surface oil contours at the 1 g/m^2 threshold show a smaller area of effect than the 80 m^3 diesel spill scenario. The stochastic modelling indicates low to moderate probabilities (< 30%) for oil to occur on the water surface at concentrations > 1 g/m^2 during each of the seasons. The 1% contour does not extend further than approximately 300 km from the spill site in any direction during each of the seasonal scenarios (Figure 3-25, Figure 3-29, Figure 3-33, Figure 3-37). Similarly, there is only 1% probability of oil > 10 g/m^2 extending more than 300 km from the spill site (Figure 3-26, Figure 3-30, Figure 3-34, Figure 3-38). Surface oil above this threshold is therefore unlikely (< 1% chance) to contact any of the surrounding shorelines (Table 3-17, Table 3-19, Table 3-21, Table 3-23).

Modelling predicts oil entrained in the water column will most likely drift towards the south-southwest to southwest during each of the seasons, with longest trajectories in this direction forecasted for the autumn scenario (Figure 3-31, Figure 3-32). Trajectories towards the north-northwest are also indicated for the summer (Figure 3-27, Figure 3-28), winter (Figure 3-35, Figure 3-36) and spring scenarios (Figure 3-39, Figure 3-40).

A low probability (1%) for entrained oil > 10 ppb to reach waters bordering the Ningaloo Coast is predicted in the spring scenario (Table 3-24). Earliest times for entrained oil to arrive at this shoreline are forecasted to be approximately 13 days, indicating that the oil is likely to be highly weathered when it reaches the shoreline.. A maximum potential short-term concentration of 60 ppb is also indicated for this shoreline during spring. Entrained oil is unlikely (< 1% chance) to be present adjacent to any other shoreline during any season (Table 3-18, Table 3-20, Table 3-22).

Dissolved aromatic hydrocarbons are not predicted (< 1% probability) to be present at concentrations > 5ppb during any season, averaged at the scale of the model grid.

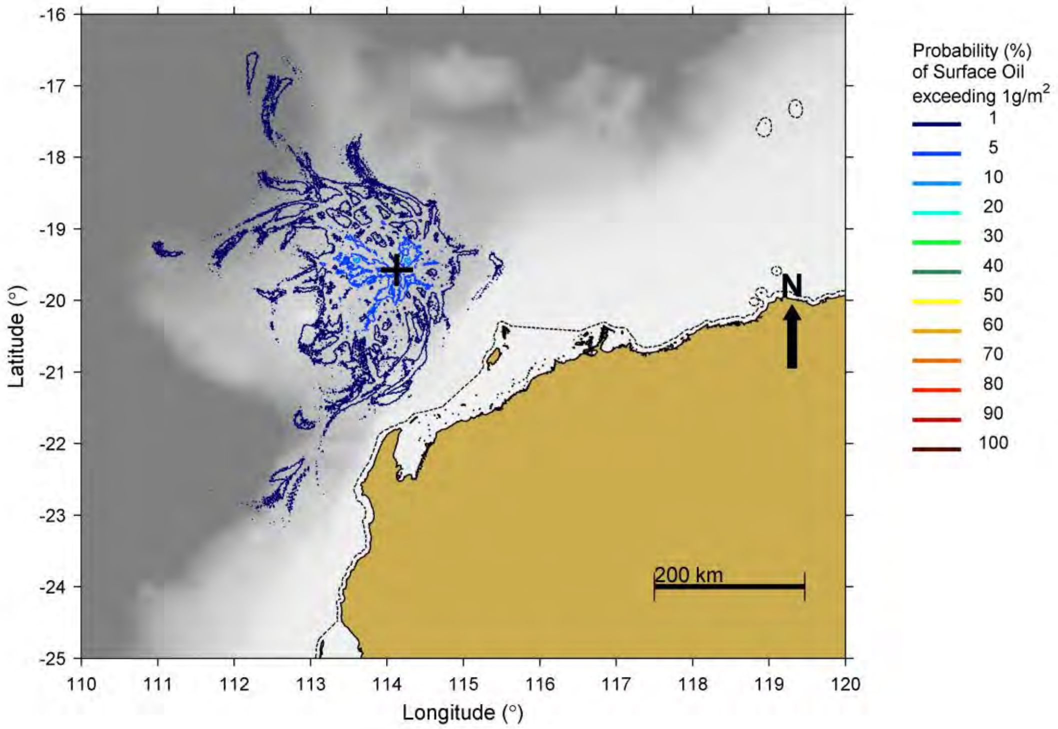
3.3.1 Summer

Surface Slicks and Films

Table 3-17: Summary of shoreline risks for different locations from a pipeline rupture at the seabed at the Chandon Manifold commencing during summer months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold



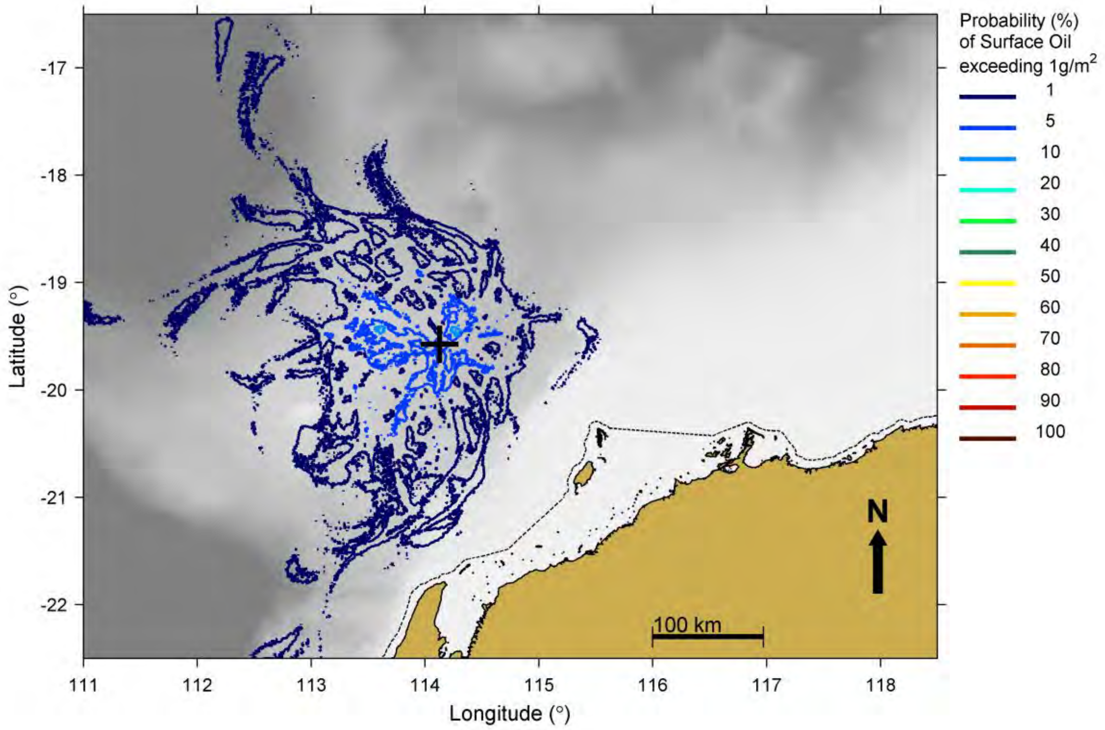


Figure 3-25: Predicted probability of sea surface contact to concentrations above 1 g/m^2 resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

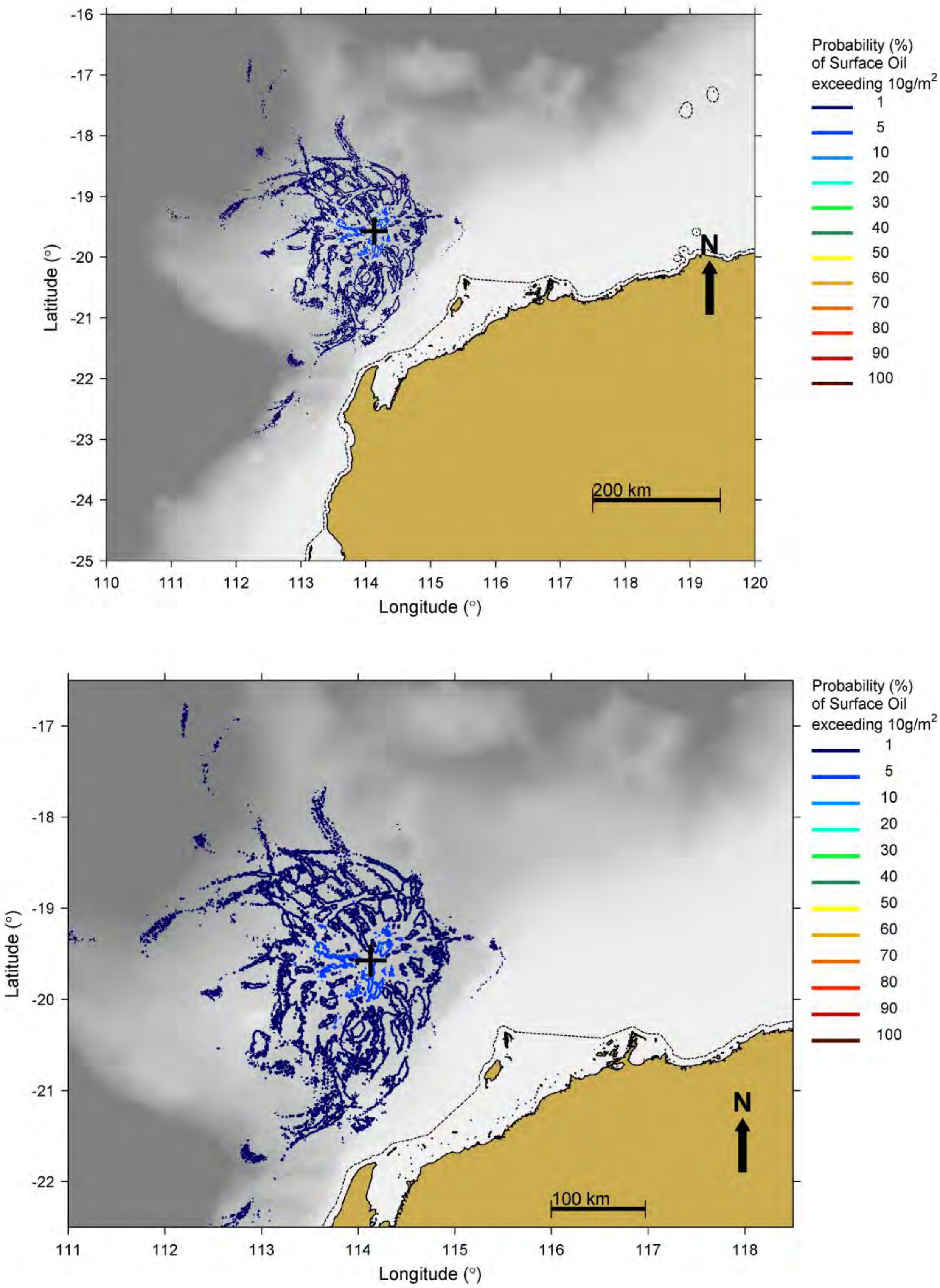


Figure 3-26: Predicted probability of sea surface contact to concentrations above 10 g/m^2 resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-18: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from a pipeline rupture at the seabed at the Chandon Manifold commencing during summer months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

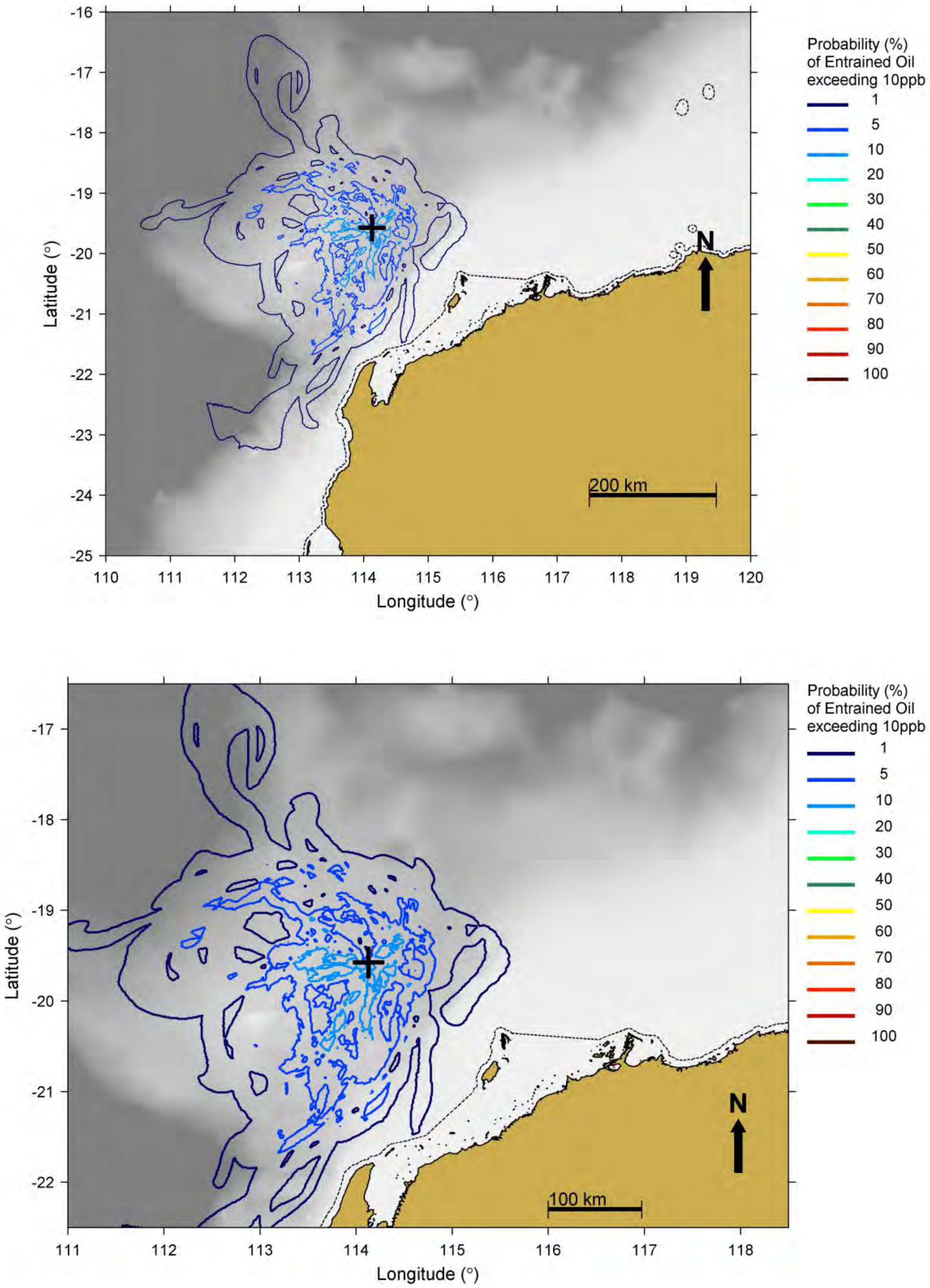


Figure 3-27: Predicted probability of entrained concentrations above 10 ppb resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

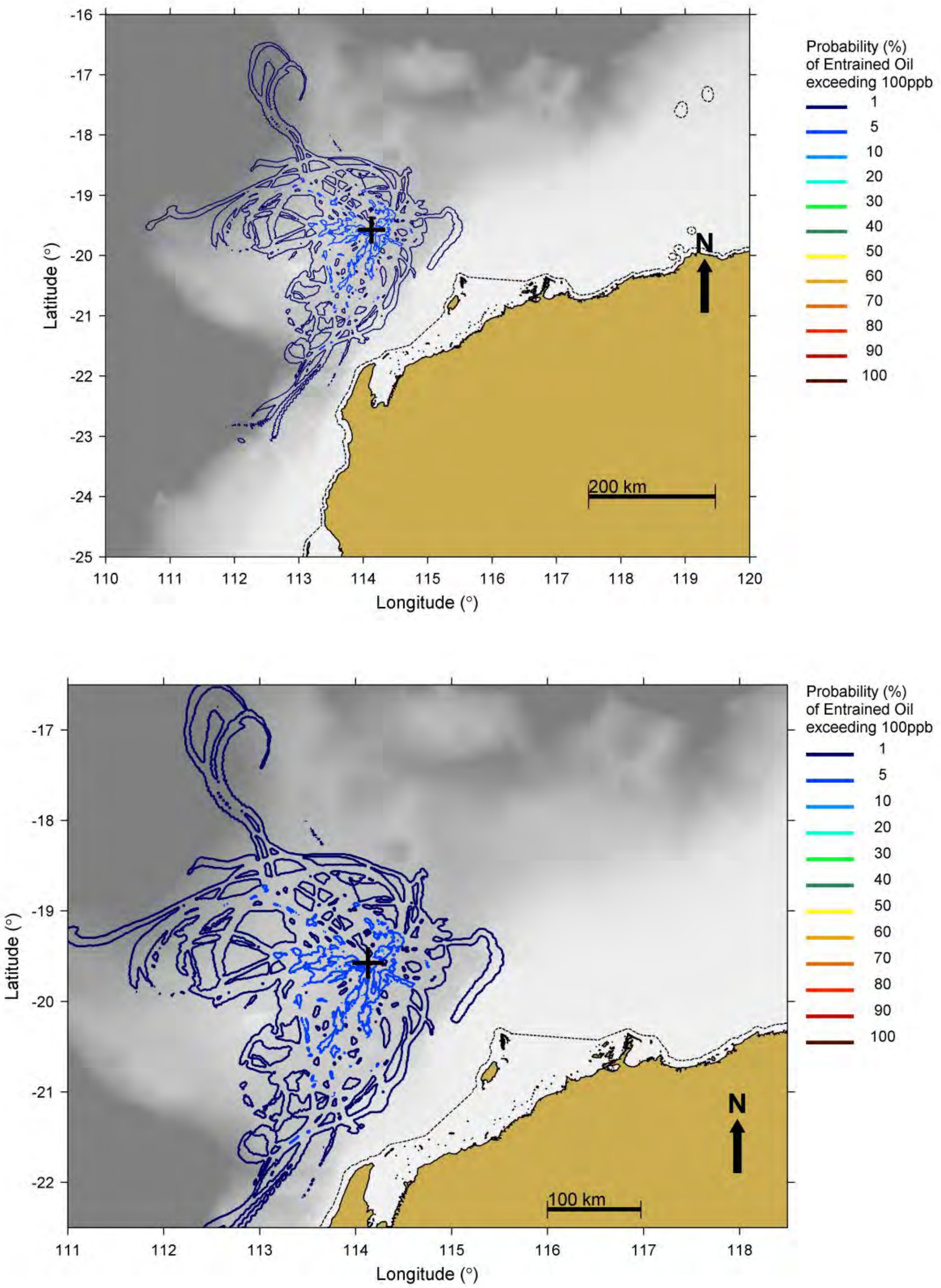


Figure 3-28: Predicted probability of entrained concentrations above 100 ppb resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

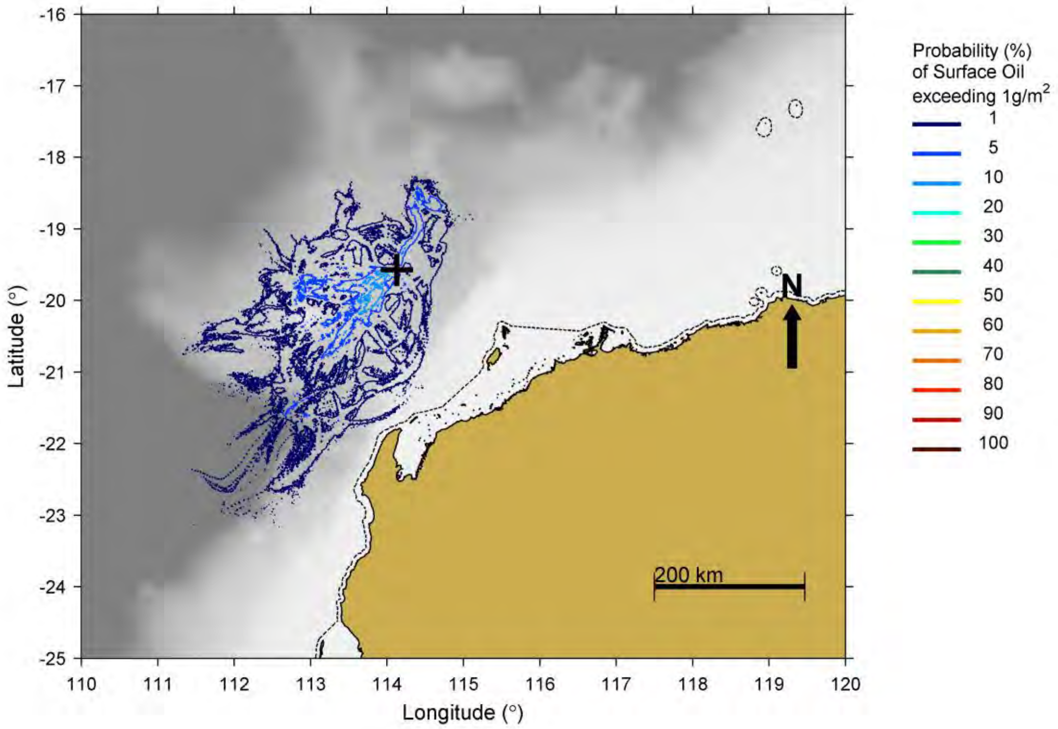
3.3.2 Autumn

Surface Slicks and Films

Table 3-19: Summary of shoreline risks for different locations from a pipeline rupture at the seabed at the Chandon Manifold commencing during autumn months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold



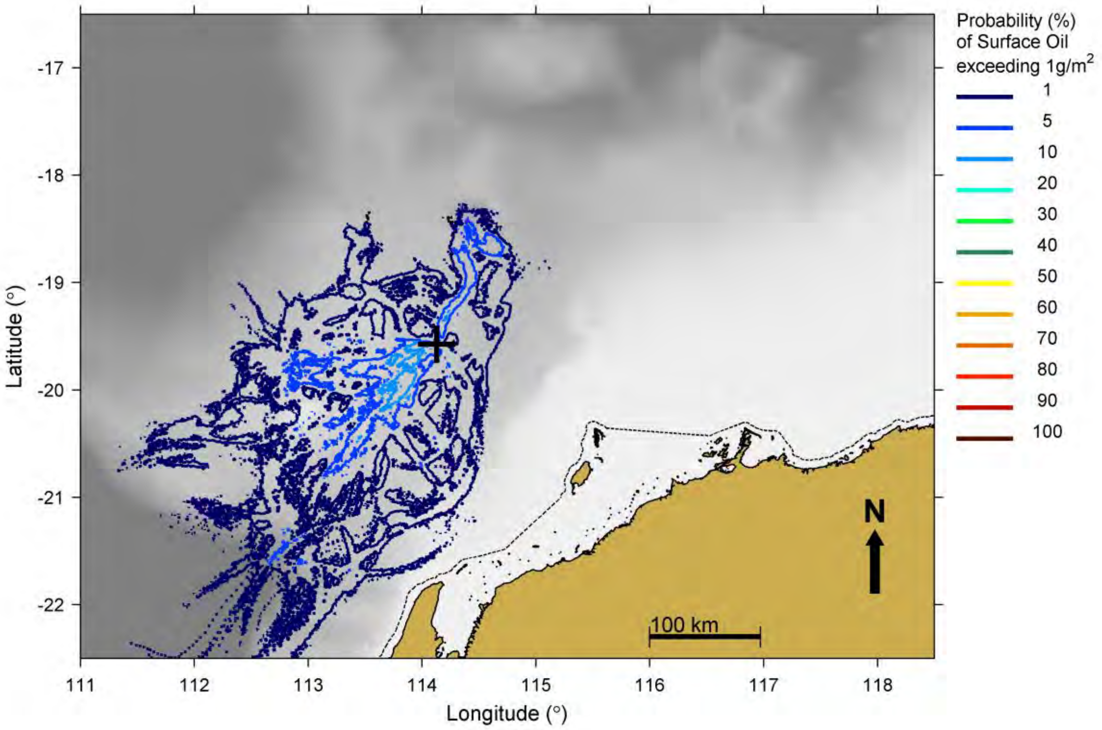


Figure 3-29: Predicted probability of sea surface contact to concentrations above 1 g/m² resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

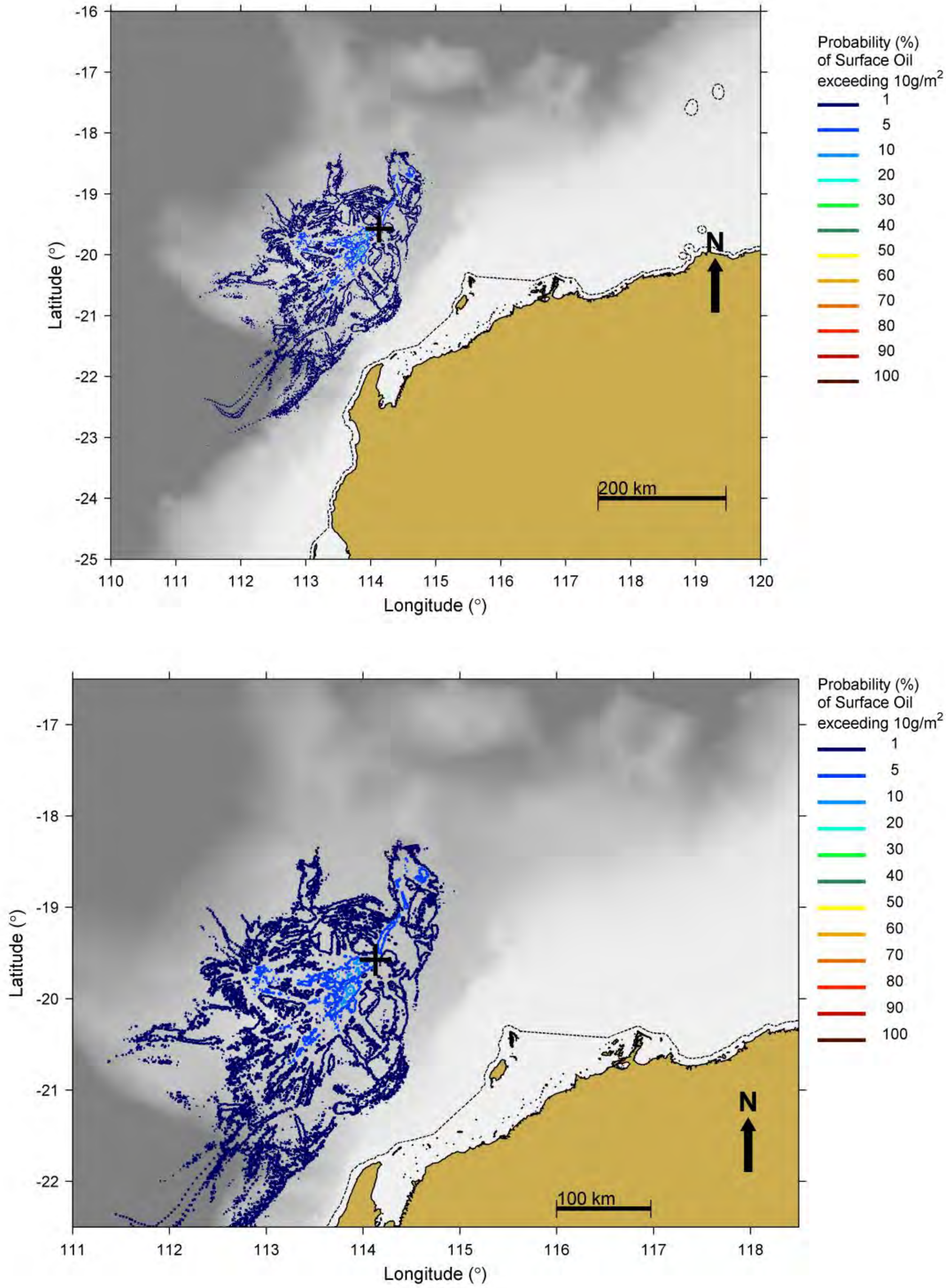


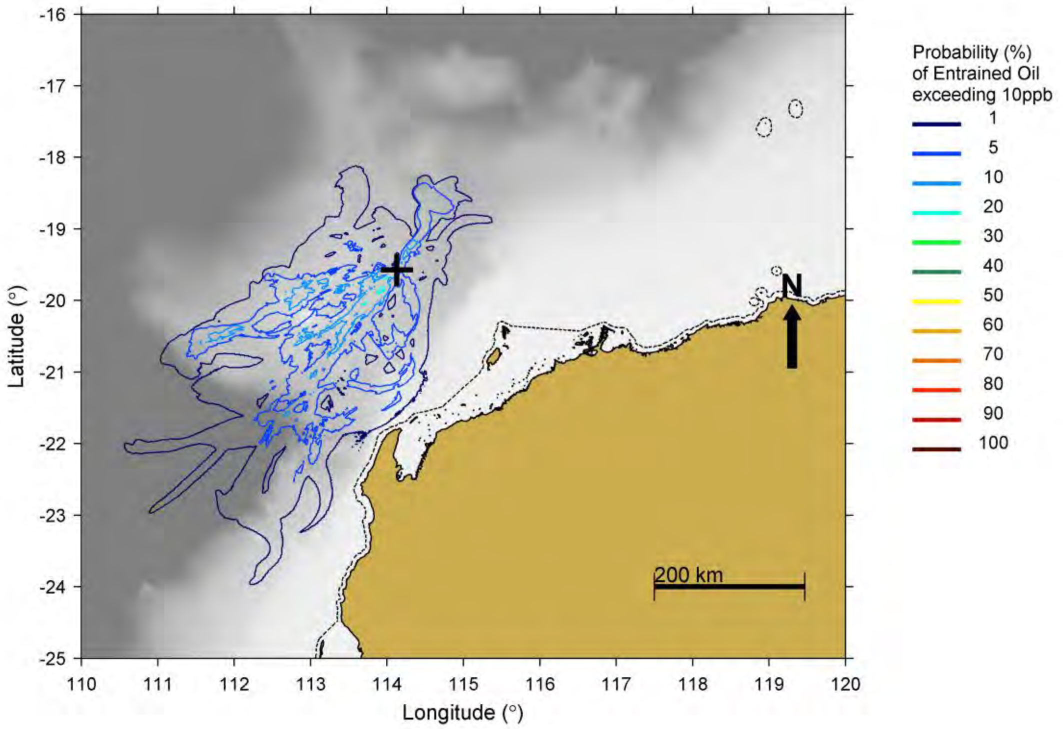
Figure 3-30: Predicted probability of sea surface contact to concentrations above 10 g/m^2 resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-20: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from a pipeline rupture at the seabed at the Chandon Manifold commencing during autumn months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold



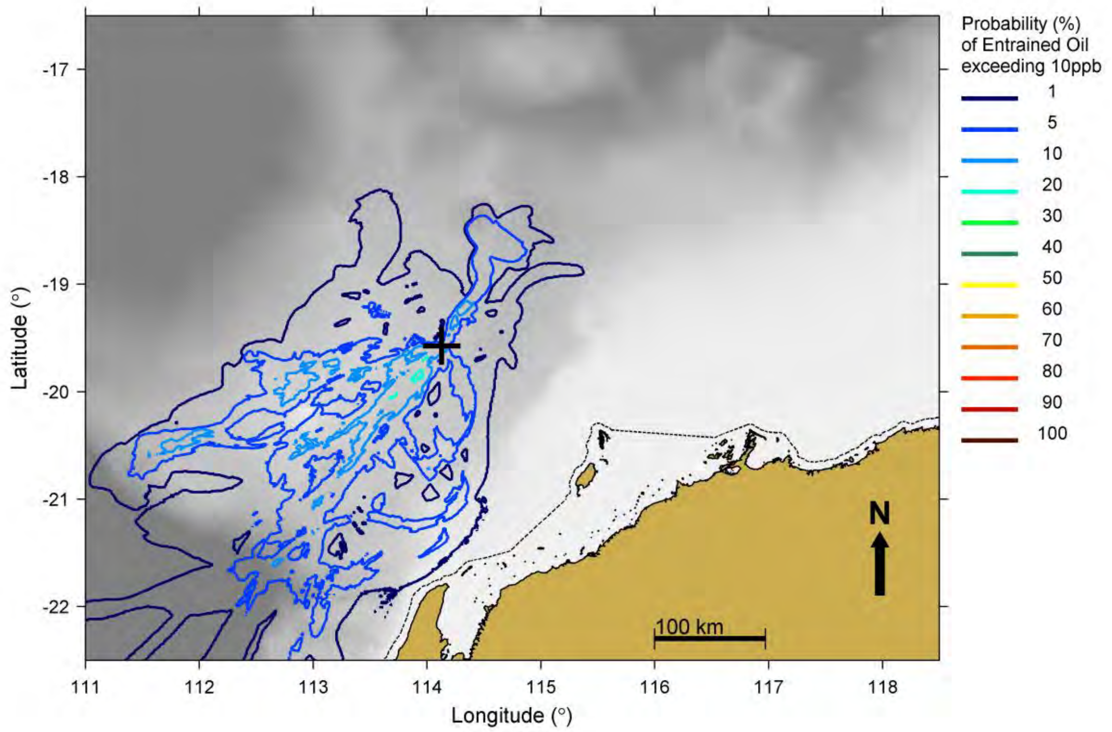


Figure 3-31: Predicted probability of entrained concentrations above 10 ppb resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

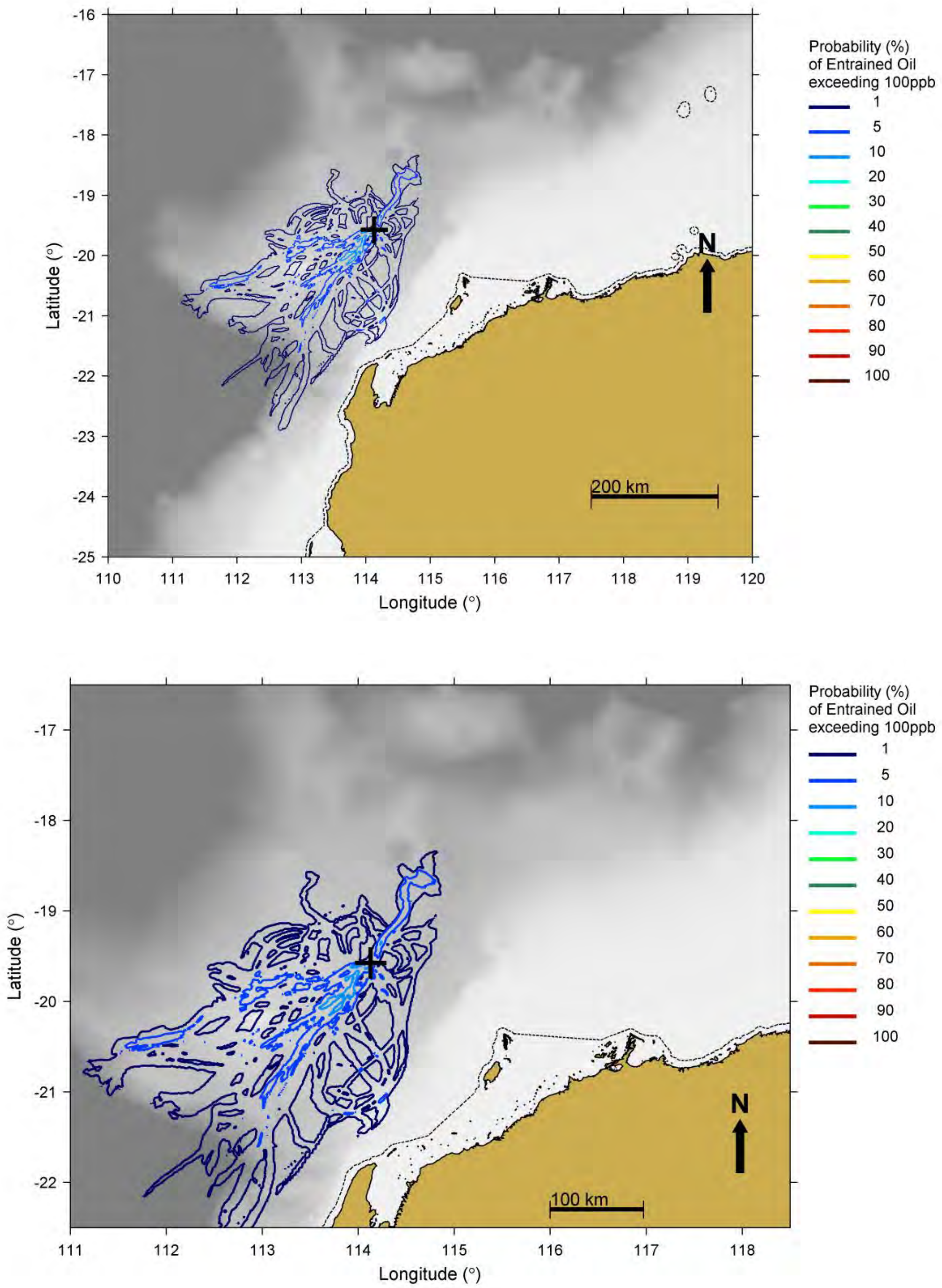


Figure 3-32: Predicted probability of entrained concentrations above 100 ppb resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

3.3.3 Winter

Surface Slicks and Films

Table 3-21: Summary of shoreline risks for different locations from a pipeline rupture at the seabed at the Chandon Manifold commencing during winter months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

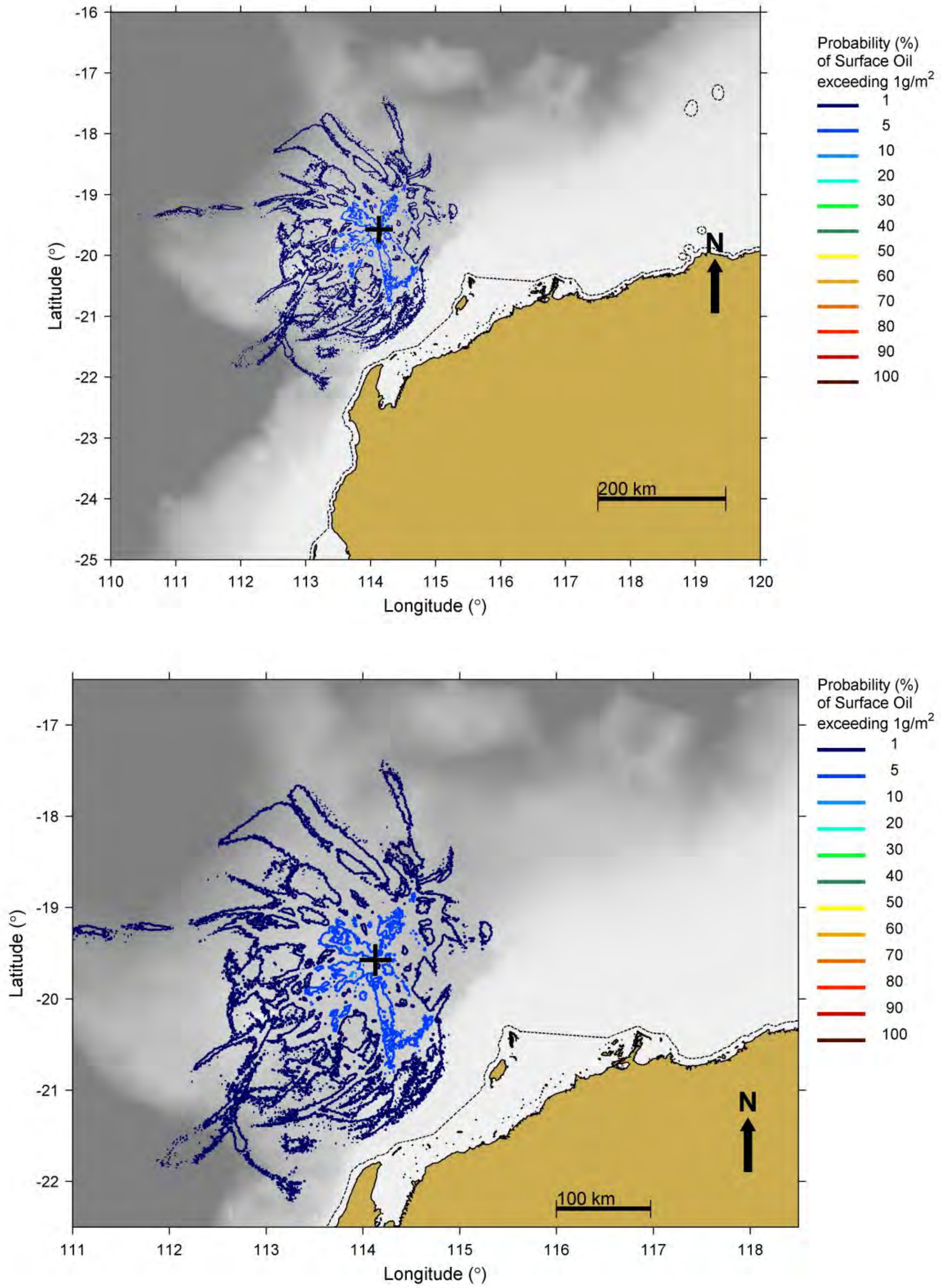


Figure 3-33: Predicted probability of sea surface contact to concentrations above 1 g/m^2 resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

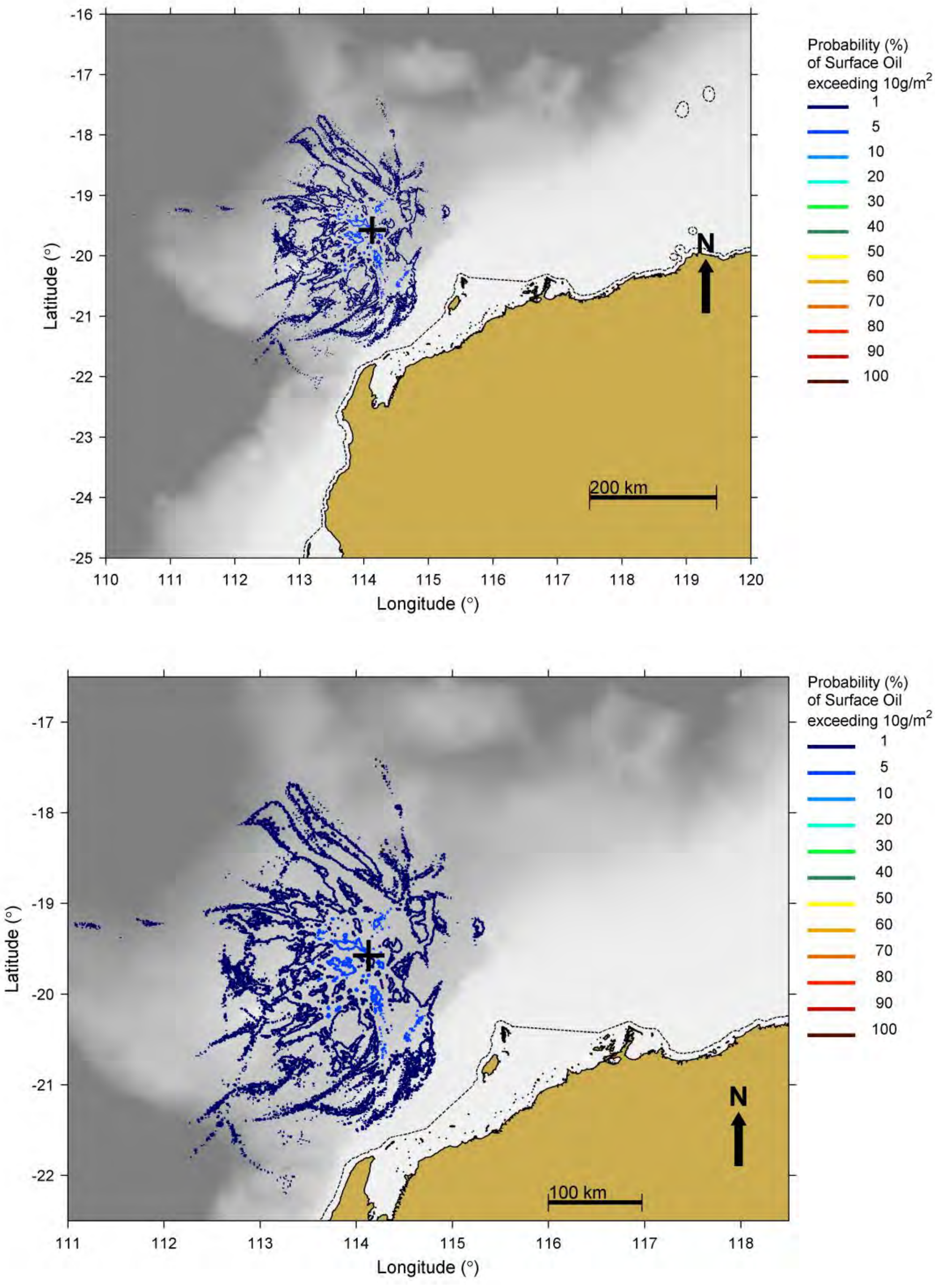


Figure 3-34: Predicted probability of sea surface contact to concentrations above 10 g/m² resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-22: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from a pipeline rupture at the seabed at the Chandon Manifold commencing during winter months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

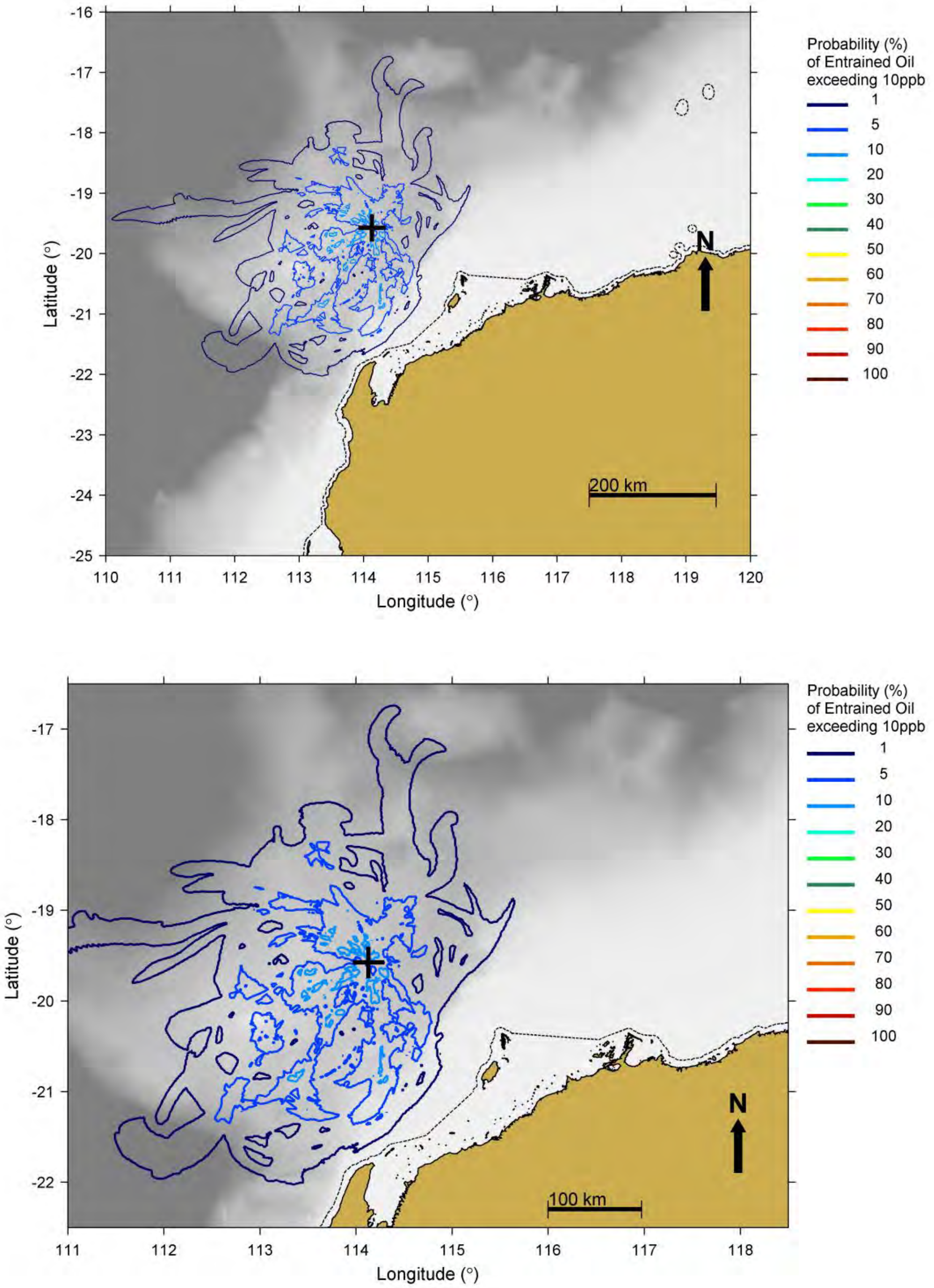


Figure 3-35: Predicted probability of entrained concentrations above 10 ppb resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

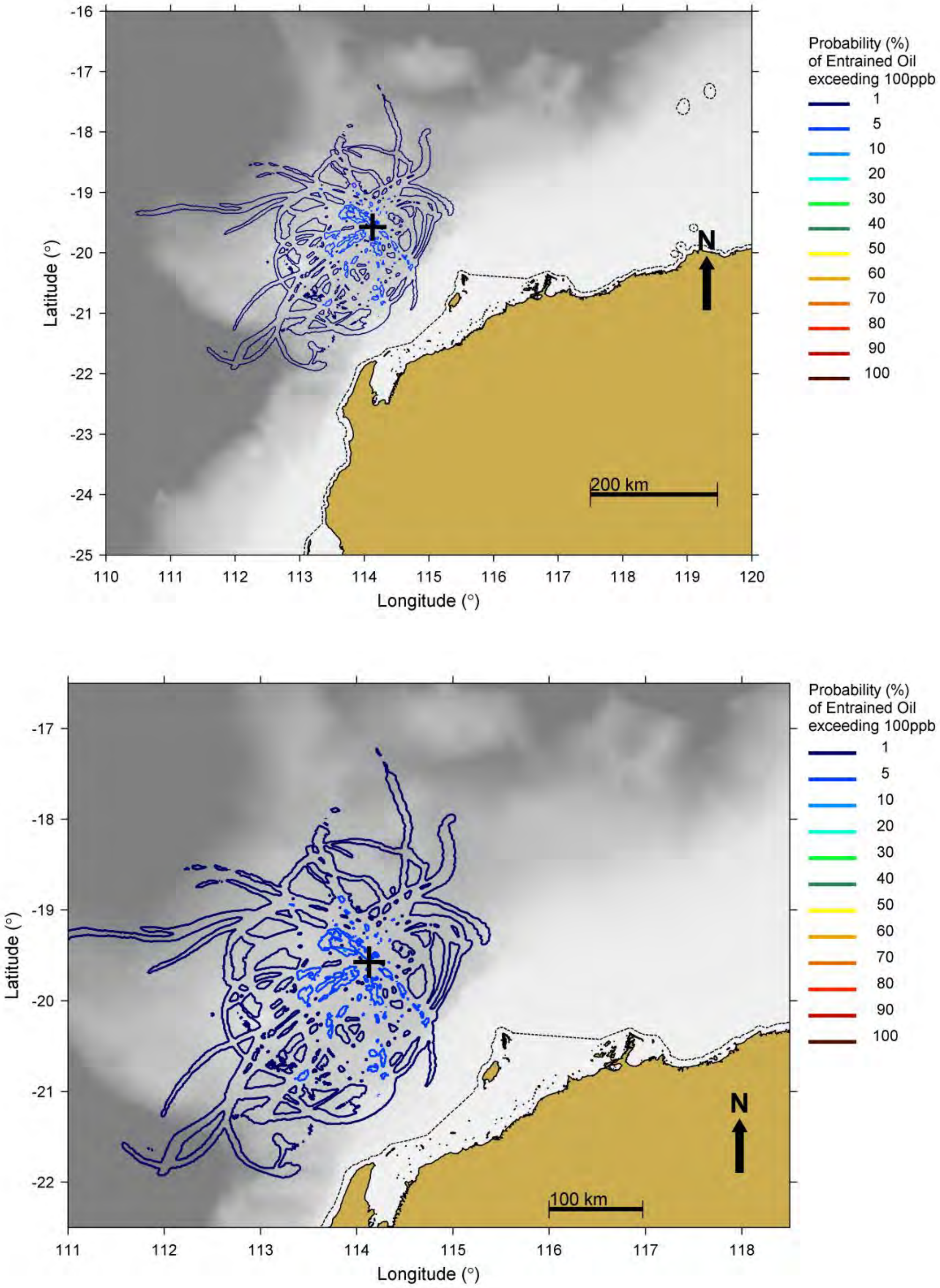


Figure 3-36: Predicted probability of entrained concentrations above 100 ppb resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

3.3.4 Spring

Surface Slicks and Films

Table 3-23: Summary of shoreline risks for different locations from a pipeline rupture at the seabed at the Chandon Manifold commencing during spring months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

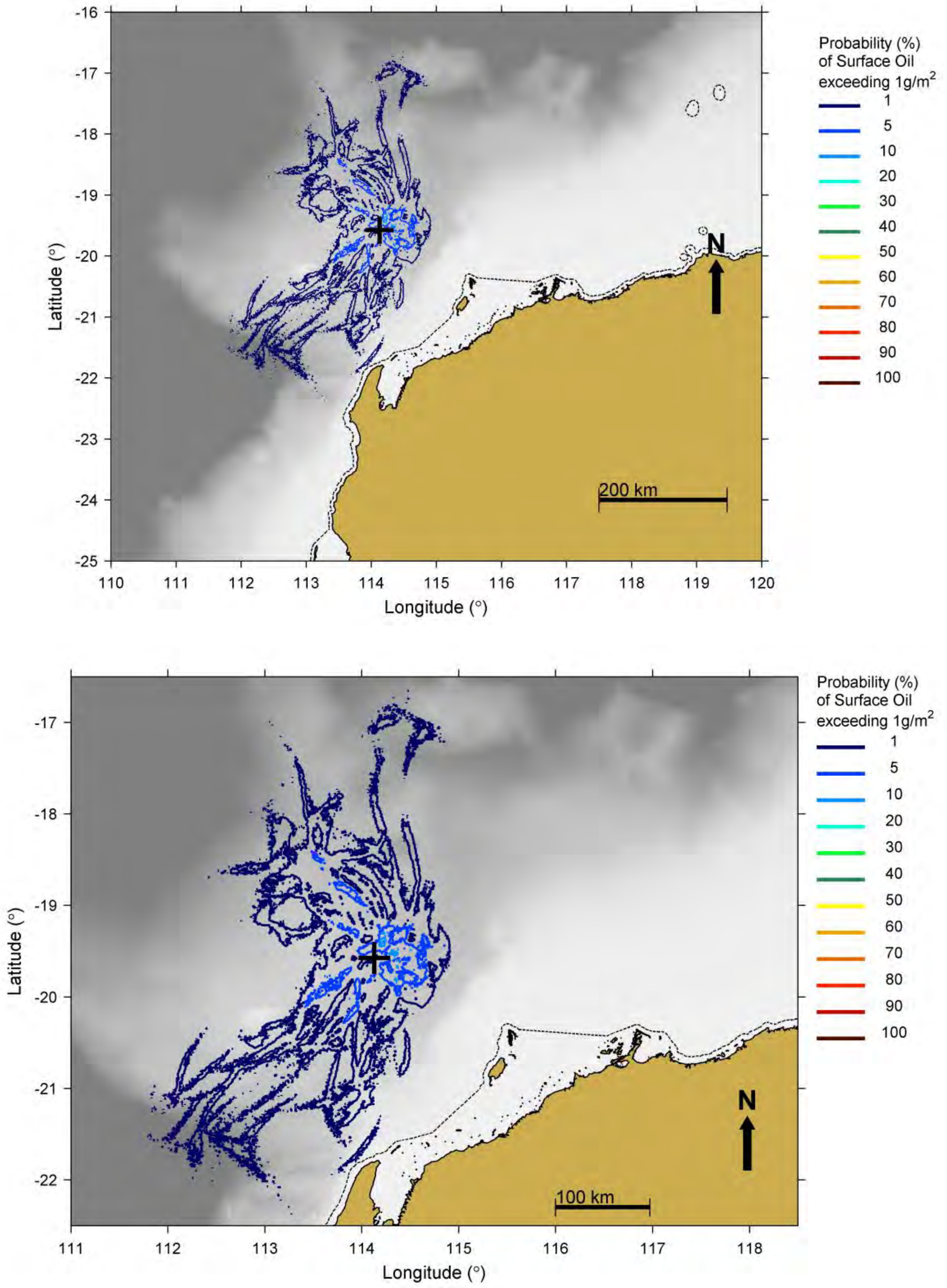


Figure 3-37: Predicted probability of sea surface contact to concentrations above 1 g/m^2 resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

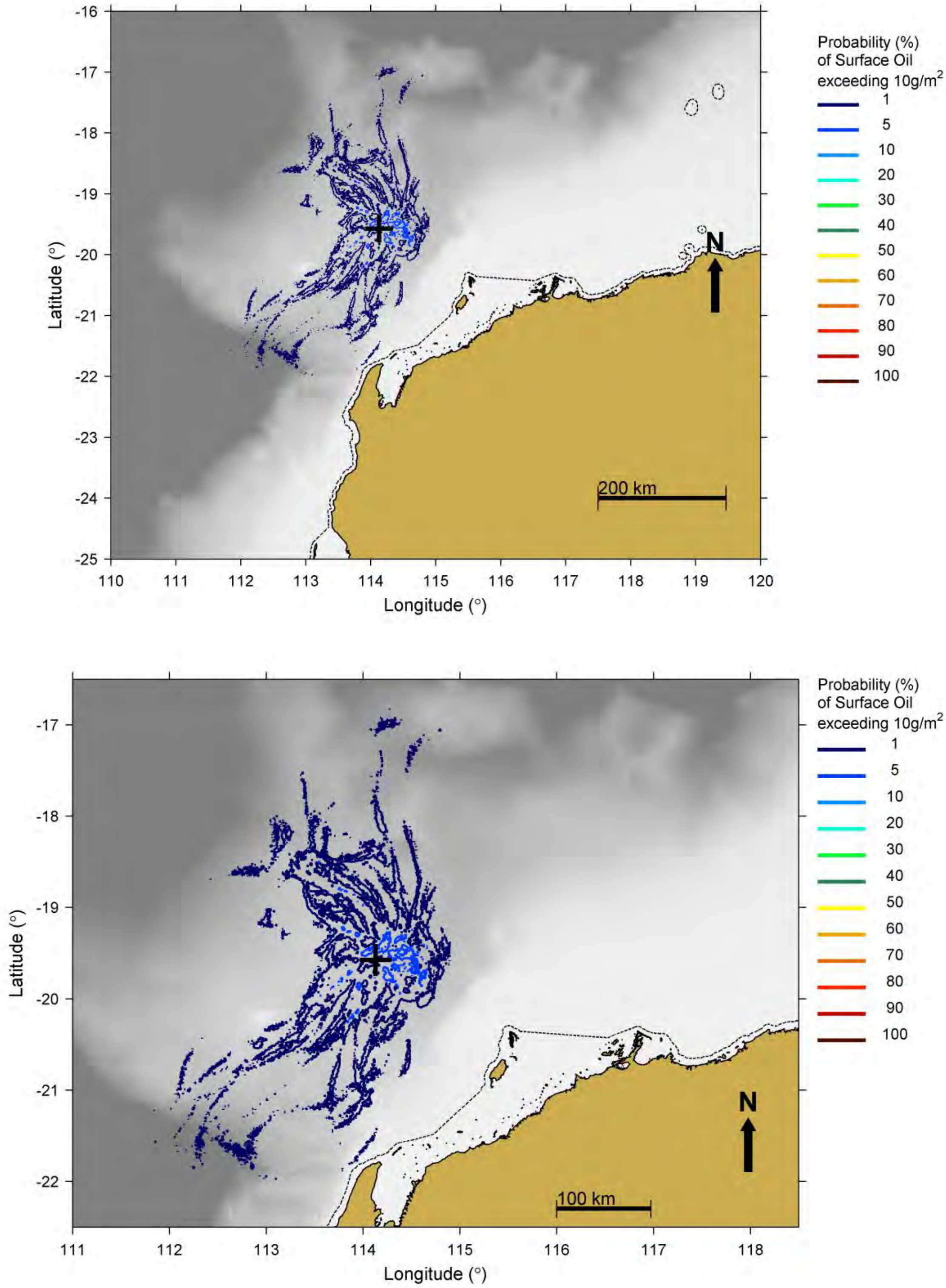


Figure 3-38: Predicted probability of sea surface contact to concentrations above 10 g/m^2 resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-24: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from a pipeline rupture at the seabed at the Chandon Manifold commencing during spring months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	1	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	13	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	< 10	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	60	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

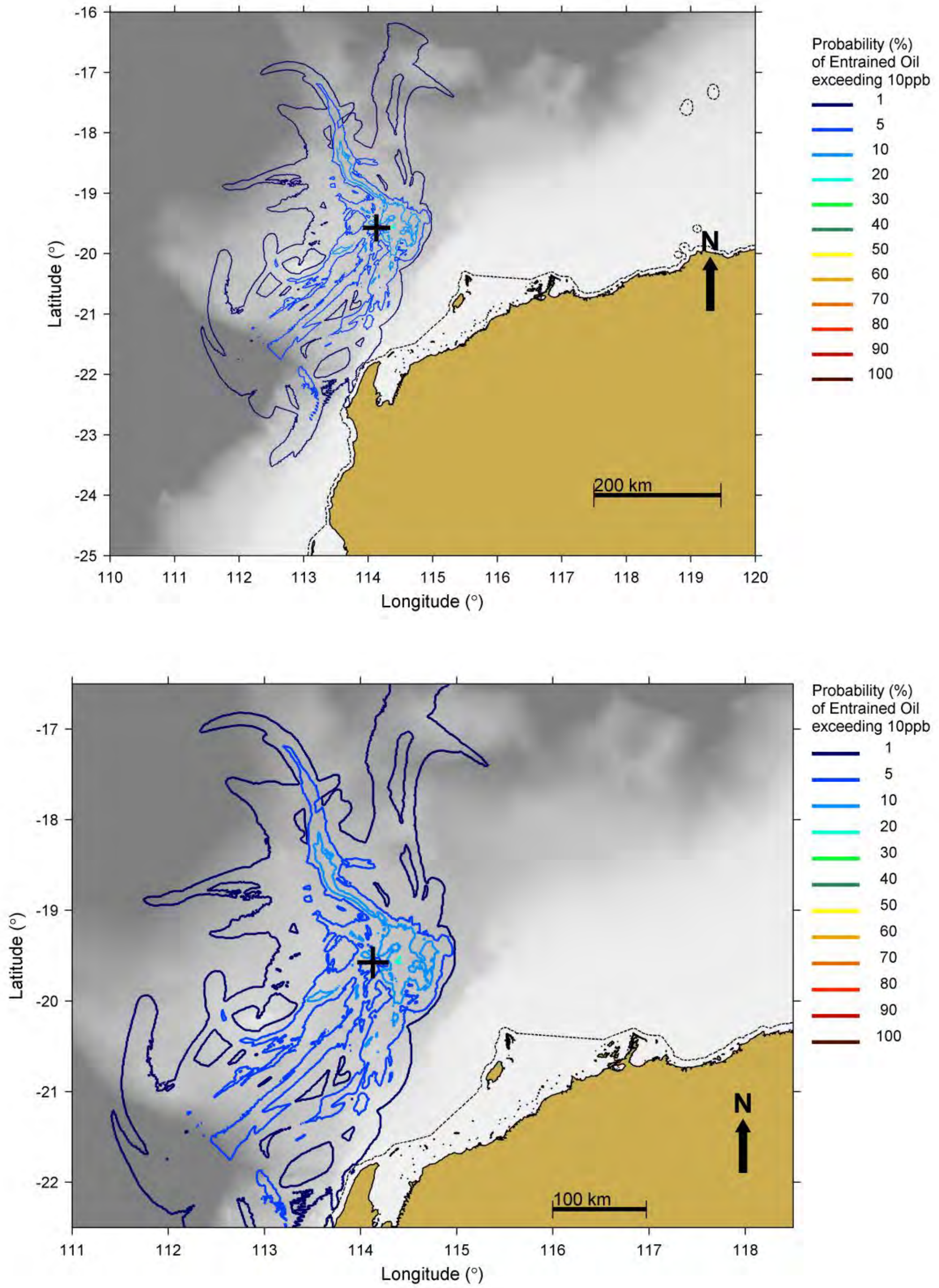


Figure 3-39: Predicted probability of entrained concentrations above 10 ppb resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

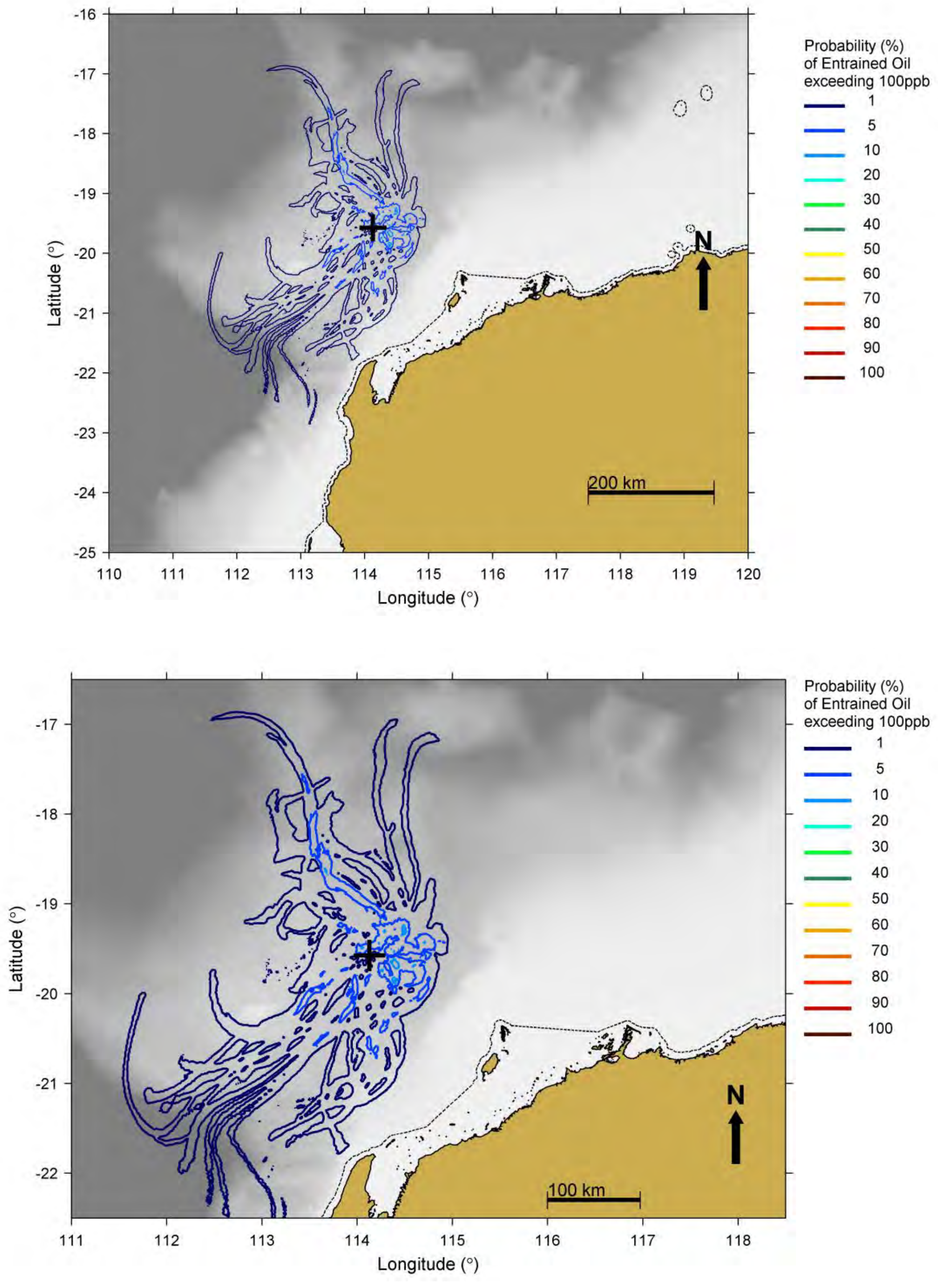


Figure 3-40: Predicted probability of entrained concentrations above 100 ppb resulting from a pipeline rupture at the seabed at the Chandon Manifold commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

3.4 Simulation of pipeline rupture at seabed at the Jansz PTS

This scenario investigated the probability of exposure to the surrounding regions by oil due to a pipeline rupture at the seabed (1,346 m depth), at the Jansz PTS location. Result figures and tables are presented for each of the seasons in the following sections.

Likely surface oil trajectories were predicted to be similar to those presented in the surface contours for the pipeline rupture at the Chandon Manifold. This was not unexpected given the similarity of the water depth and the proximity of the locations. Oceanographic conditions are not expected to vary significantly between these sites.

Surface oil is most likely to drift towards the west and southwest during summer (Figure 3-41, Figure 3-42) and autumn (Figure 3-45, Figure 3-46), with a 5% probability of oil > 10 g/m^2 extending approximately 150 km southwest of the rupture location in both seasons. During winter and spring, surface oil is most likely to drift to the southwest (Figure 3-49, Figure 3-50, Figure 3-53, Figure 3-54).

The stochastic modelling indicates low to moderate probabilities (< 30%) for oil to occur on the water surface at concentrations > 1 g/m^2 during each of the seasons. There is only 1% probability that surface oil > 1 g/m^2 will extend further than approximately 300 km from the spill site in any direction during any of the seasonal scenarios (Figure 3-41, Figure 3-45, Figure 3-49, Figure 3-53). Surface oil above this threshold is therefore unlikely (< 1% chance) to contact any of the surrounding shorelines (Table 3-25, Table 3-27, Table 3-29, Table 3-31).

Modelling predicts oil entrained in the water column will most likely drift towards the south-southwest to southwest during each of the seasons, with the longest trajectories in this direction forecasted in summer (Figure 3-43, Figure 3-44) and autumn (Figure 3-47, Figure 3-48). Trajectories towards the north-northwest are also indicated for the winter (Figure 3-51, Figure 3-52) and spring (Figure 3-55, Figure 3-56) scenarios.

A low probability (1%) for entrained oil > 10 ppb to reach waters bordering the Ningaloo Coast is predicted in the summer scenario (Table 3-26). Earliest times for entrained oil to arrive at this shoreline are forecasted to be approximately 12 days, indicating the oil will likely be weathered, with the loss of the more soluble components. A maximum potential short-term concentration of 25 ppb is also indicated for this shoreline during summer. Entrained oil is unlikely (< 1% chance) to be present at any other shoreline during each of the seasons (Table 3-28, Table 3-30, Table 3-32).

Dissolved aromatic hydrocarbons are not predicted (< 1% probability) to be present anywhere in the water column at concentrations > 5 ppb during any of the seasons, averaged at the scale of the model grid.

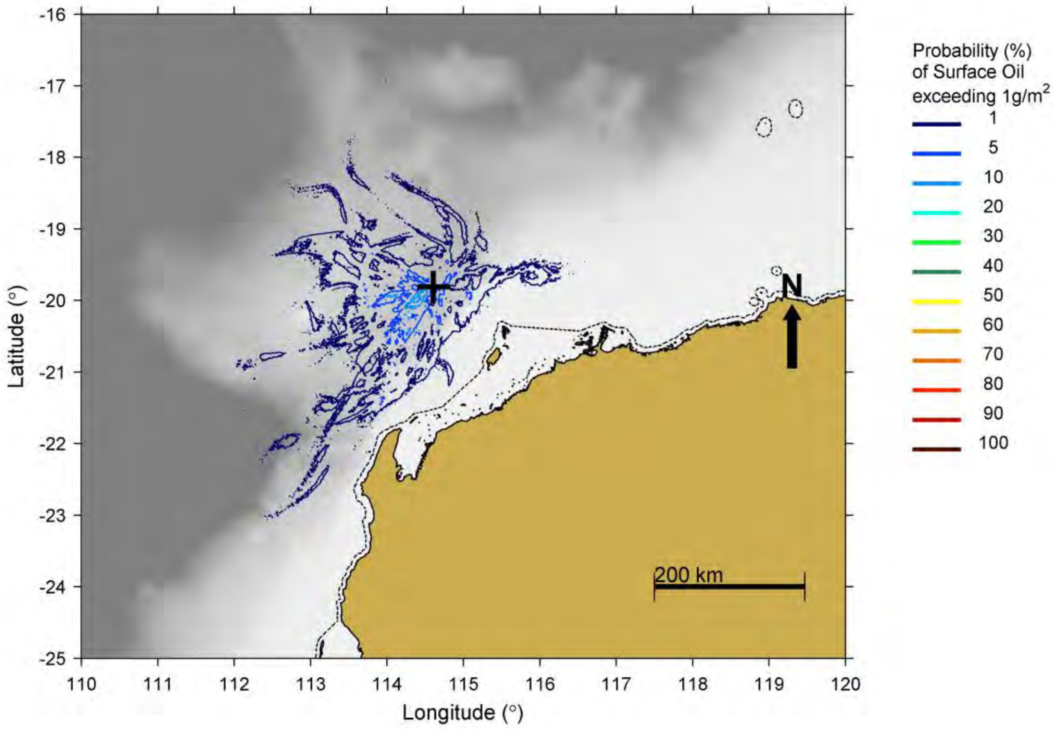
3.4.1 Summer

Surface Slicks and Films

Table 3-25: Summary of shoreline risks for different locations from a pipeline rupture at the seabed at the Jansz PTS commencing during summer months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m²)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m²)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold



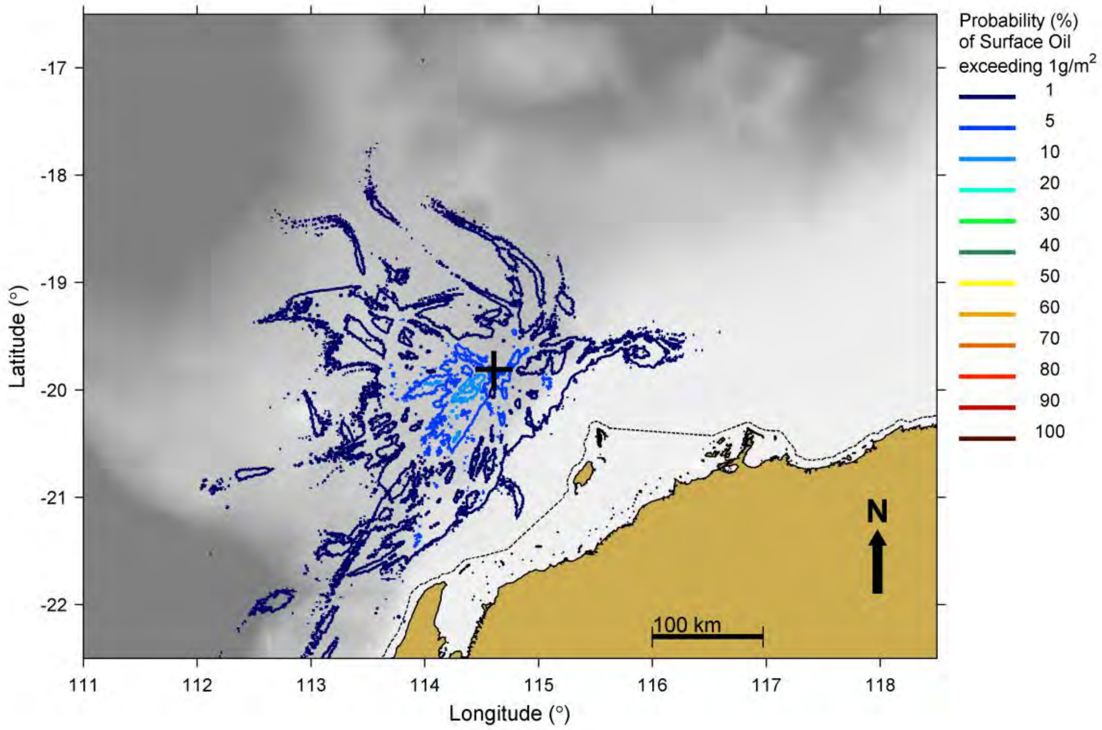


Figure 3-41: Predicted probability of sea surface contact to concentrations above 1 g/m^2 resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

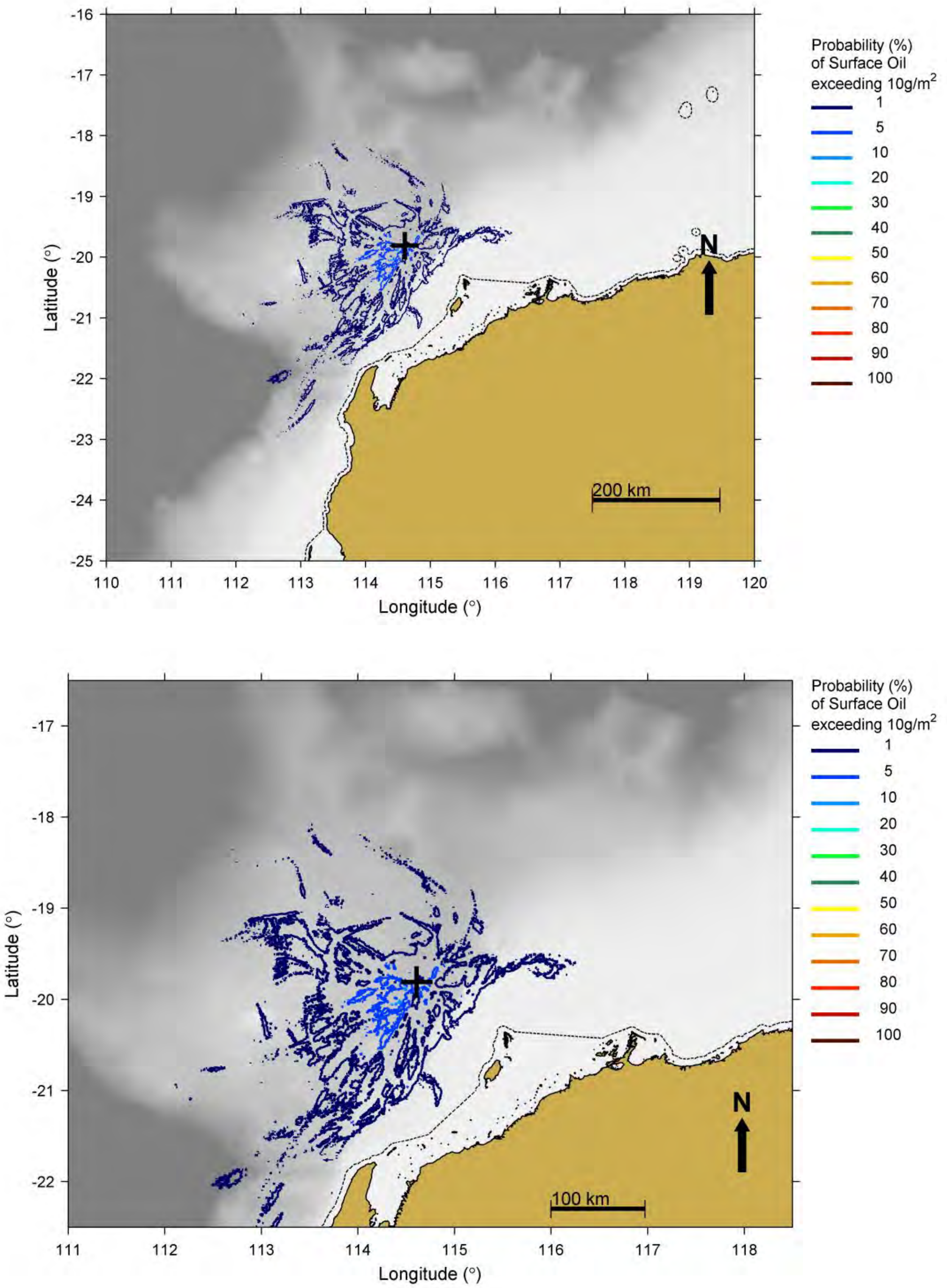


Figure 3-42: Predicted probability of sea surface contact to concentrations above 10 g/m² resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-26: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from a pipeline rupture at the seabed at the Jansz PTS commencing during summer months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	1	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	12	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	< 10	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	25	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

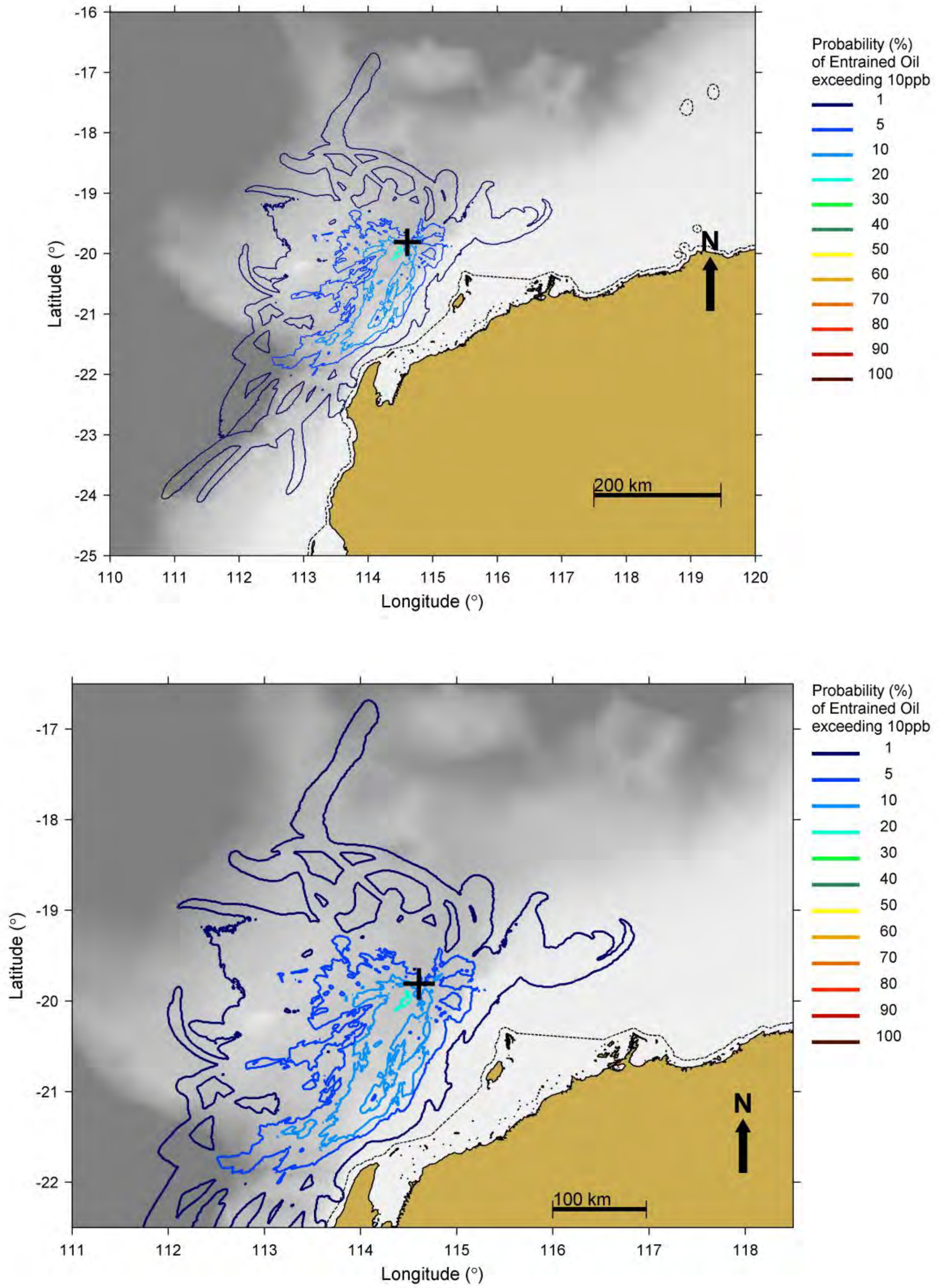


Figure 3-43: Predicted probability of entrained concentrations above 10 ppb resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

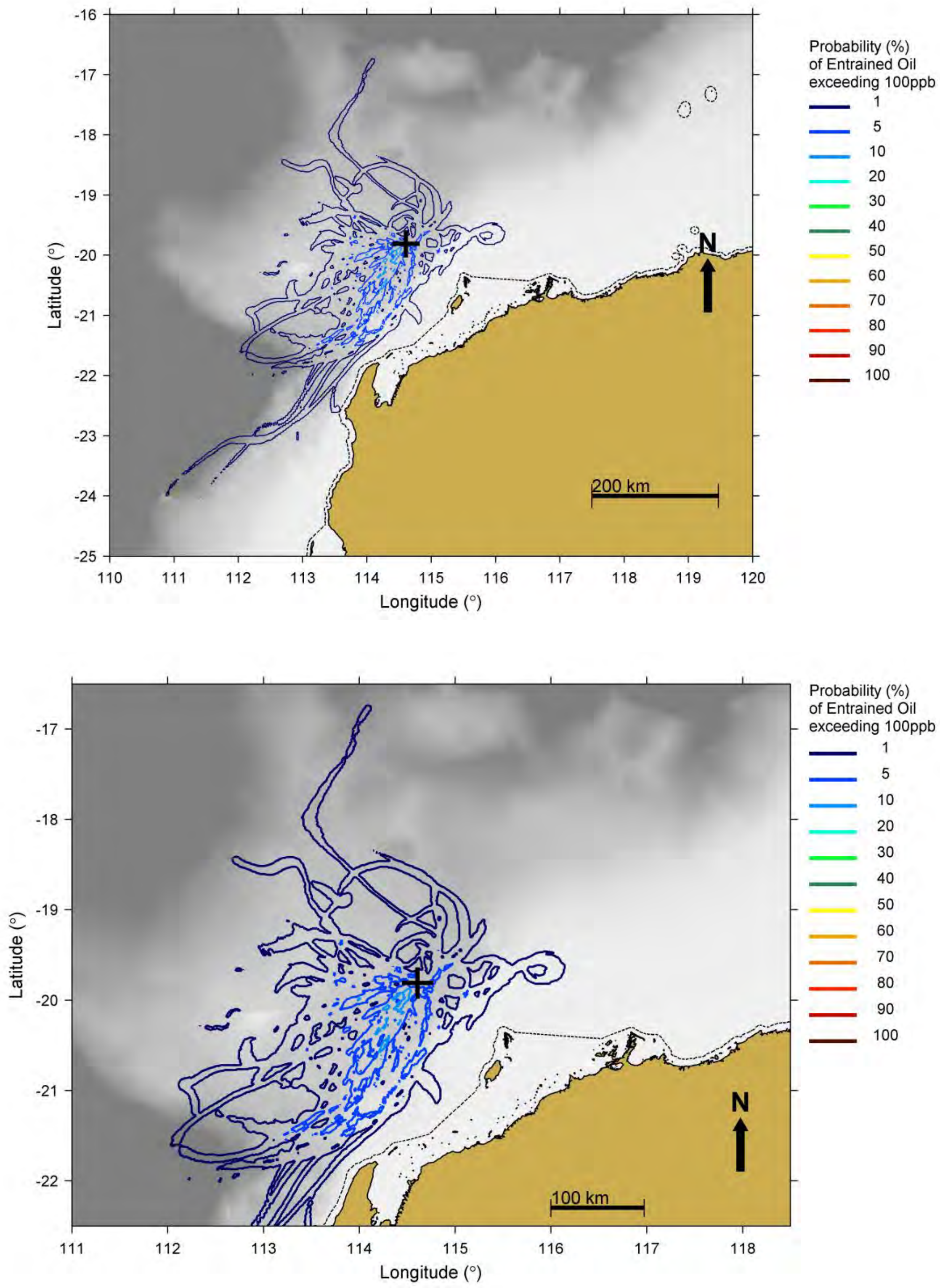


Figure 3-44: Predicted probability of entrained concentrations above 100 ppb resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

3.4.2 Autumn

Surface Slicks and Films

Table 3-27: Summary of shoreline risks for different locations from a pipeline rupture at the seabed the Jansz PTS commencing during autumn months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

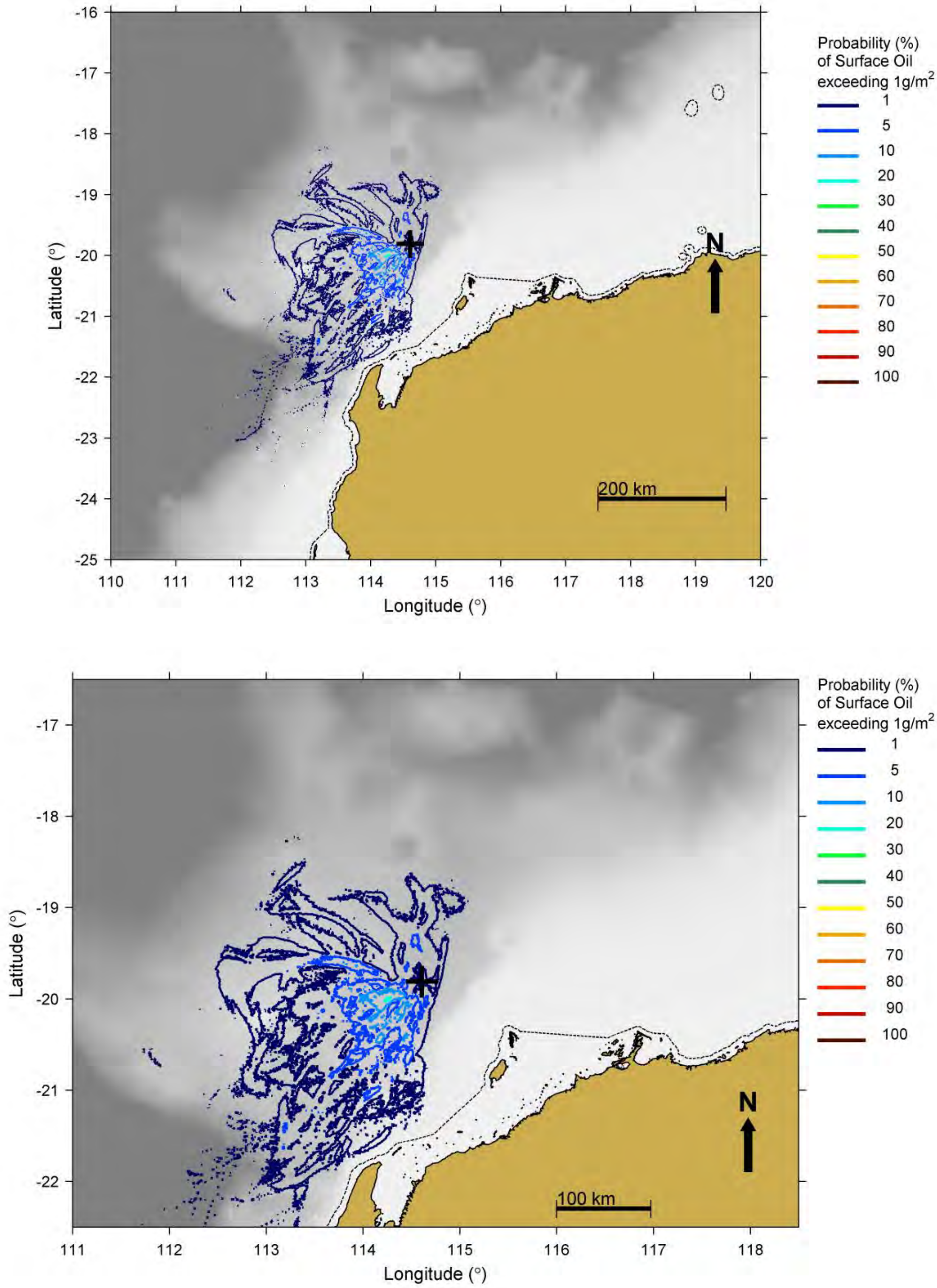


Figure 3-45: Predicted probability of sea surface contact to concentrations above 1 g/m² resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

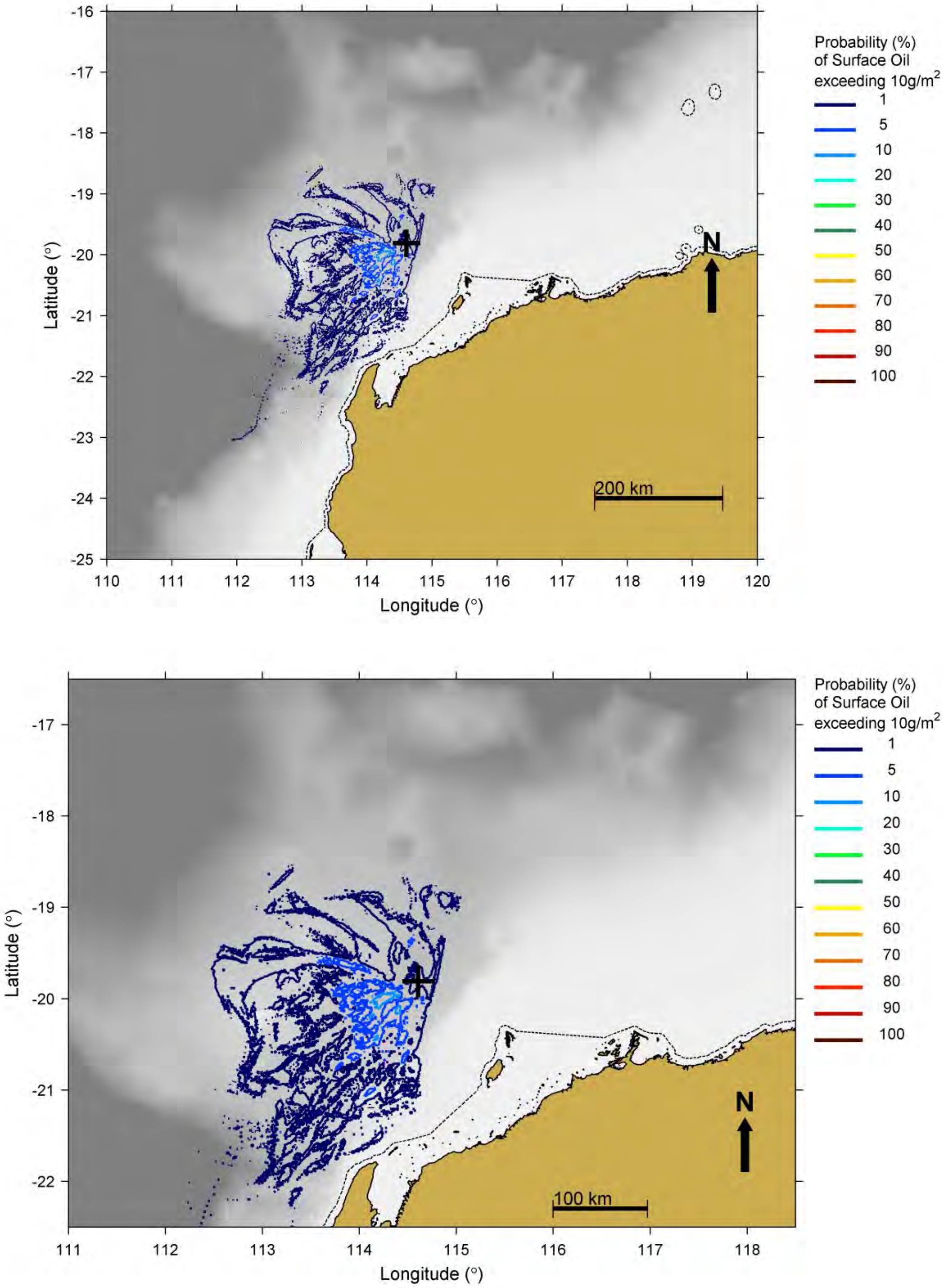


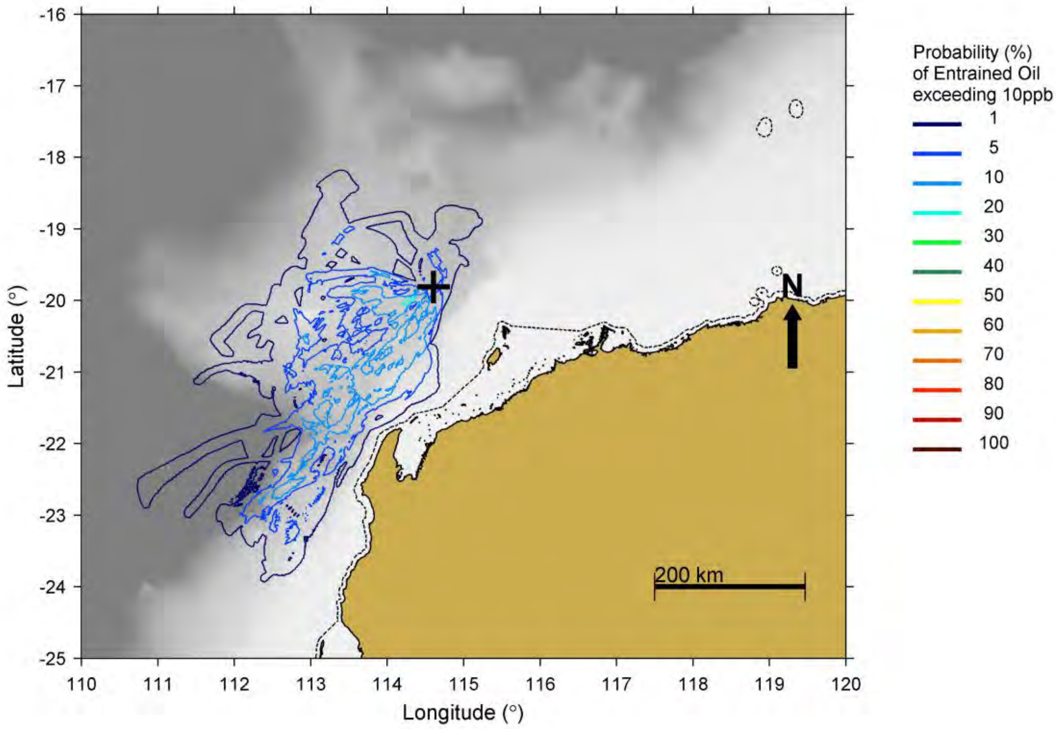
Figure 3-46: Predicted probability of sea surface contact to concentrations above 10 g/m^2 resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-28: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from a pipeline rupture at the seabed at the Jansz PTS commencing during autumn months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold



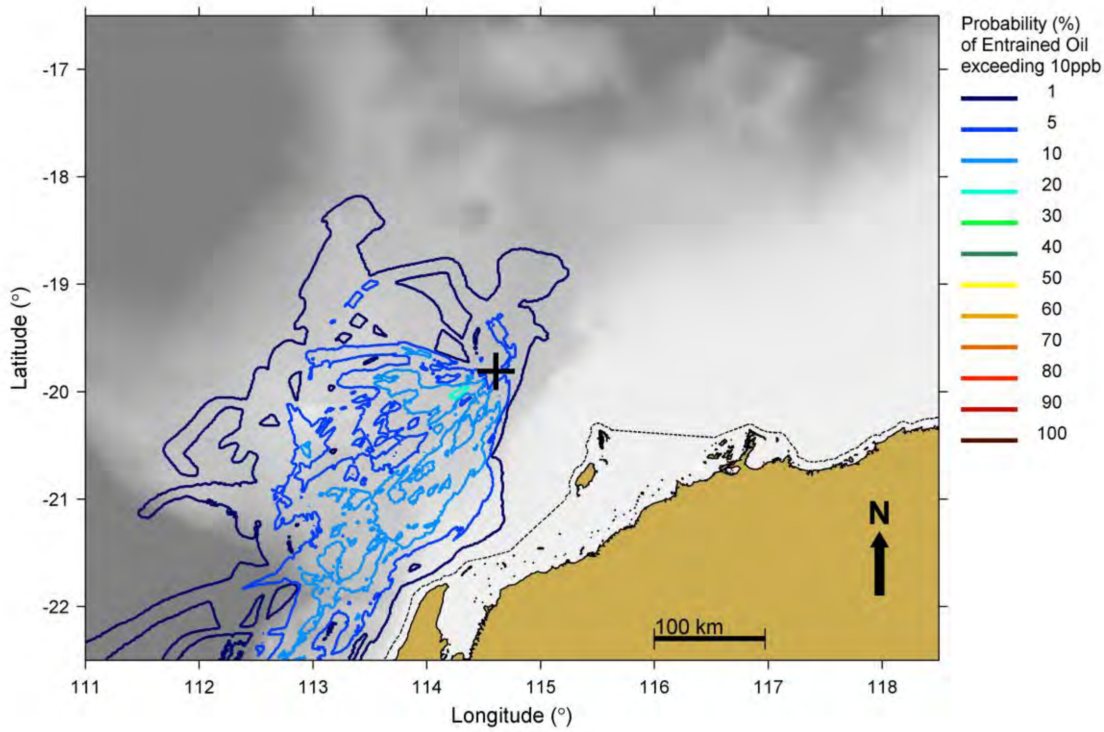


Figure 3-47: Predicted probability of entrained concentrations above 10 ppb resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

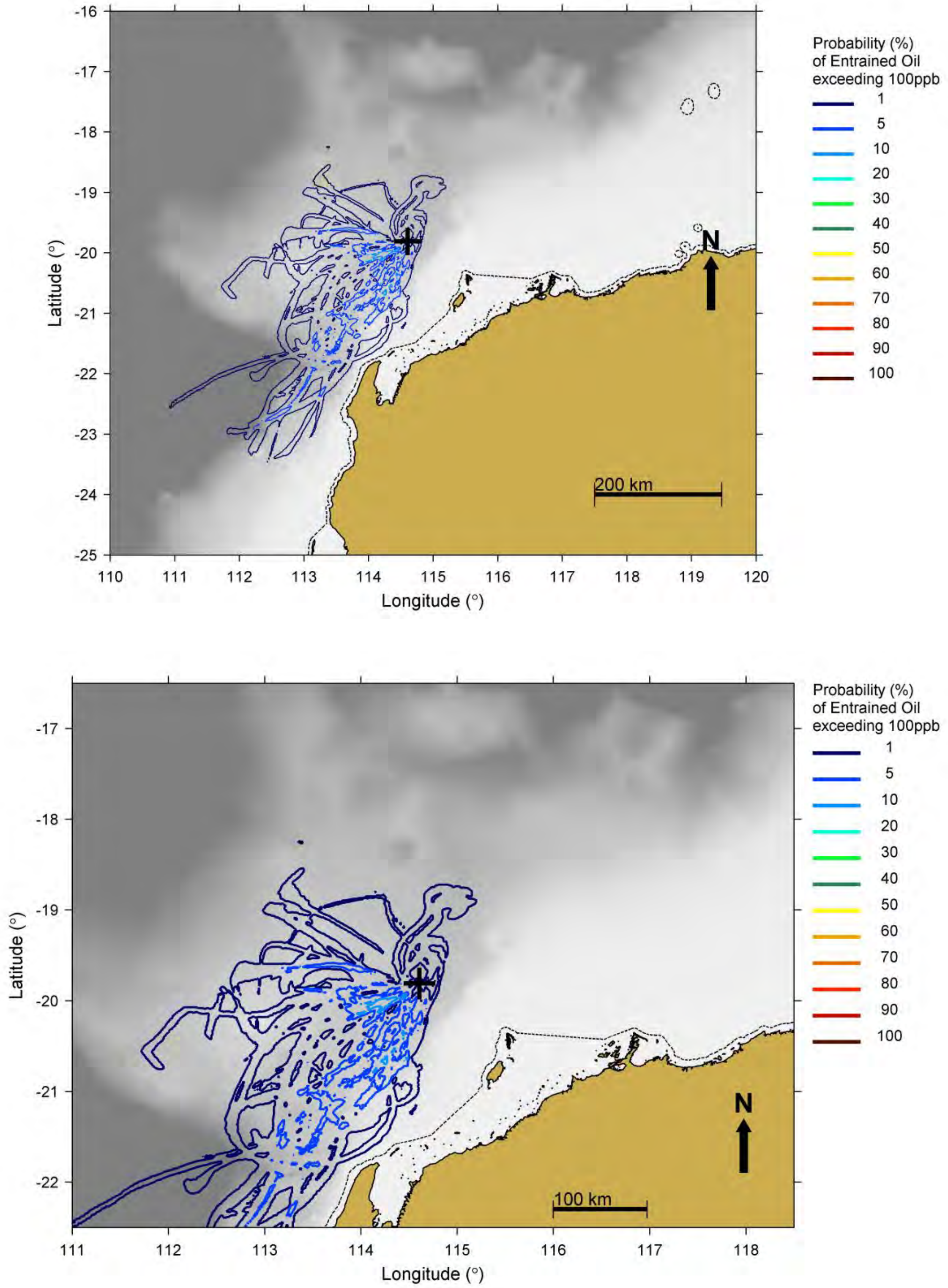


Figure 3-48: Predicted probability of entrained concentrations above 100 ppb resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

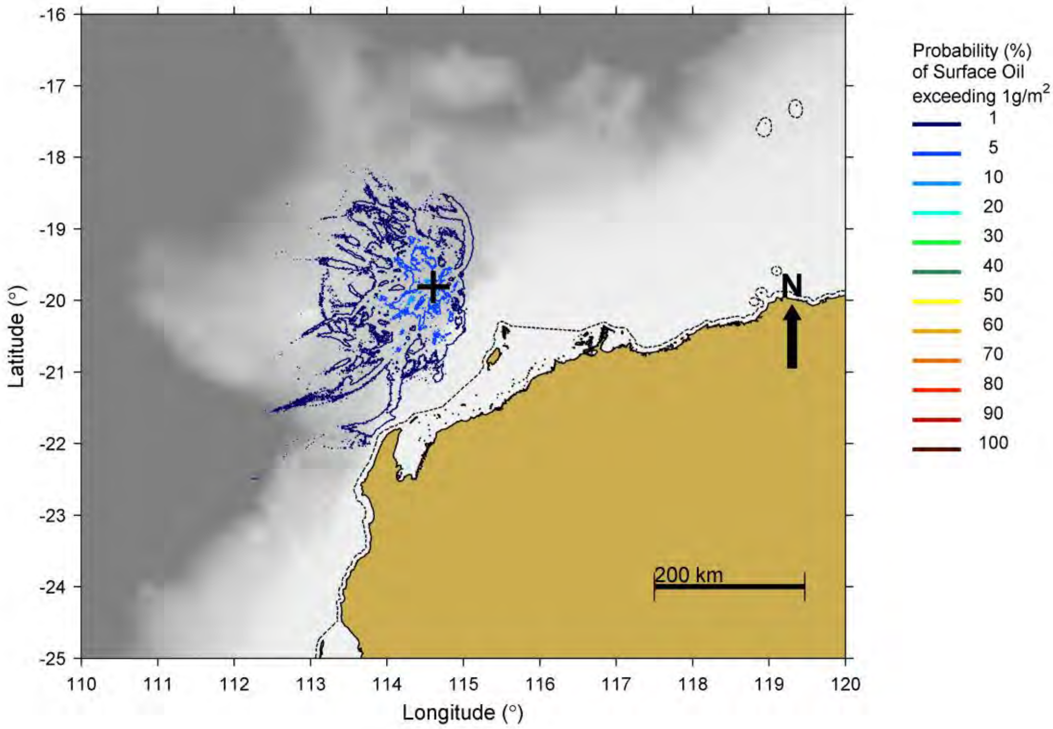
3.4.3 Winter

Surface Slicks and Films

Table 3-29: Summary of shoreline risks for different locations from a pipeline rupture at the seabed at the Jansz PTS commencing during winter months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold



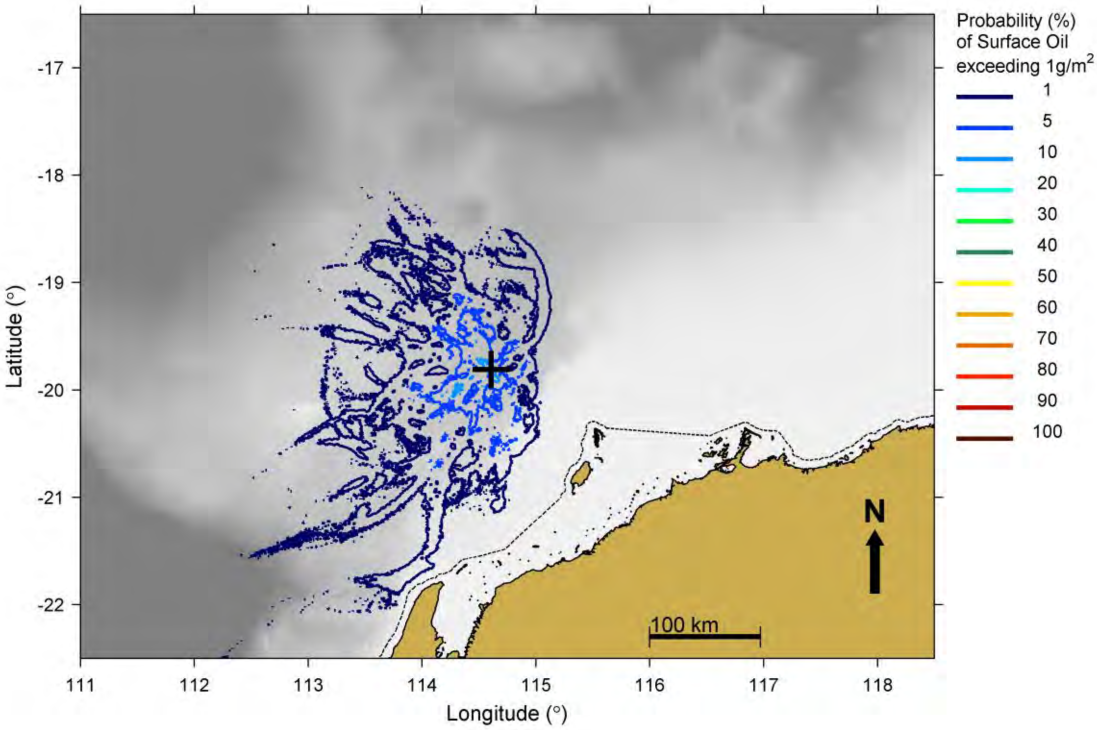


Figure 3-49: Predicted probability of sea surface contact to concentrations above 1 g/m^2 resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

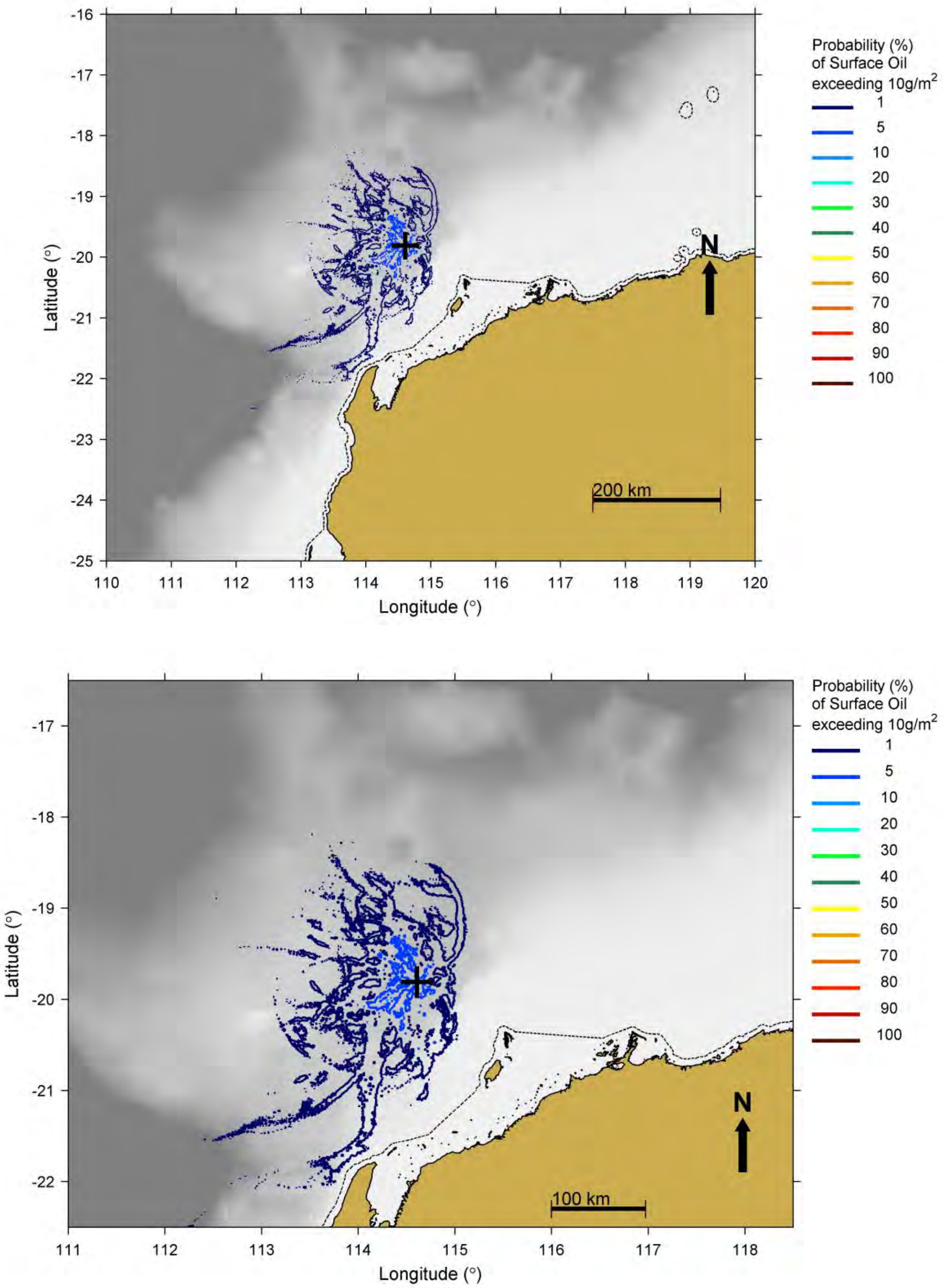


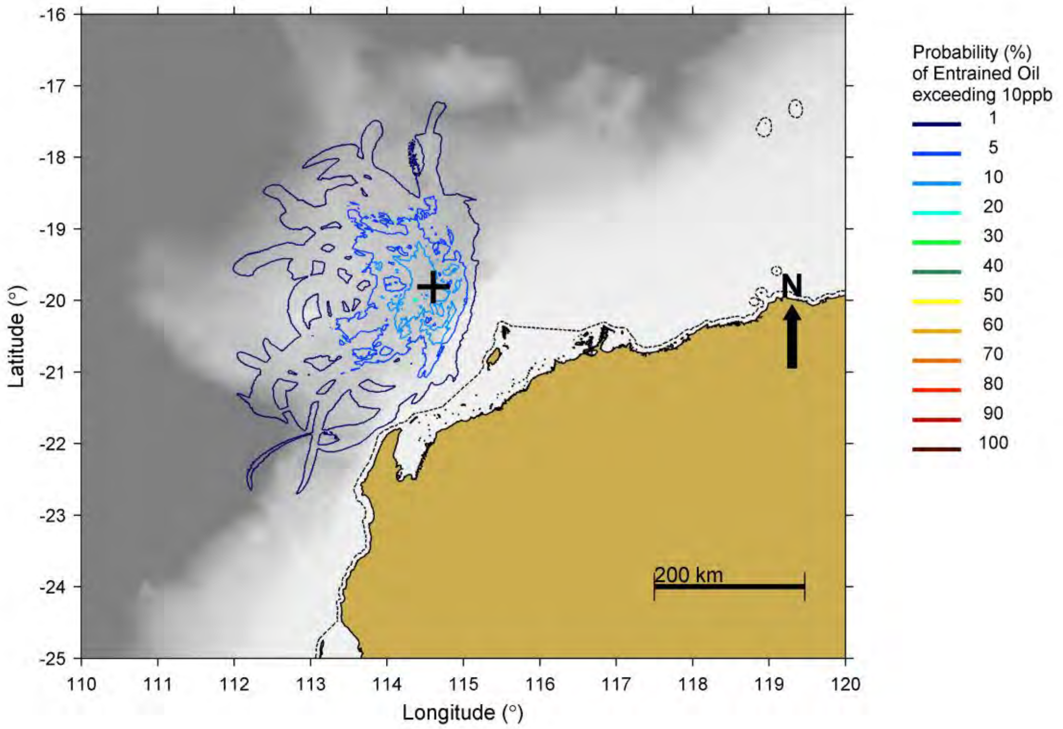
Figure 3-50: Predicted probability of sea surface contact to concentrations above 10 g/m² resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-30: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from a pipeline rupture at the seabed at the Jansz PTS commencing during winter months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold



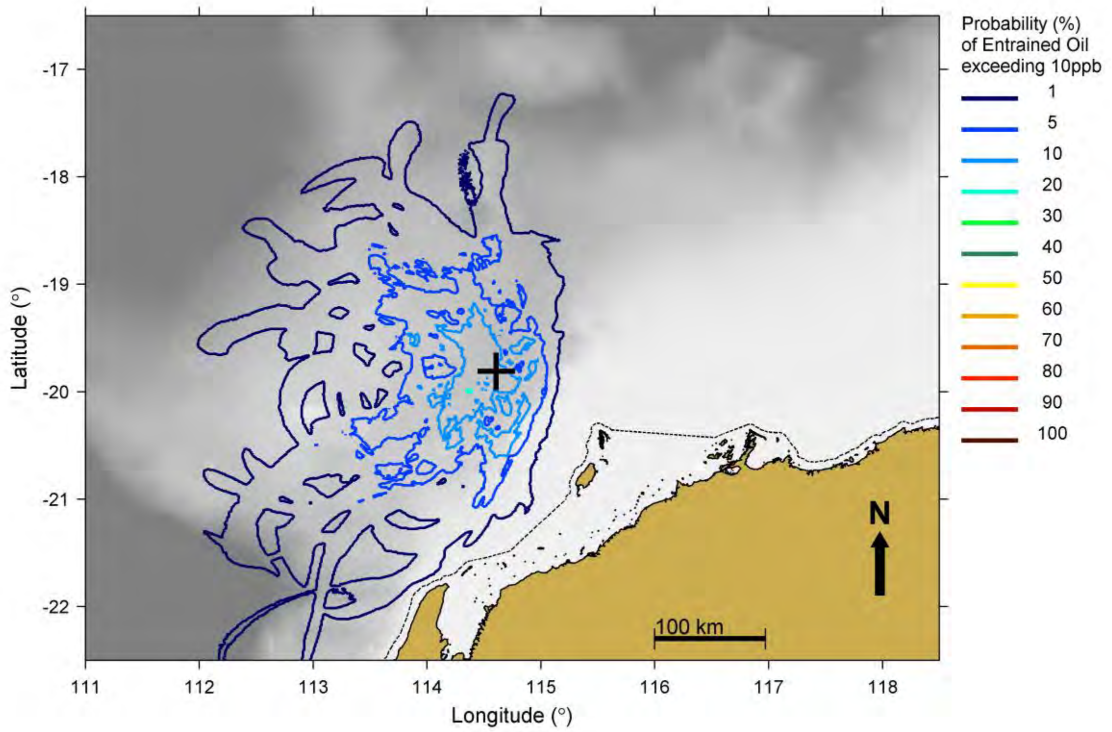


Figure 3-51: Predicted probability of entrained concentrations above 10 ppb resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

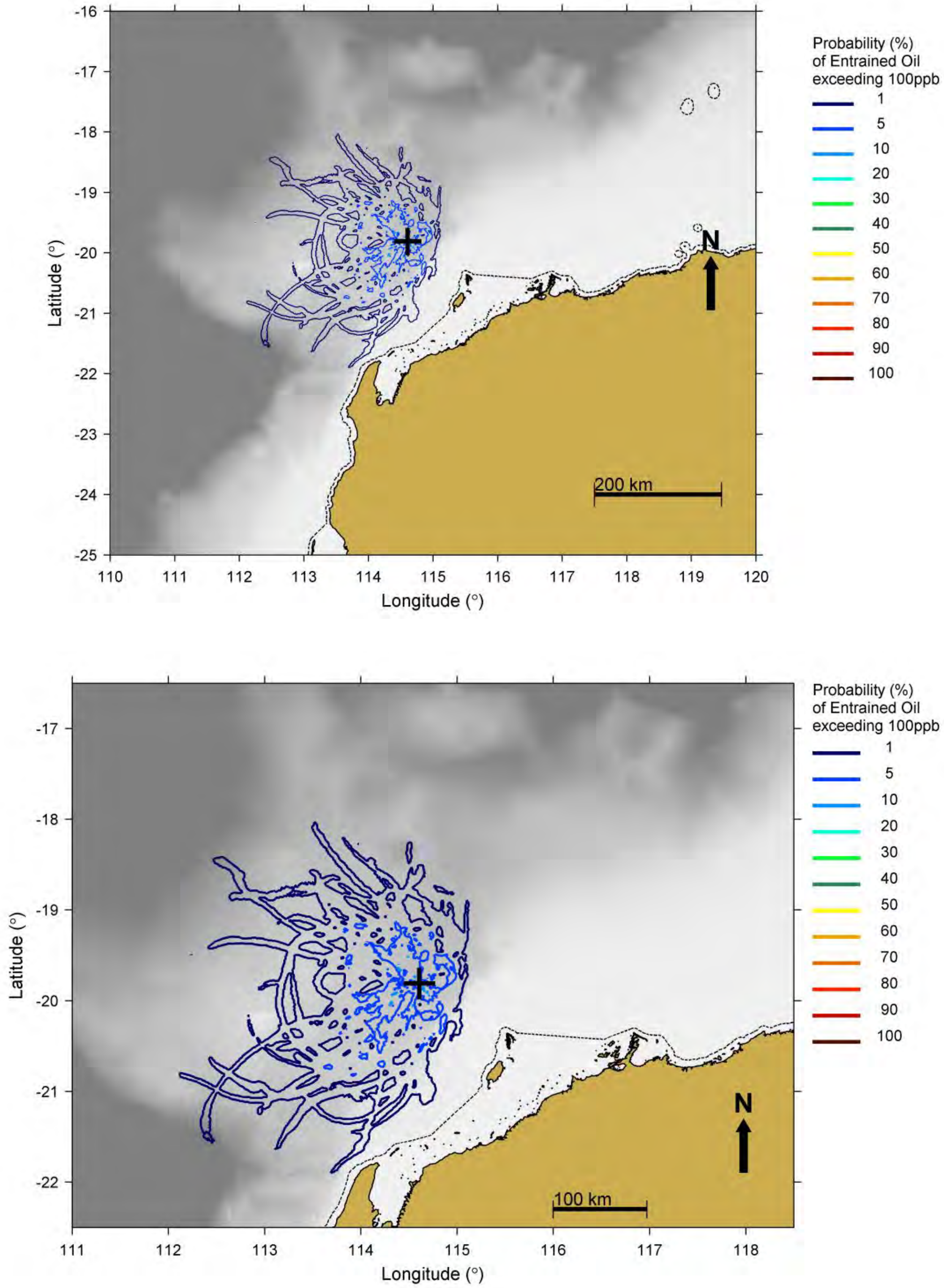


Figure 3-52: Predicted probability of entrained concentrations above 100 ppb resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

3.4.4 Spring

Surface Slicks and Films

Table 3-31: Summary of shoreline risks for different locations from a pipeline rupture at the seabed at the Jansz PTS commencing during spring months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

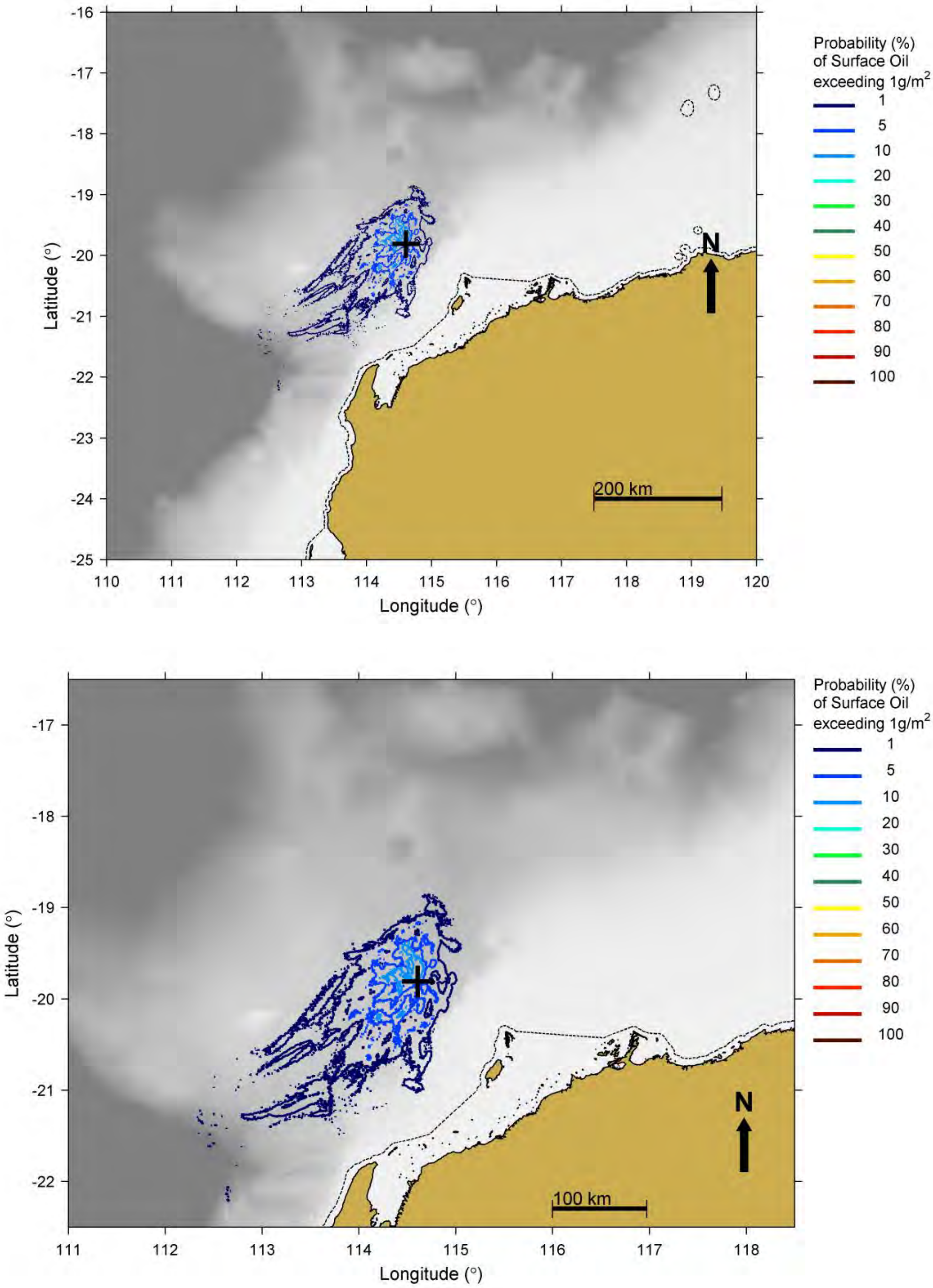
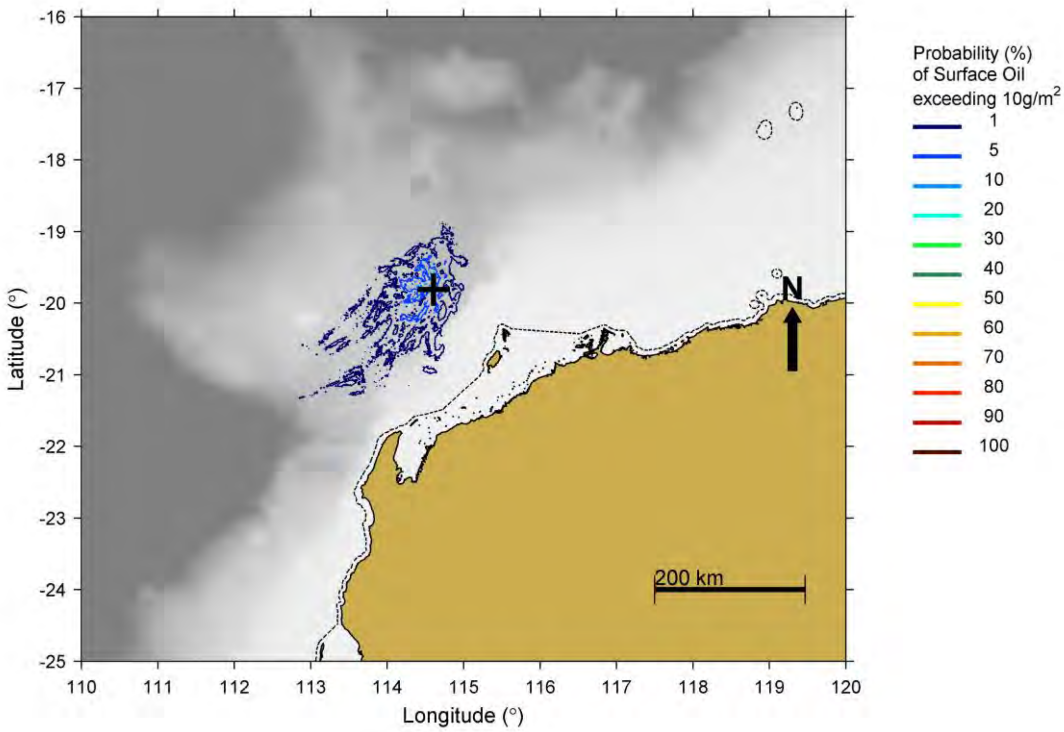


Figure 3-53: Predicted probability of sea surface contact to concentrations above 1 g/m^2 resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.



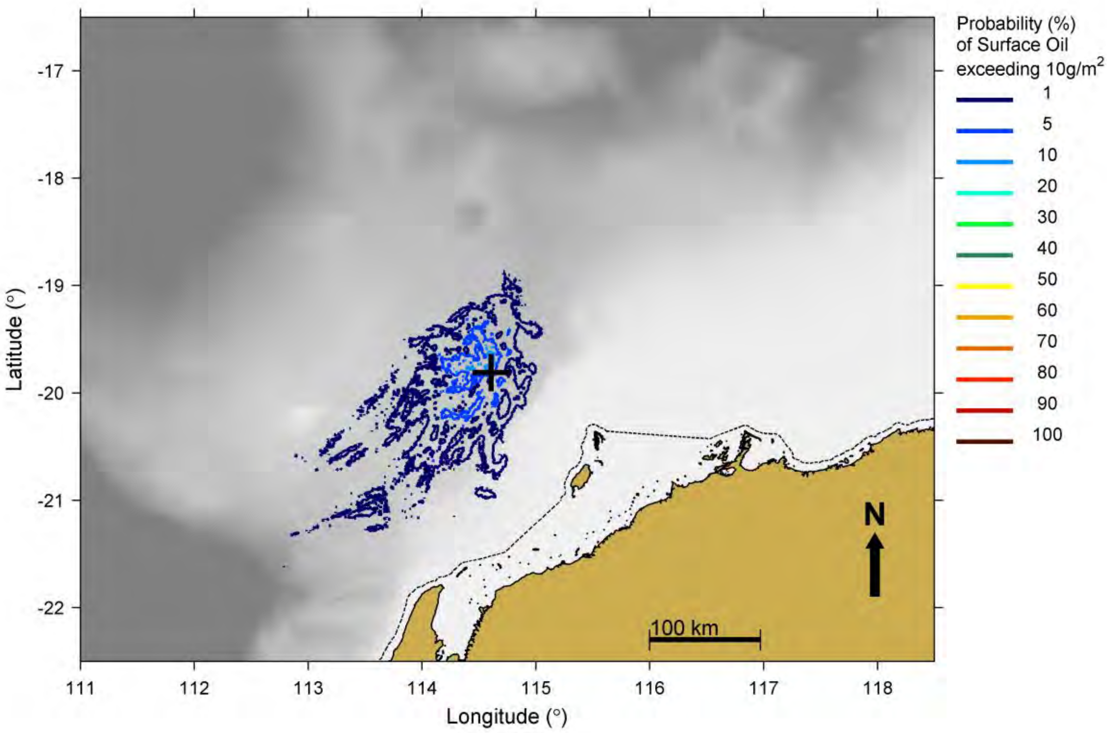


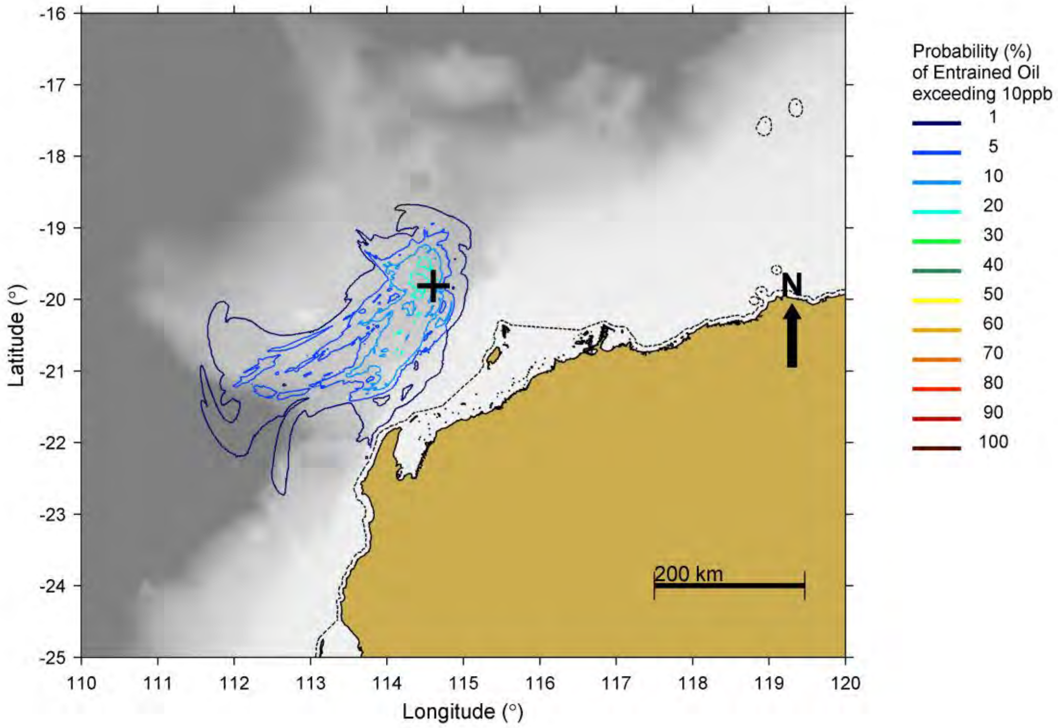
Figure 3-54: Predicted probability of sea surface contact to concentrations above 10 g/m^2 resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-32: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from a pipeline rupture at the seabed at the Jansz PTS commencing during spring months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 100 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean of the expected maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold



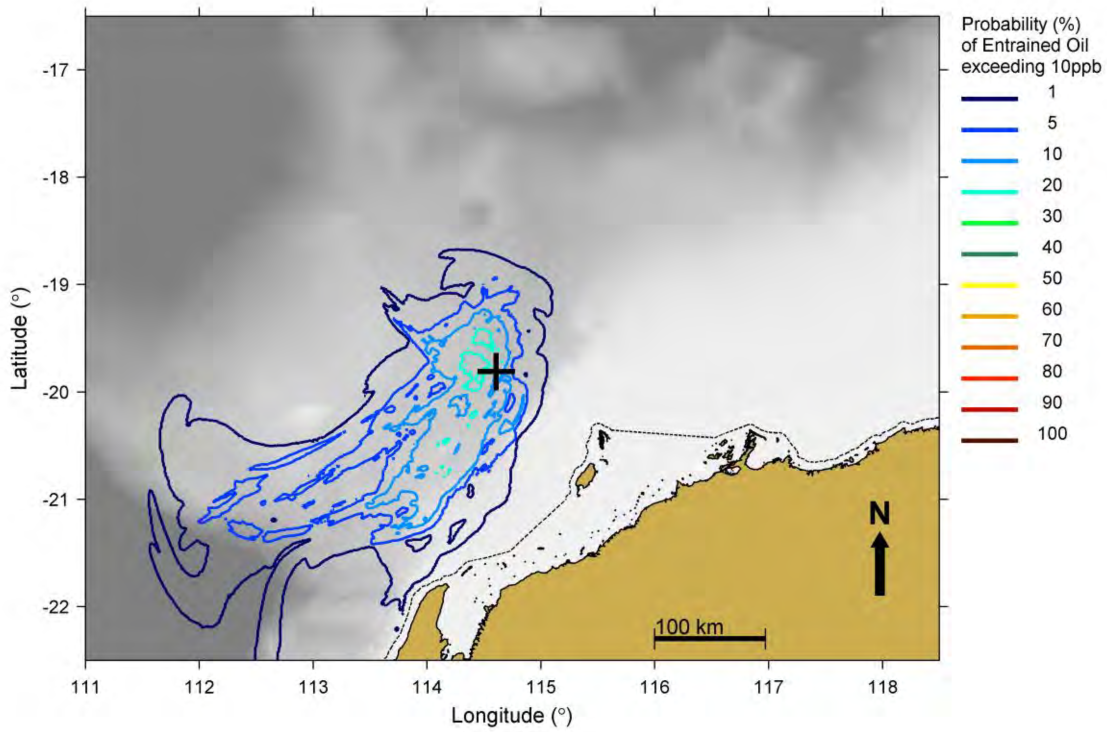
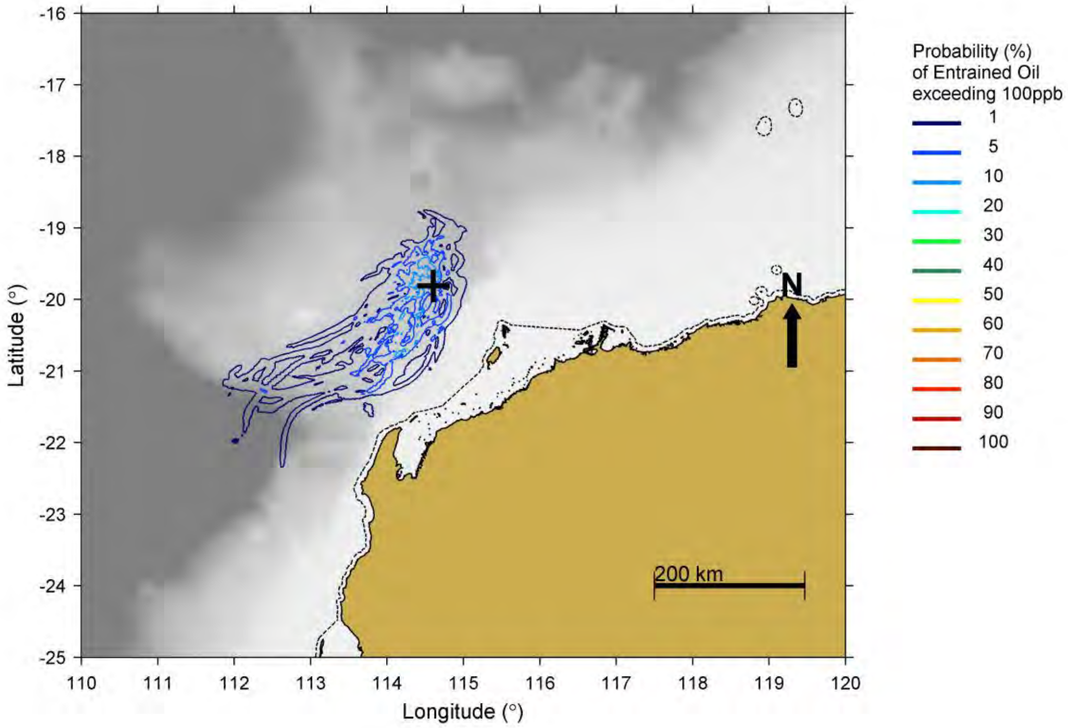


Figure 3-55: Predicted probability of entrained concentrations above 10 ppb resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.



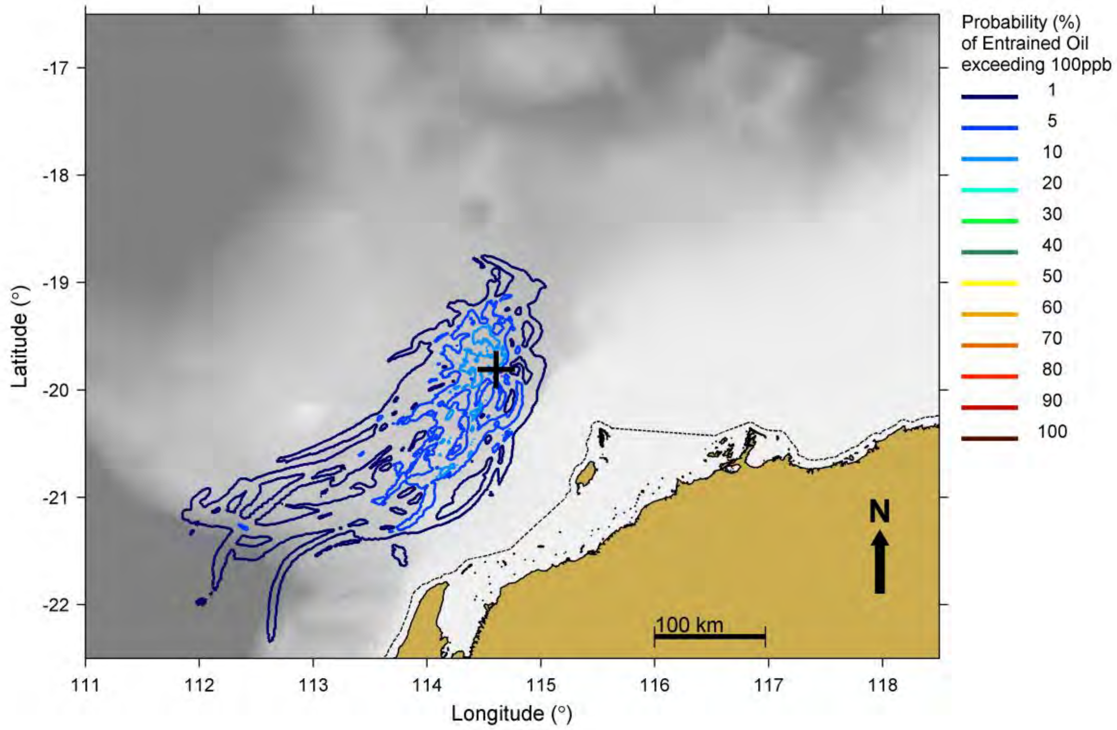


Figure 3-56: Predicted probability of entrained concentrations above 100 ppb resulting from a pipeline rupture at the seabed at the Jansz PTS commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

3.5 Simulation of 11 week blowout at seabed at the Chandon Well

This scenario investigated the probability of exposure to surrounding regions by oil due to a blowout of Chandon Condensate from 1,200 m below sea level at the Chandon Well location that continued for 11 weeks. A discharge rate of 2,349 bbl/d (373.6 m³/d) was assumed, resulting in a total discharge volume of 180,873 bbl (28,756.5 m³). Result figures and tables are presented for each of the seasons in the following sections.

The probability contours calculated for surface oil due to this event indicate that dull metallic coloured oil sheen (> 10 g/m²) of residual oil could be broadcast over a large region due to oil surfacing after being transported and dispersed by the prevailing drift currents. The wide distribution of the contours in the simulations can be attributed to the large variability and high complexity of the drift currents in the region, which would transport different portions of the release over different trajectories during the long periods of each simulation. Note again that the probability contours do not represent any single event outcome, but are a summary of many model simulations.

The risk contours are strongly affected by the residual components, in particular, because they remain locally concentrated above the threshold concentrations over the full duration of the simulation. Trajectories into offshore areas, which are strongly affected by drift currents, are forecasted to result in longer trajectories, adding to the potential distance that these weathered components of the oil could travel.

Surface oil is forecast to travel in almost any direction from the release site if a blowout were to commence during summer (Figure 3-57, Figure 3-58) or winter (Figure 3-69, Figure 3-70), with south-westerly or north-westerly trajectories most likely. There is a low (20%) probability that surface oil concentrations up to 1 g/m^2 will occur up to 150km from the blowout site for the summer scenario, or up to 50km for the winter scenario. For blowouts beginning during autumn, trajectories are forecast to be predominantly towards the northeast or west-southwest (Figure 3-63, Figure 3-64). There is a probability of 30% forecasted for surface oil concentrations > 1 g/m^2 within 150km from the blowout site for an autumn blowout. If the blowout were to commence during spring, there is a lower probability (20%) that surface oil > 1 g/m^2 will occur up to 300 km north-northwest or south-southwest of the blowout site (Figure 3-75, Figure 3-76).

There is a probability of 3% forecasted for shoreline contact by surface oil > 1 g/m² for the Ningaloo Coast in winter (Table 3-39). The earliest time for oil to reach this shoreline during autumn was calculated to be approximately 29 days, indicating the oil is likely to be highly weathered. No other shoreline contact by surface oil > 1 g/m² is predicted.

Maximum short-term concentrations were calculated to be highest for Murion Islands in summer (60 g/m²) and spring (47 g/m²). Short-term concentrations are also forecasted for Ningaloo Coast during winter (26 g/m²) autumn (33 g/m²) and summer (43 g/m²) and Southern Island Group during spring (13 g/m²).

The probability contours for entrained oil indicate that oil in the water column is most likely to be transported to the south-southwest if a blowout were to commence during summer, with shorter trajectories to the west and northwest also likely (Figure 3-59, Figure 3-60, Figure

3-61). For blowouts commencing during autumn, long trajectories towards the south-southwest and southwest are forecast to be the most common (Figure 3-65, Figure 3-66 and Figure 3-67). For a winter blowout event, drift is most likely to trend towards the southwest, west and north (Figure 3-71, Figure 3-72, Figure 3-73). If a blowout began during spring, modelling predicts entrained oil is most likely to be transported to the south-southwest and southwest, with shorter trajectories towards the north also likely (Figure 3-77, Figure 3-78, Figure 3-79).

A 70% probability is predicted for entrained oil > 10 ppb to reach near-shore waters off the Ningaloo Coast in the autumn scenario, with a minimum time to shoreline of approximately 11 days (Table 3-37). This probability is reduced when thresholds of 100 ppb (20%) and 500 ppb (3%) are applied. Lower probabilities for contact > 10 ppb are predicted for this shoreline for the summer (40%, Table 3-34), winter (36%, Table 3-40) and spring (50%, Table 3-43) scenarios. Earliest times for shoreline contact were calculated to be approximately 10 days for each of these three seasons.

Entrained oil > 10 ppb is also predicted to contact shorelines of the Muiron Islands, at 23 – 46% probability, and the Southern Island Group (16 – 43%) during each of the seasons. Modelling predicts entrained oil above this threshold could reach the Muiron Islands after only 13 days if a blowout began during autumn. Earliest times for shoreline contact to Southern Island Group are predicted for the summer, winter and spring scenarios (15 days). Lower probabilities (6 – 16%) are forecast for entrained oil > 10 ppb to contact Barrow Island, Lowendal Islands and Montebello Islands for summer and spring and to Barrow Island and Montebello Islands for winter.

Probabilities for contact to each shoreline are generally significantly reduced when thresholds of 100 ppb and 500 ppb are applied. However, in the event of a blowout commencing during the spring month, modelling predicts a 43% chance of contact by oil > 100 ppb to the Muiron Islands and a 36% chance for Ningaloo Coast. These probabilities are reduced to 23% for each shoreline for contact above 500 ppb.

High potential short-term entrained oil concentrations are forecast for Ningaloo Coast for spring (2.9 ppm), summer (2 ppm) and winter (1.3 ppm). Short-term concentrations are also forecast to potentially be high along shorelines of the Muiron Islands in the spring (2.2 ppm) and summer (1.4 ppm) scenarios. A maximum short-term concentration of 2.1 ppm is predicted for the Southern Island Group in the winter scenario.

Modelling forecasts dissolved aromatic hydrocarbons > 5 ppb are most likely to occur in a small region immediately to the east of the blowout location for each of the seasons (Figure 3-62, Figure 3-68, Figure 3-74, Figure 3-80). Aromatic hydrocarbon concentrations > 5 ppb are not forecast beyond 150 km from the blowout location in autumn, while in spring, summer and winter, aromatic hydrocarbon concentrations > 5 ppb may occur up to 250 km south from the blowout location and reach the coastline. Aromatic concentrations > 50 ppb are not predicted (< 1% probability) to occur in the water column in any waters surrounding the blowout location for any season, averaged at the scale of the model grid.

Moderate probabilities (23%) for shoreline contact by aromatics > 5 ppb are forecasted for Ningaloo Coast, Muiron Islands and Southern Island Group in the spring scenario, with a maximum short-term concentration of 30 ppb along Ningaloo Coast (Table 3-44). Low probabilities (3 – 6%) are predicted for these shorelines in the summer (Table 3-35) and winter (Table 3-41) scenarios. Contact to any shoreline is highly unlikely in the autumn scenario (Table 3-38).

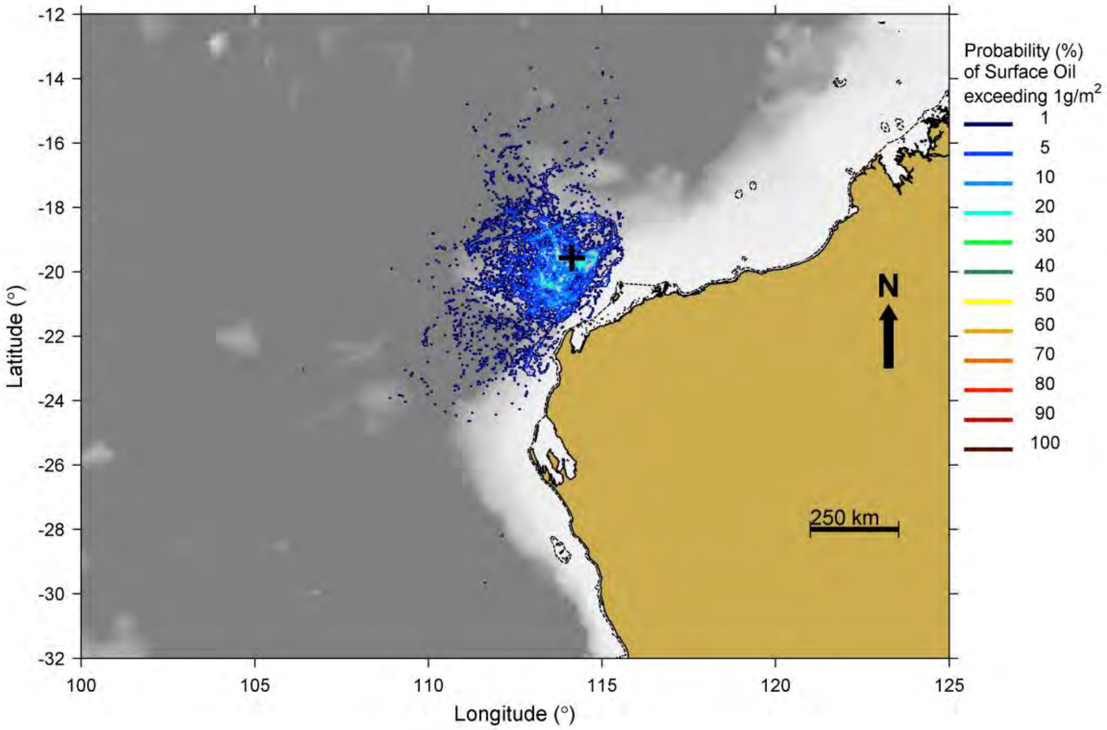
3.5.1 Summer

Surface Slicks and Films

Table 3-33: Summary of shoreline risks for different locations from an 11 week blowout at the seabed at the Chandon Well commencing during summer months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group	Bernier/Dorre Islands	Abrolhos Islands
Probability (%) of oil > 1 g/m^2 arriving at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m^2 arriving at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 1 g/m^2	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 g/m^2	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m^2)	NC	1	NC	1	1	NC	1	NC	NC	NC	NC
Maximum shoreline concentration (g/m^2)	NC	1	NC	60	43	NC	2	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold



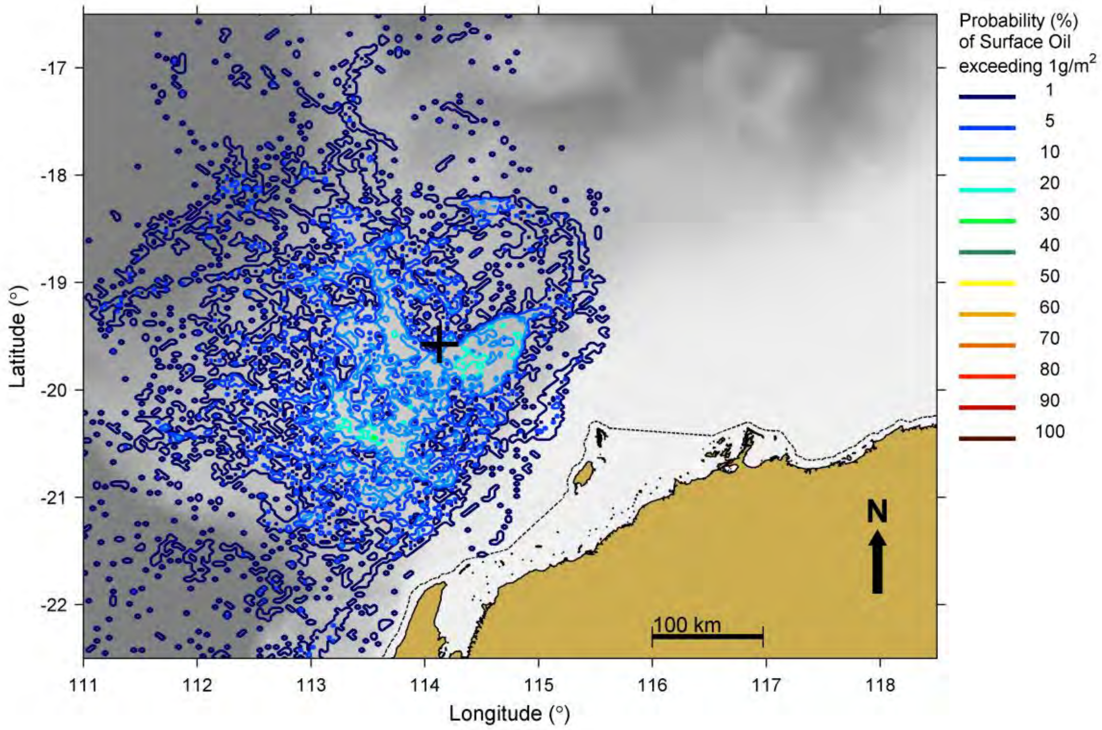


Figure 3-57: Predicted probability of sea surface contact to concentrations above 1 g/m^2 resulting from an 11 week blowout at the seabed at the Chandon Well commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

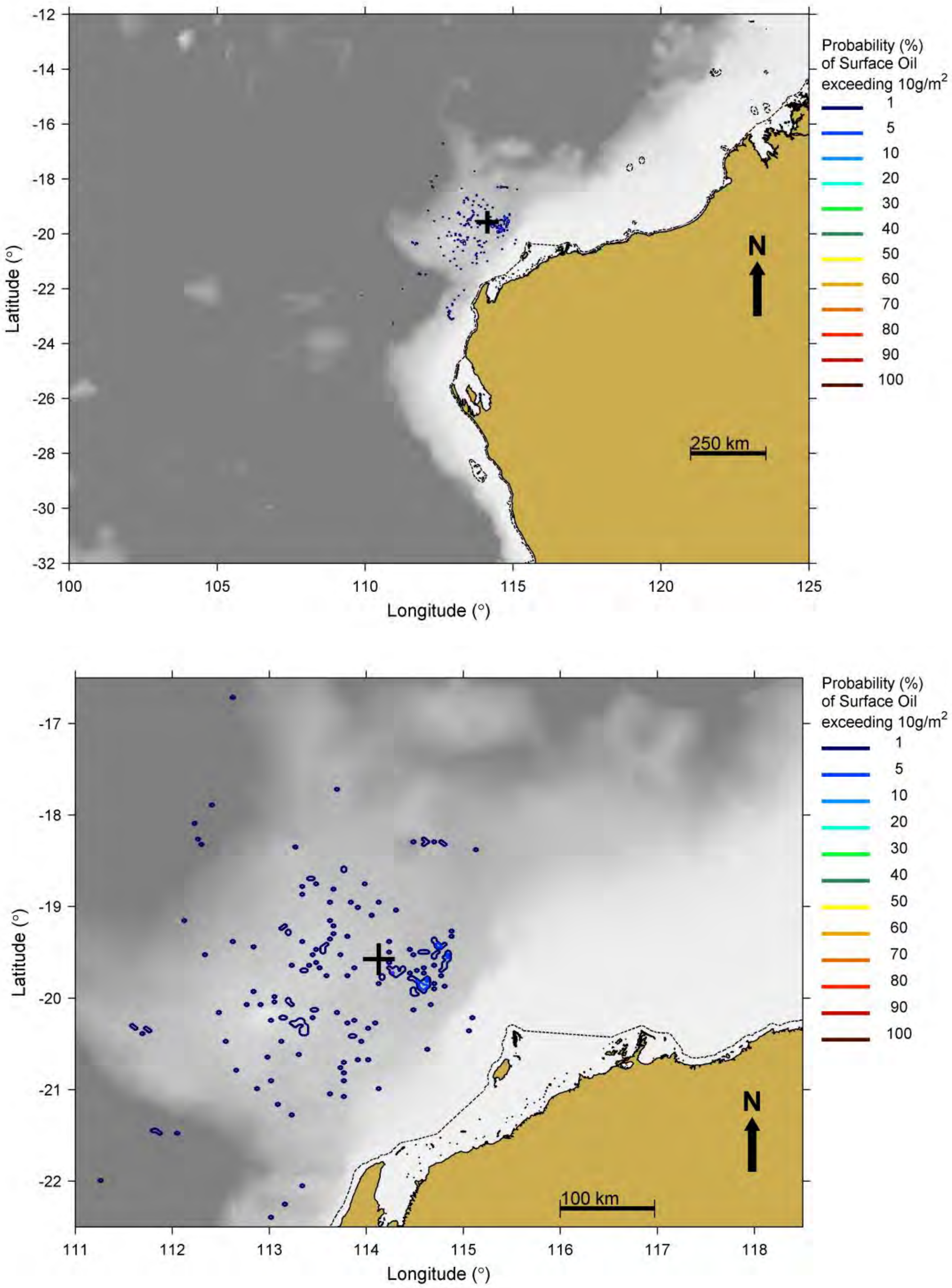


Figure 3-58: Predicted probability of sea surface contact to concentrations above 10 g/m^2 resulting from an 11 week blowout at the seabed at the Chandon Well commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-34: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from an 11 week blowout at the seabed at the Chandon Well commencing during summer months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group	Bernier/ Dorre Islands	Abrolhos Islands
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	6	16	6	33	40	NC	20	NC	NC	3	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	20	23	NC	3	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 500 ppb	NC	NC	NC	3	6	NC	3	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 ppb	25	12	30	15	10	NC	15	NC	NC	68	NC
Minimum time to shoreline (days) at >100 ppb	NC	NC	NC	15	10	NC	16	NC	NC	NC	NC
Minimum time to shoreline (days) at >500 ppb	NC	NC	NC	16	17	NC	25	NC	NC	NC	NC
Mean expected maximum entrained concentration (ppb)	< 10	< 10	< 10	90	115	NC	30	NC	NC	< 10	NC
Maximum entrained hydrocarbon concentration (ppb)	30	55	20	1,375	1,975	NC	715	NC	NC	20	NC

NC: No contact to shoreline predicted for specified threshold

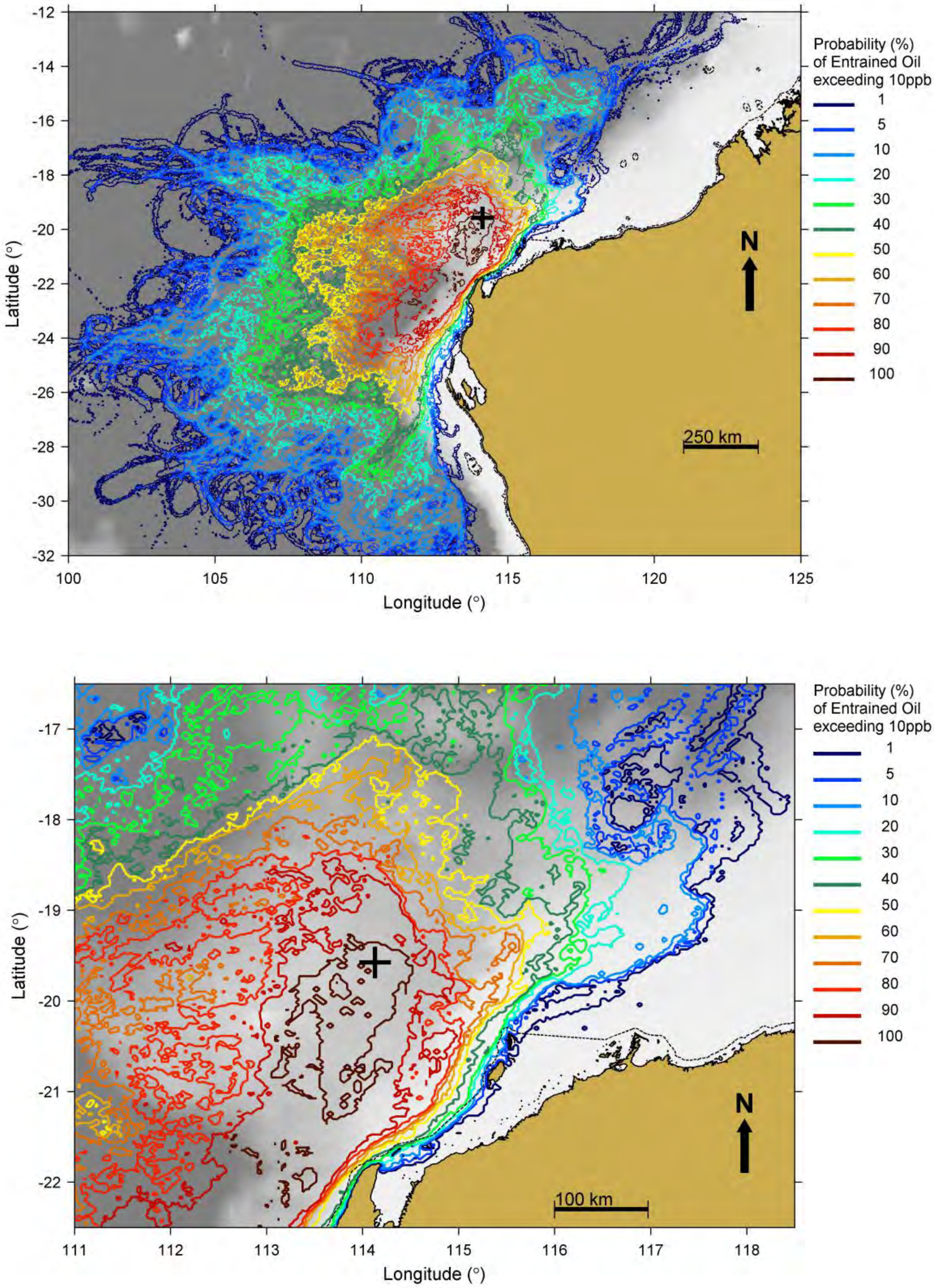
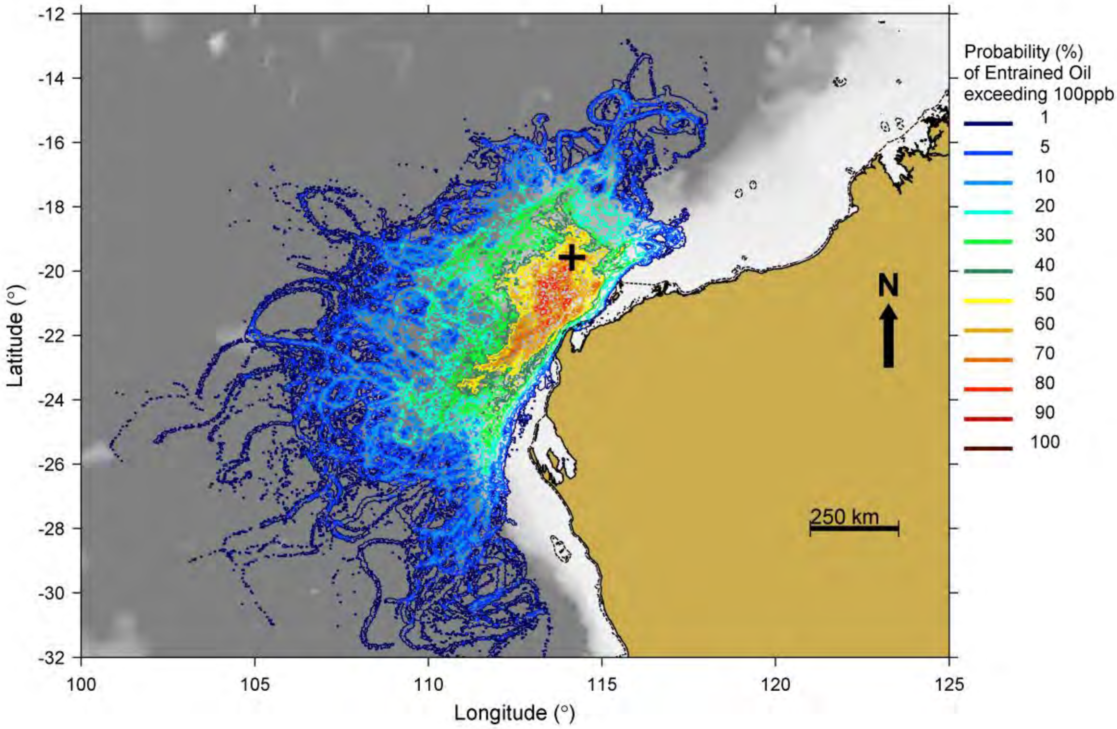


Figure 3-59: Predicted probability of entrained concentrations above 10 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary



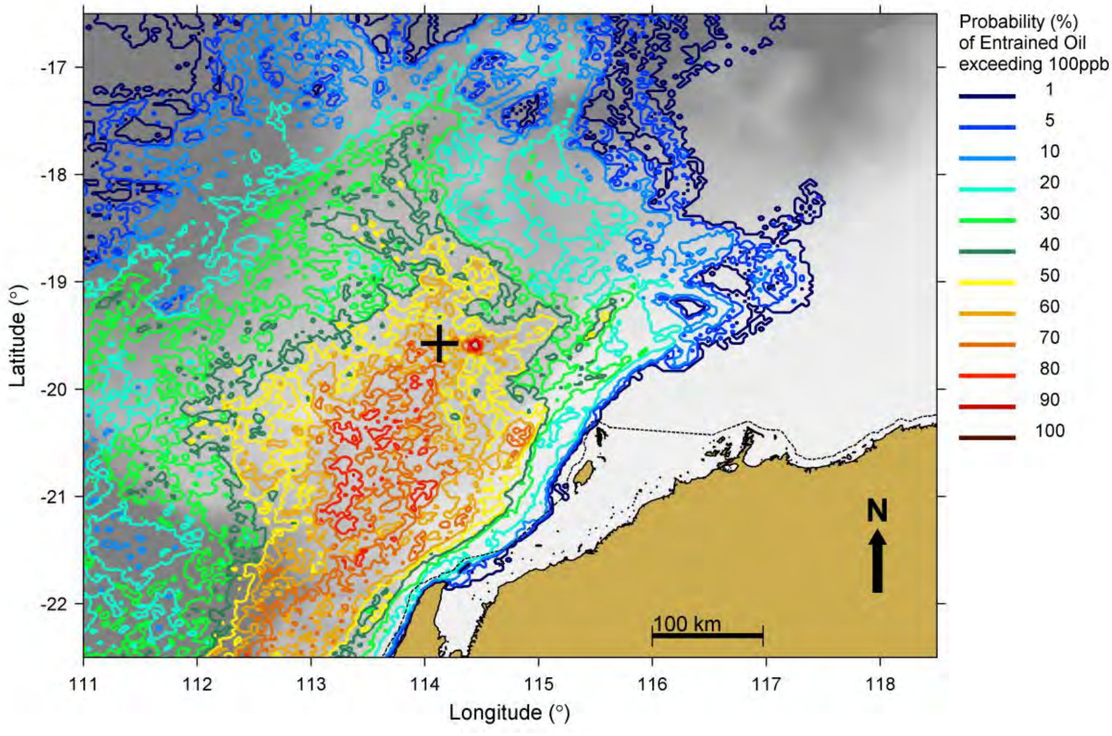


Figure 3-60: Predicted probability of entrained concentrations above 100 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

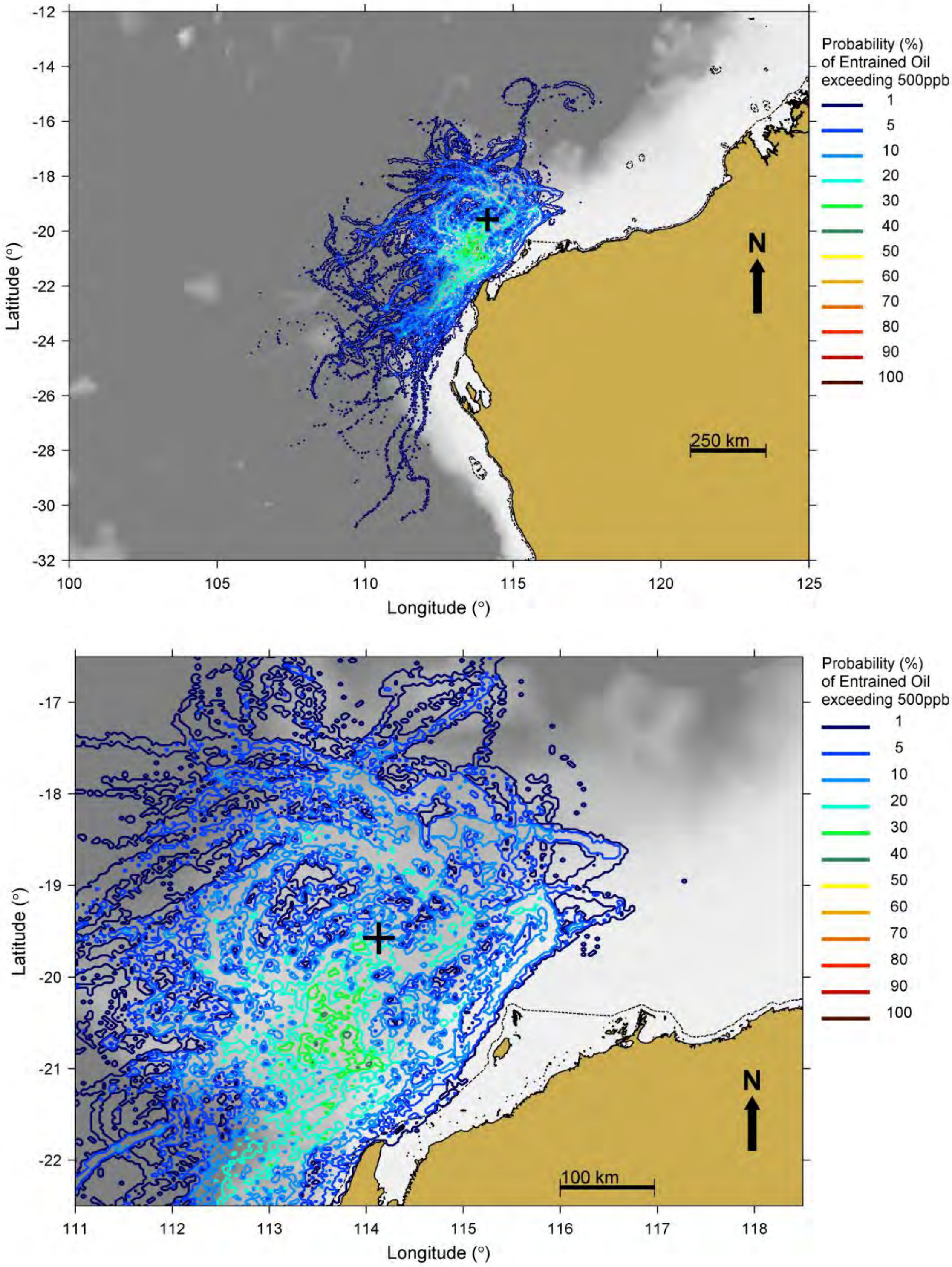


Figure 3-61: Predicted probability of entrained concentrations above 500 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during summer months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Dissolved Aromatic Hydrocarbons

Table 3-35: Summary of risks for dissolved aromatic concentrations in shallow waters adjacent to shorelines, from an 11 week blowout at the seabed at the Chandon Well commencing during summer months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group	Bernier/ Dorre Islands	Abrolhos Islands
Probability (%) of dissolved aromatic concentrations > 5 ppb	NC	NC	NC	3	6	NC	3	NC	NC	NC	NC
Probability (%) of dissolved aromatic concentrations > 50 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of dissolved aromatic concentrations > 500 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum aromatic concentration (ppb)	NC	NC	NC	< 5	< 5	NC	< 5	NC	NC	NC	NC
Maximum dissolved aromatic concentration (ppb)	NC	NC	NC	20	25	NC	15	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

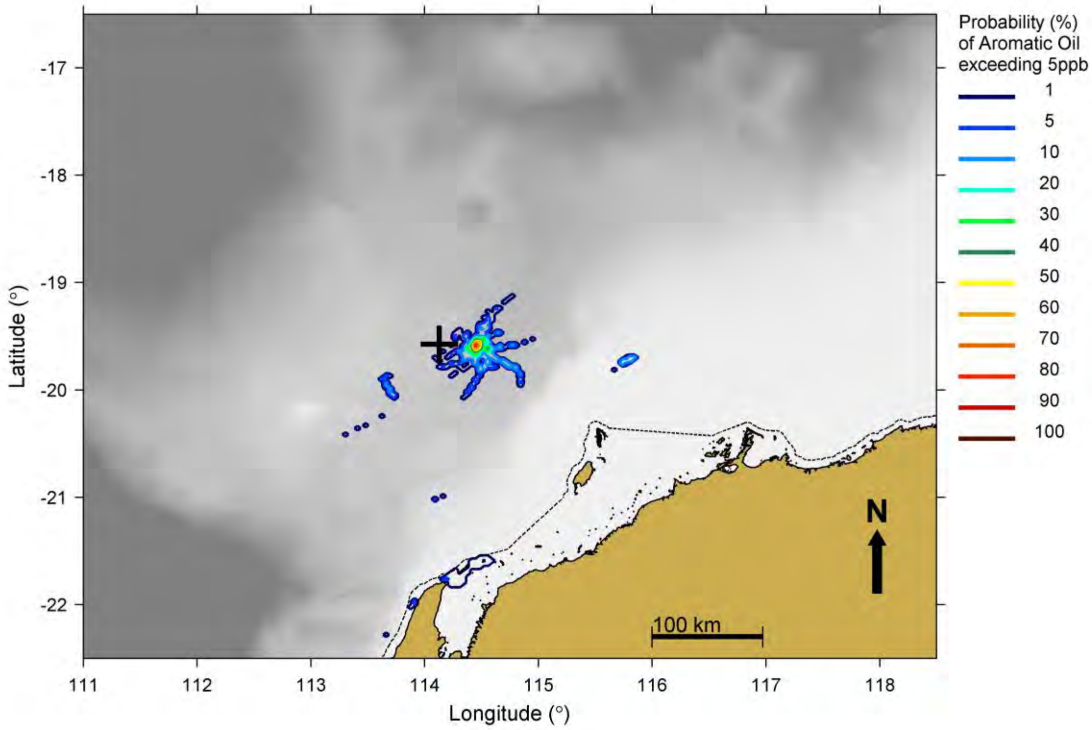


Figure 3-62: Predicted probability of dissolved aromatic hydrocarbons above 5 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during summer months. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

3.5.2 Autumn

Surface Slicks and Films

Table 3-36: Summary of shoreline risks for different locations from an 11 week blowout at the seabed at the Chandon Well commencing during autumn months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group	Bernier/Dorre Islands	Abrolhos Islands
Probability (%) of oil > 1 g/m^2 arriving at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m^2 arriving at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 1 g/m^2	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at > 10 g/m^2	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m^2)	NC	NC	NC	NC	1	NC	NC	NC	NC	1	1
Maximum shoreline concentration (g/m^2)	NC	NC	NC	1	33	NC	NC	NC	NC	1	1

NC: No contact to shoreline predicted for specified threshold

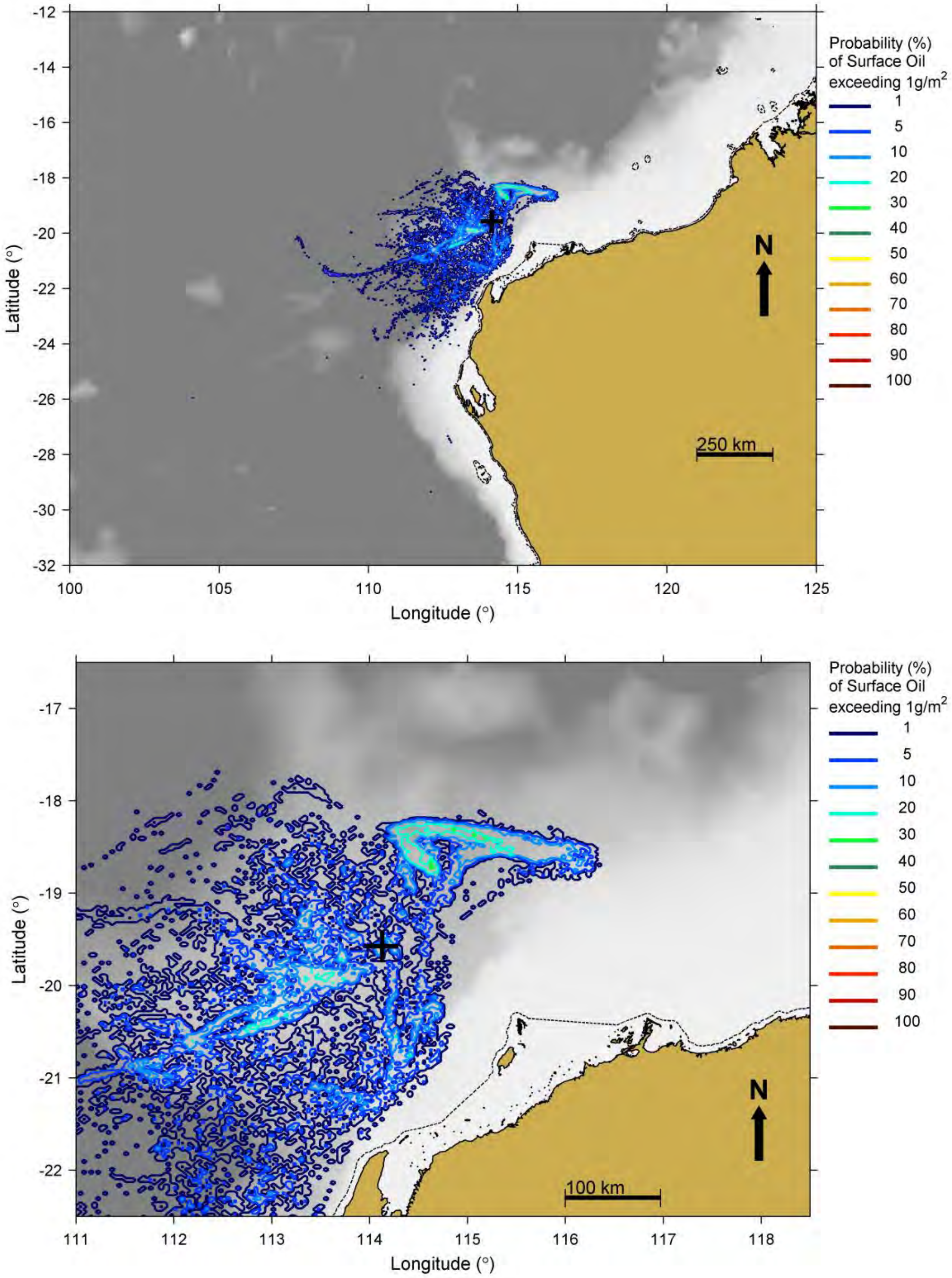


Figure 3-63: Predicted probability of sea surface contact to concentrations above 1 g/m^2 resulting from an 11 week blowout at the seabed at the Chandon Well commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

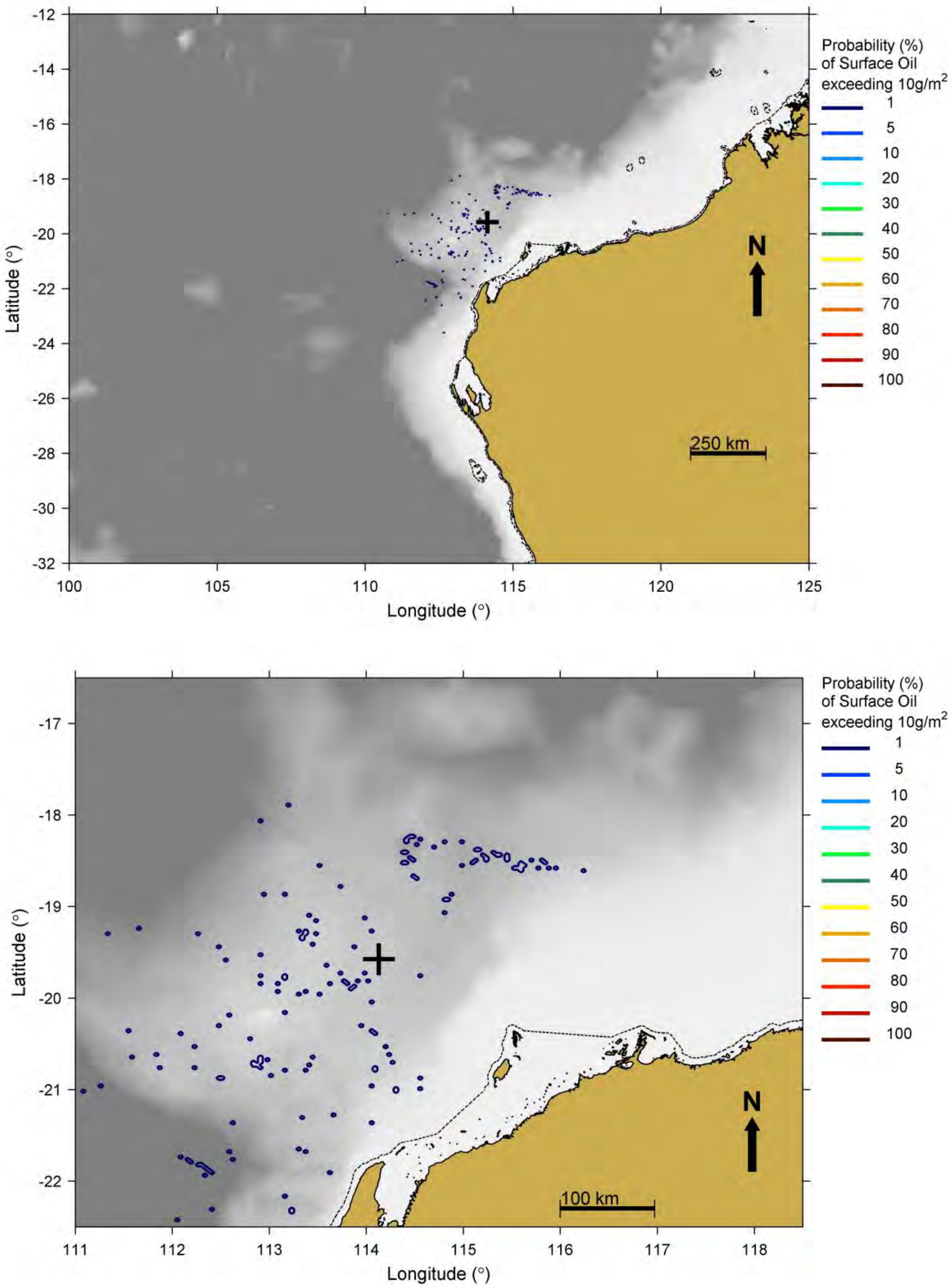


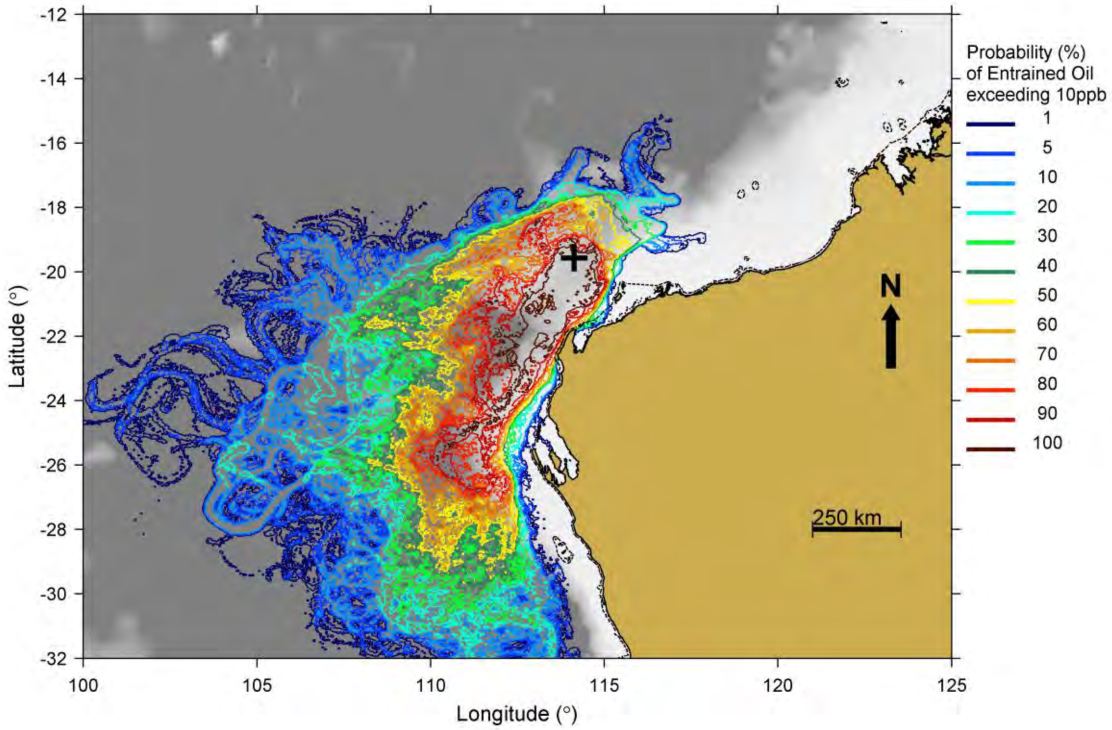
Figure 3-64: Predicted probability of sea surface contact to concentrations above 10 g/m^2 resulting from an 11 week blowout at the seabed at the Chandon Well commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-37: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from an 11 week blowout at the seabed at the Chandon Well commencing during the autumn month.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group	Bernier/ Dorre Islands	Abrolhos Islands
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	NC	NC	NC	46	70	NC	30	NC	NC	3	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	16	20	NC	3	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 500 ppb	NC	NC	NC	NC	3	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 ppb	NC	NC	NC	13	11	NC	20	NC	NC	38	NC
Minimum time to shoreline (days) at >100 ppb	NC	NC	NC	16	12	NC	25	NC	NC	NC	NC
Minimum time to shoreline (days) at >500 ppb	NC	NC	NC	NC	21	NC	NC	NC	NC	NC	NC
Mean expected maximum entrained concentration (ppb)	NC	NC	NC	50	55	NC	10	NC	NC	< 10	NC
Maximum entrained hydrocarbon concentration (ppb)	NC	NC	NC	400	560	NC	120	NC	NC	25	NC

NC: No contact to shoreline predicted for specified threshold



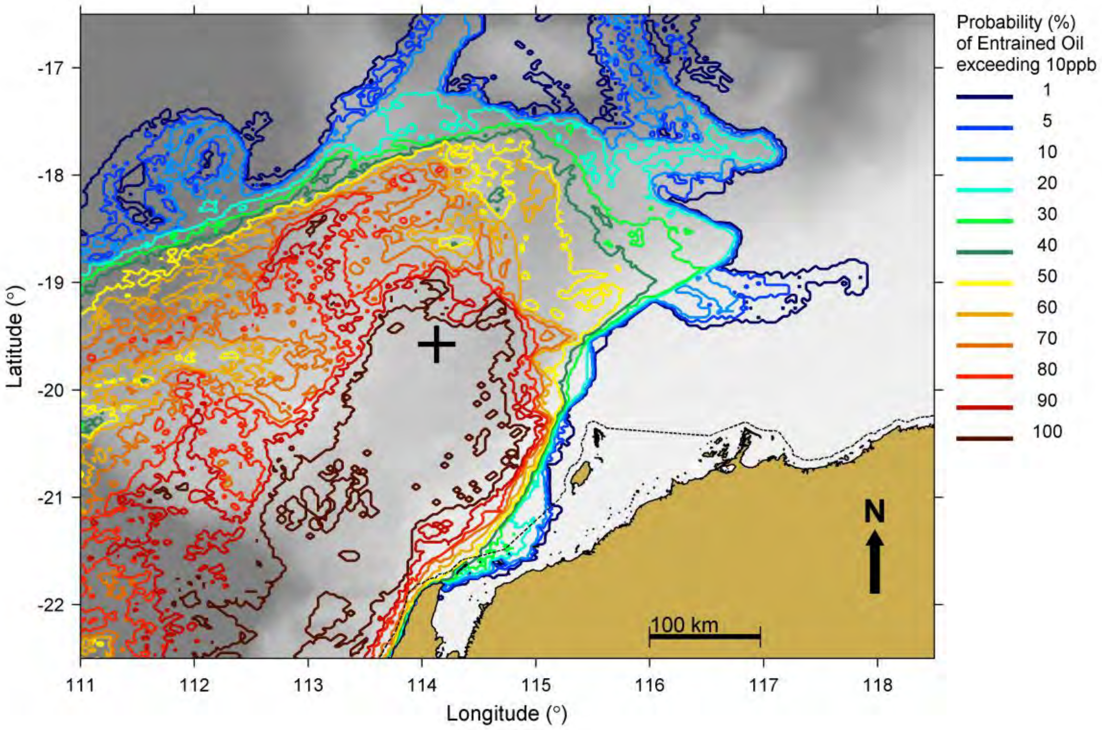
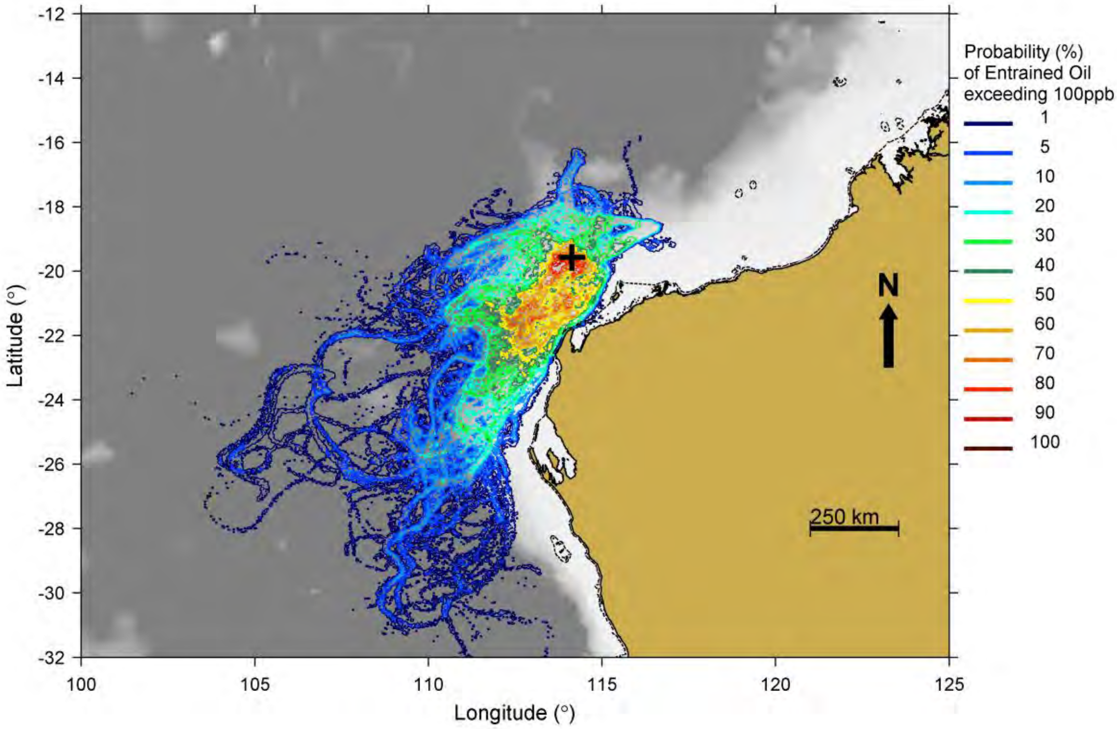


Figure 3-65: Predicted probability of entrained concentrations above 10 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.



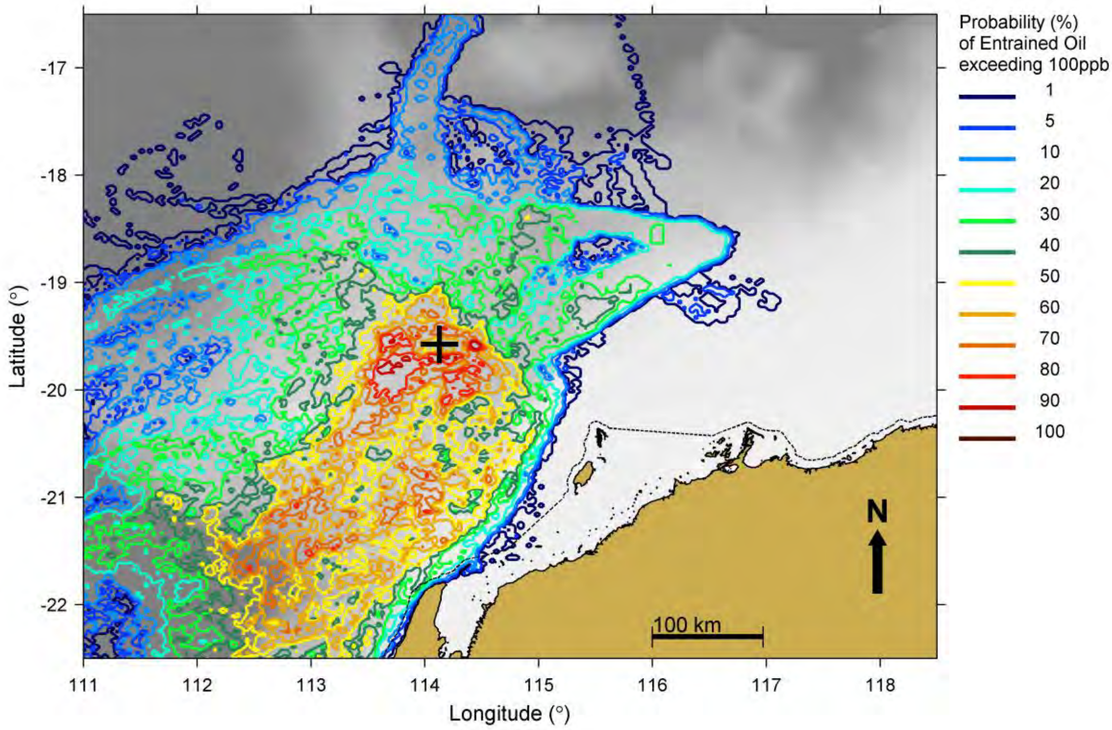


Figure 3-66: Predicted probability of entrained concentrations above 100 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

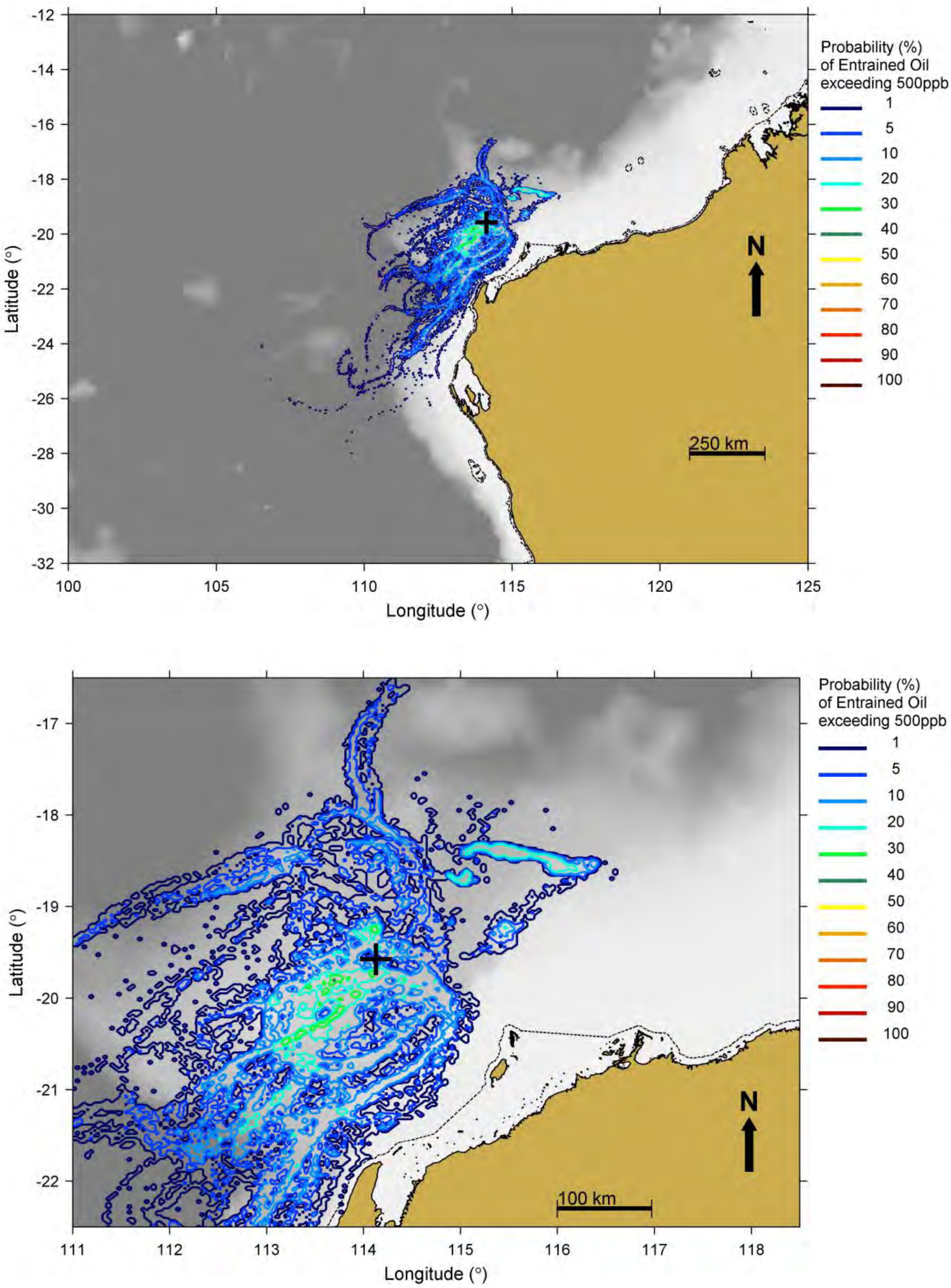


Figure 3-67: Predicted probability of entrained concentrations above 500 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during autumn months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Dissolved Aromatic Hydrocarbons

Table 3-38: Summary of risks for dissolved aromatic concentrations in shallow waters adjacent to shorelines, from an 11 week blowout at the seabed at the Chandon Well commencing during the autumn month.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group	Bernier/ Dorre Islands	Abrolhos Islands
Probability (%) of dissolved aromatic concentrations > 5 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of dissolved aromatic concentrations > 50 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of dissolved aromatic concentrations > 500 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum aromatic concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Maximum dissolved aromatic concentration (ppb)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

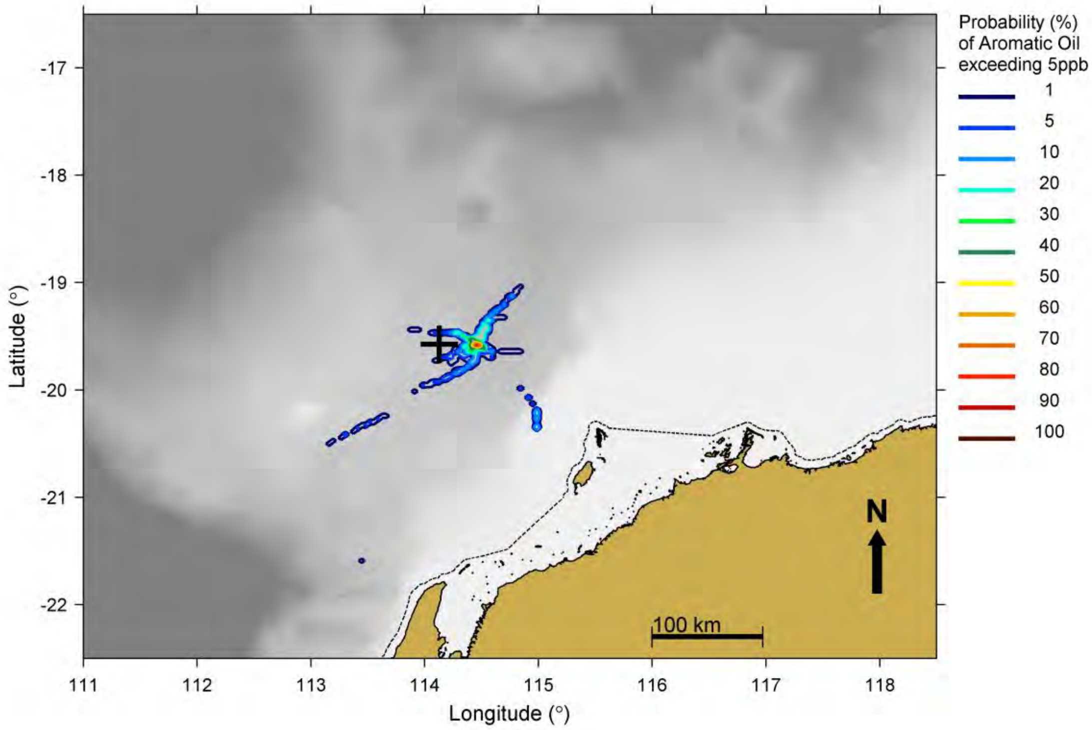


Figure 3-68: Predicted probability of dissolved aromatic hydrocarbons above 5 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during autumn months. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

3.5.3 Winter

Surface Slicks and Films

Table 3-39: Summary of shoreline risks for different locations from an 11 week blowout at the seabed at the Chandon Well commencing during winter months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group	Bernier/Dorre Islands	Abrolhos Islands
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	3	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	29	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m^2)	NC	NC	NC	1	1	NC	NC	NC	NC	NC	1
Maximum shoreline concentration (g/m^2)	NC	NC	NC	1	26	NC	1	NC	NC	NC	1

NC: No contact to shoreline predicted for specified threshold

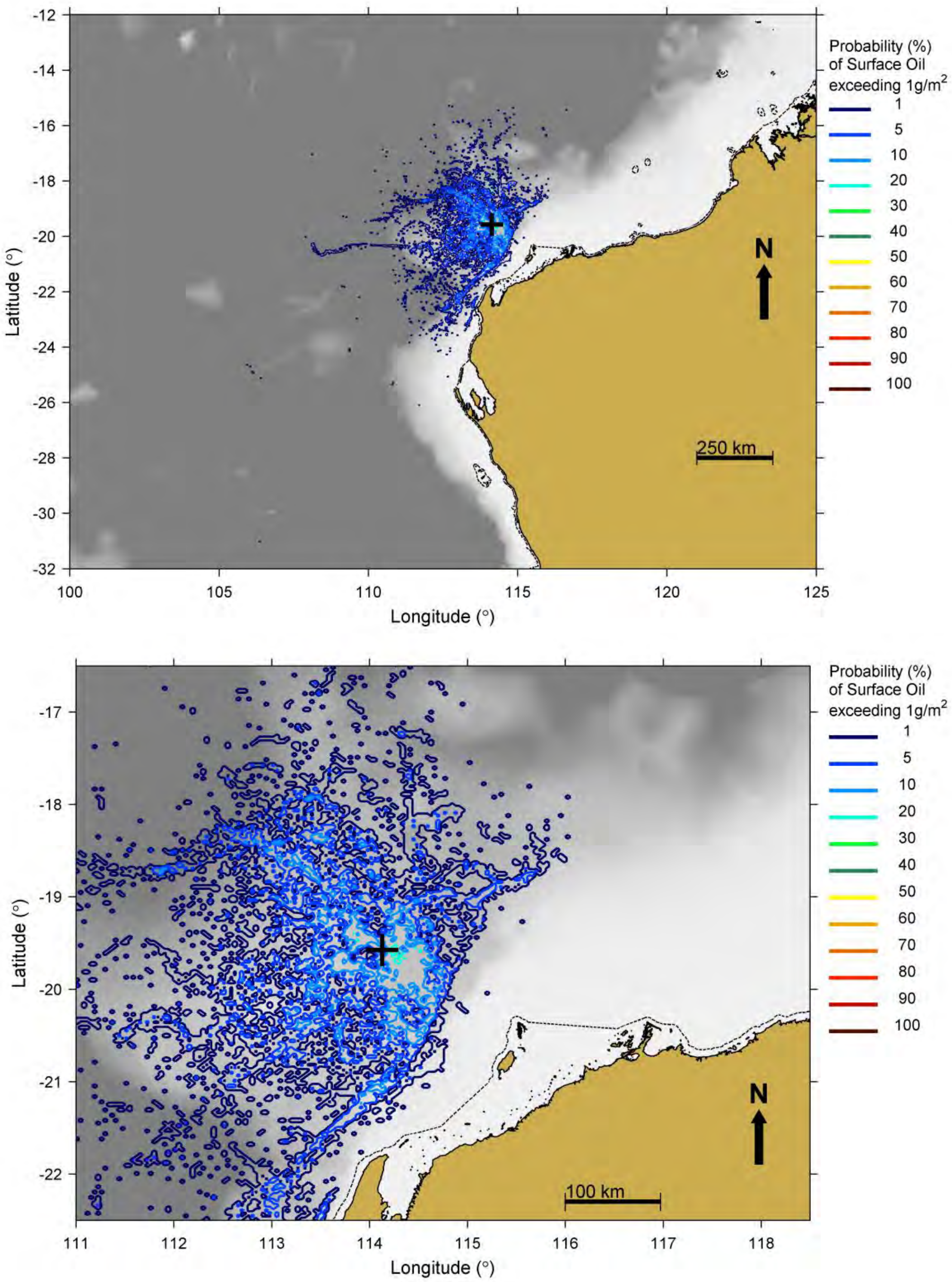
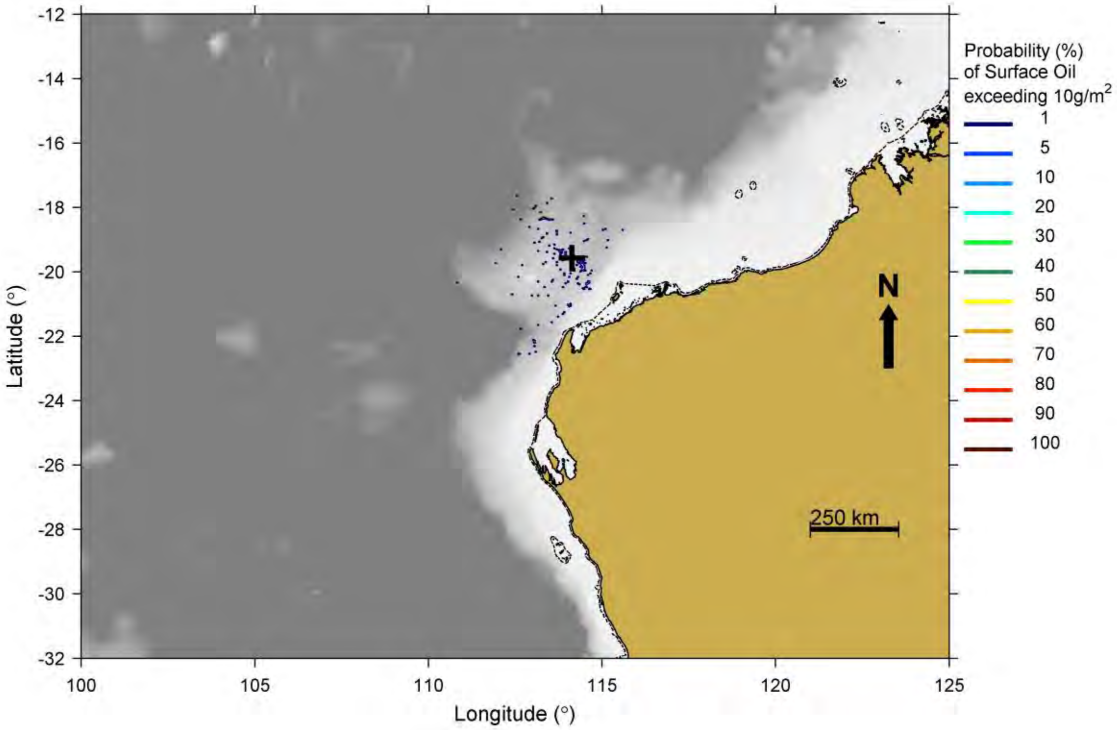


Figure 3-69: Predicted probability of sea surface contact to concentrations above 1 g/m^2 (top) resulting from an 11 week blowout at the seabed at the Chandon Well commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.



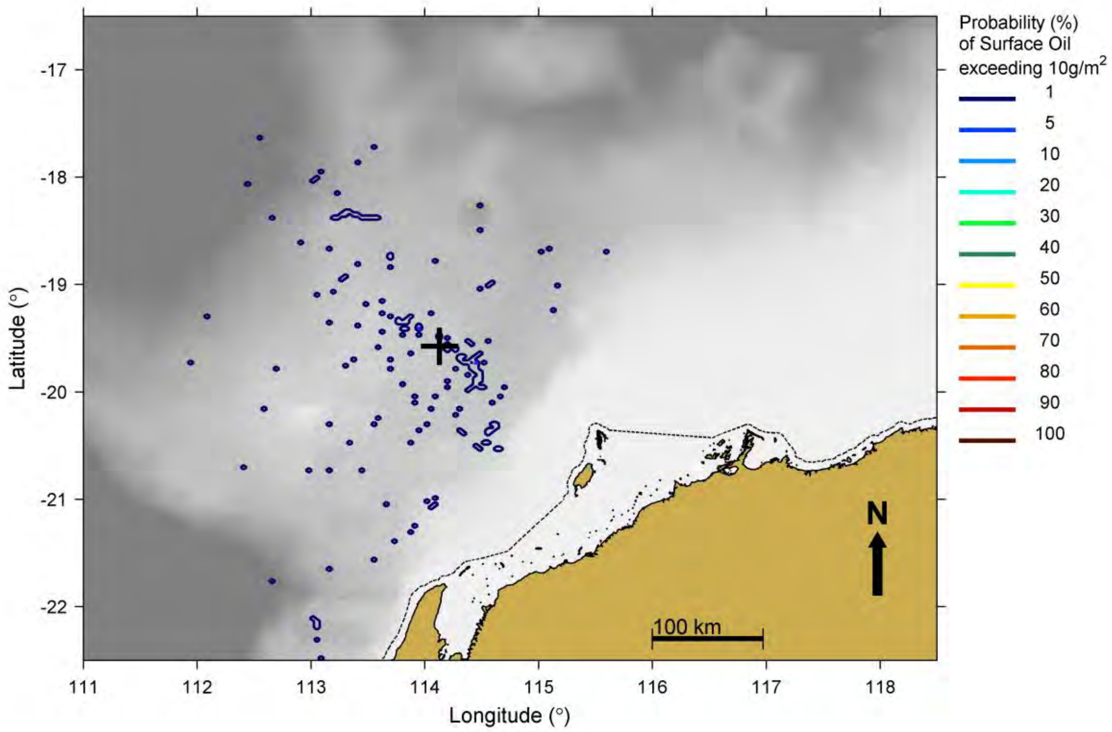


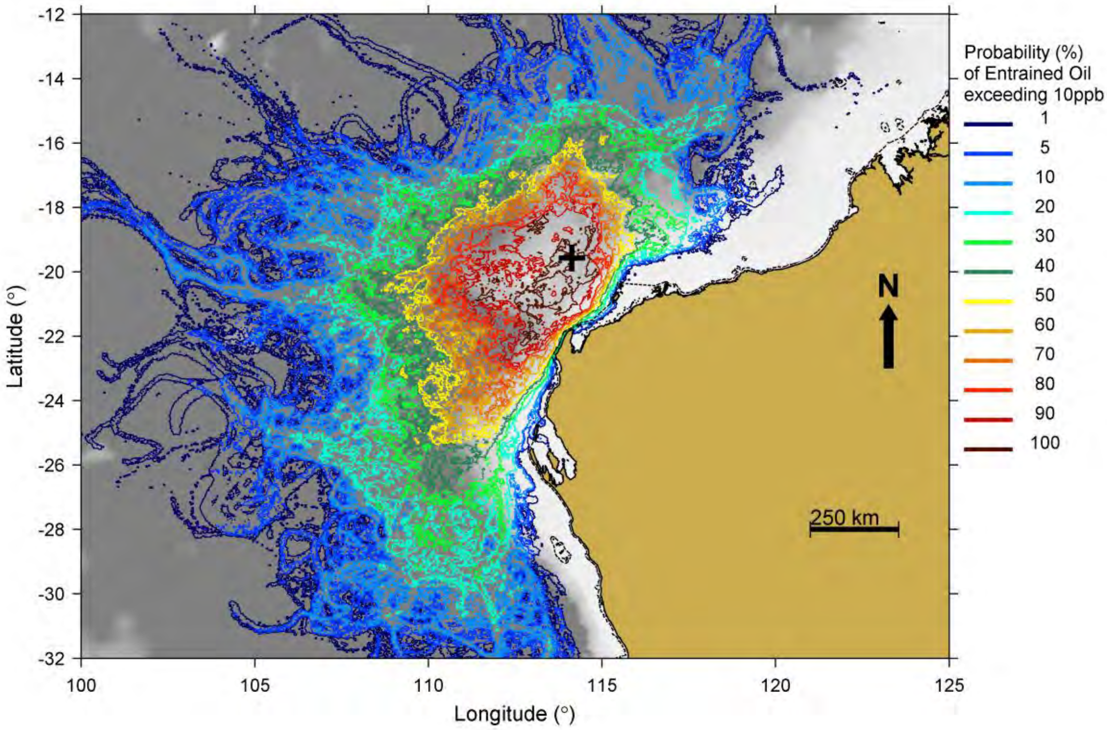
Figure 3-70: Predicted probability of sea surface contact to concentrations above 10 g/m^2 resulting from an 11 week blowout at the seabed at the Chandon Well commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-40: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from an 11 week blowout at the seabed at the Chandon Well commencing during winter months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group	Bernier/ Dorre Islands	Abrolhos Islands
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	10	13	NC	23	36	NC	16	NC	NC	10	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	NC	NC	NC	6	13	NC	6	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 500 ppb	NC	NC	NC	6	6	NC	6	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 ppb	21	17	NC	15	10	NC	15	NC	NC	35	NC
Minimum time to shoreline (days) at >100 ppb	NC	NC	NC	15	10	NC	15	NC	NC	NC	NC
Minimum time to shoreline (days) at >500 ppb	NC	NC	NC	25	16	NC	15	NC	NC	NC	NC
Mean expected maximum entrained concentration (ppb)	< 10	< 10	NC	55	70	NC	105	NC	NC	< 10	NC
Maximum entrained hydrocarbon concentration (ppb)	45	30	NC	905	1,265	NC	2,105	NC	NC	25	NC

NC: No contact to shoreline predicted for specified threshold



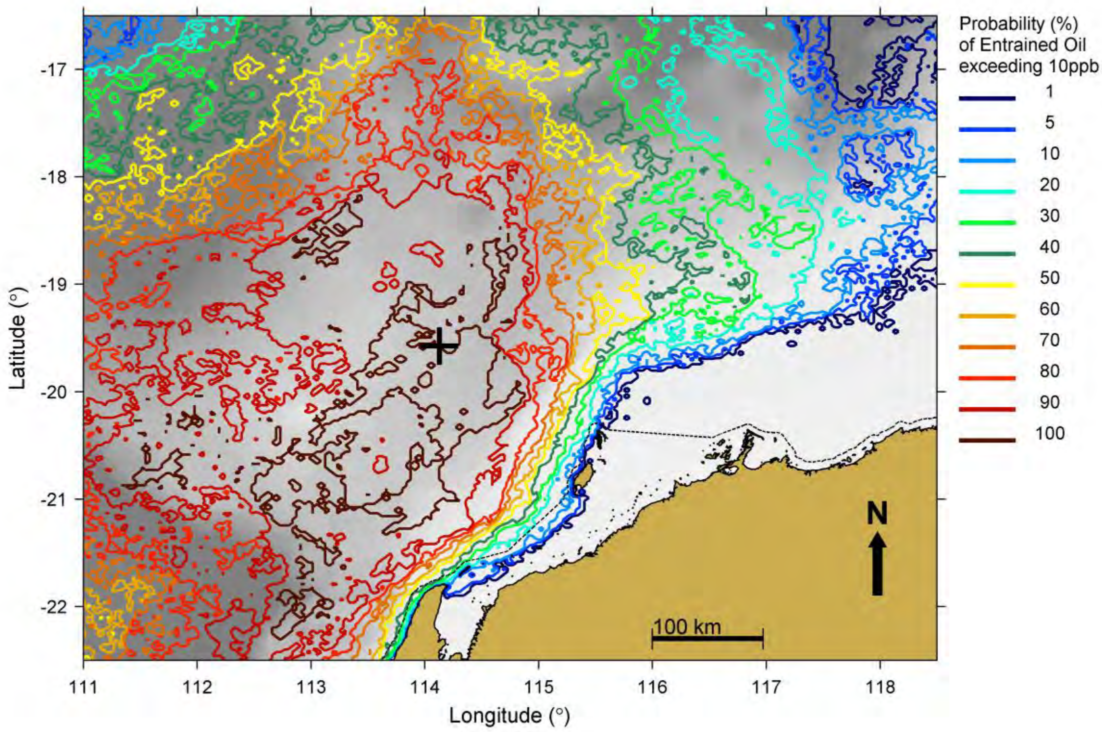


Figure 3-71: Predicted probability of entrained concentrations above 10 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

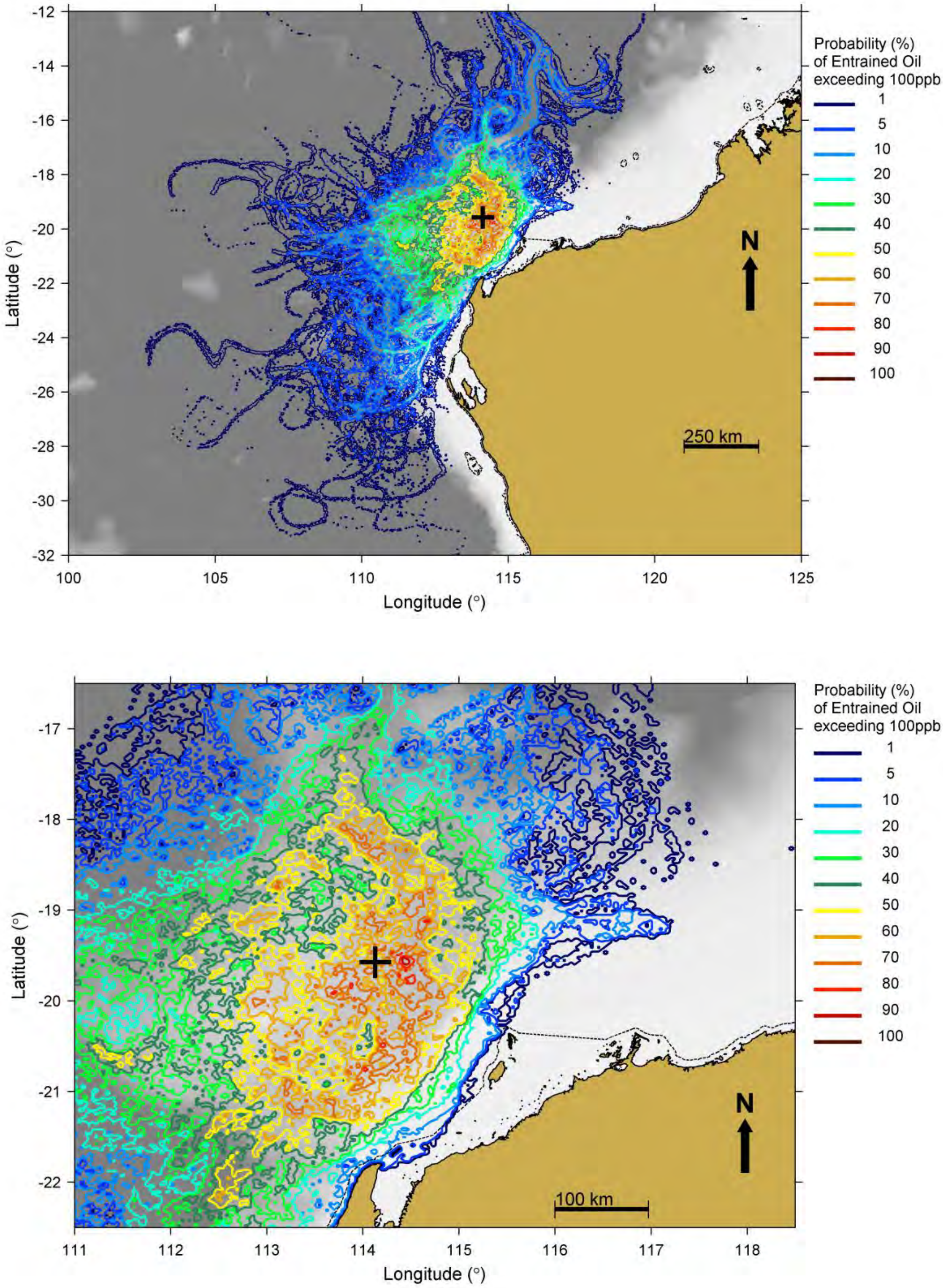


Figure 3-72: Predicted probability of entrained concentrations above 100 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

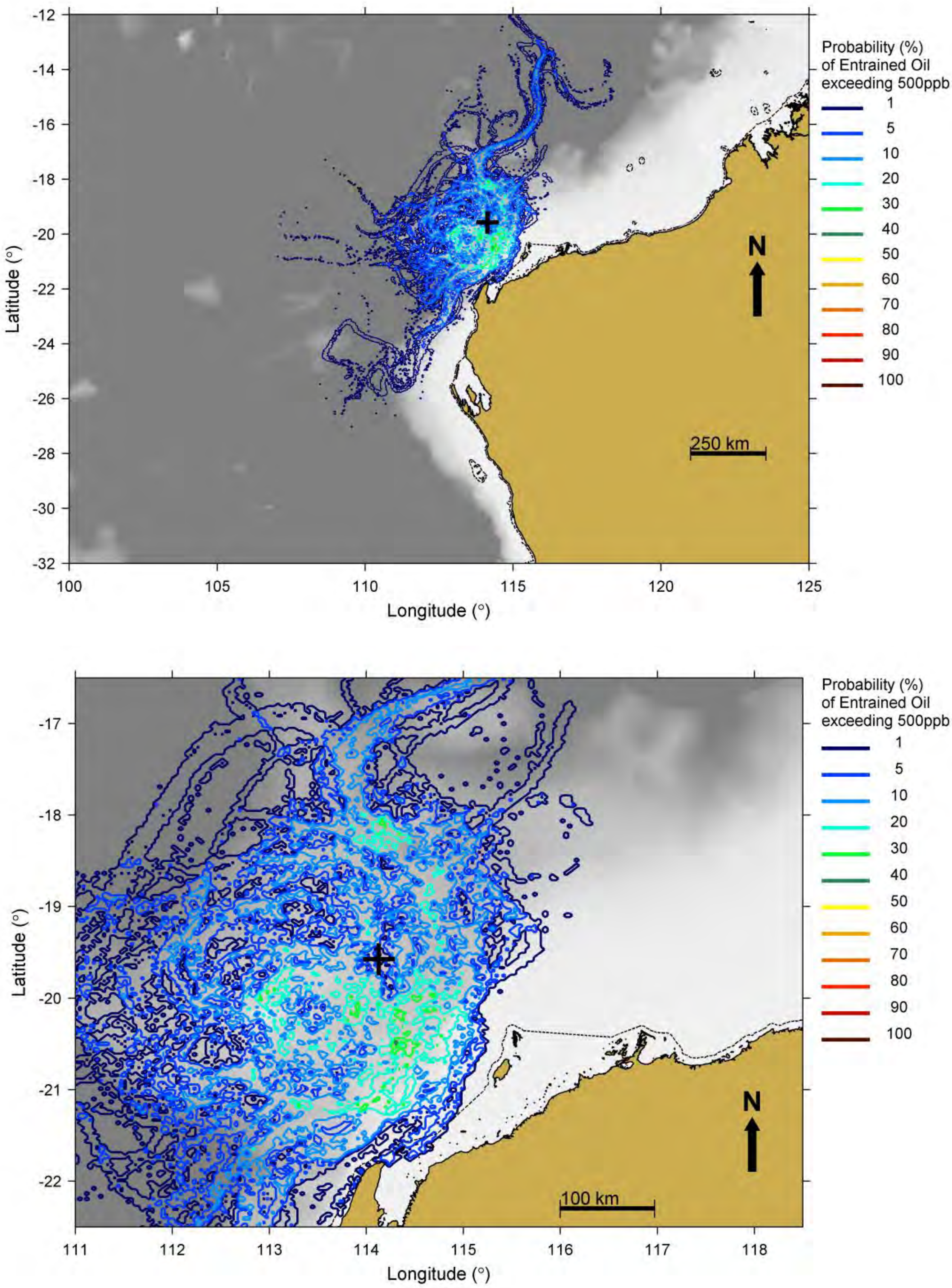


Figure 3-73: Predicted probability of entrained concentrations above 500 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during winter months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Dissolved Aromatic Hydrocarbons

Table 3-41: Summary of risks for dissolved aromatic concentrations in shallow waters adjacent to shorelines, from an 11 week blowout at the seabed at the Chandon Well commencing during winter months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group	Bernier/ Dorre Islands	Abrolhos Islands
Probability (%) of dissolved aromatic concentrations > 5 ppb	NC	NC	NC	6	6	NC	6	NC	NC	NC	NC
Probability (%) of dissolved aromatic concentrations > 50 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of dissolved aromatic concentrations > 500 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum aromatic concentration (ppb)	NC	NC	NC	< 5	< 5	NC	< 5	NC	NC	NC	NC
Maximum dissolved aromatic concentration (ppb)	NC	NC	NC	25	25	NC	15	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

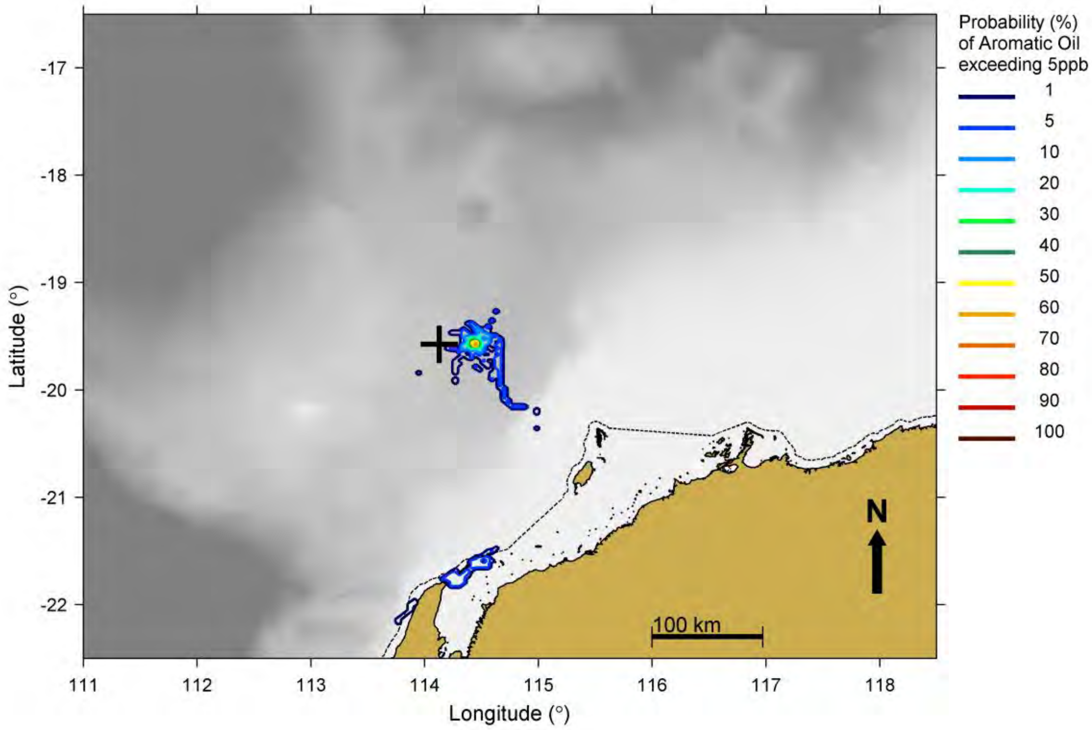


Figure 3-74: Predicted probability of dissolved aromatic hydrocarbons above 5 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during winter months. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

3.5.4 Spring

Surface Slicks and Films

Table 3-42: Summary of shoreline risks for different locations from an 11 week blowout at the seabed at the Chandon Well commencing during spring months. Shoreline statistics allow for accumulation of oil on shorelines over time during an individual spill.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group	Bernier/Dorre Islands	Abrolhos Islands
Probability (%) of oil>1 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of oil > 10 g/m² at shorelines	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >1 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 g/m²	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum shoreline concentration (g/m^2)	NC	1	NC	1	1	NC	1	NC	NC	NC	NC
Maximum shoreline concentration (g/m^2)	NC	1	NC	47	1	NC	13	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

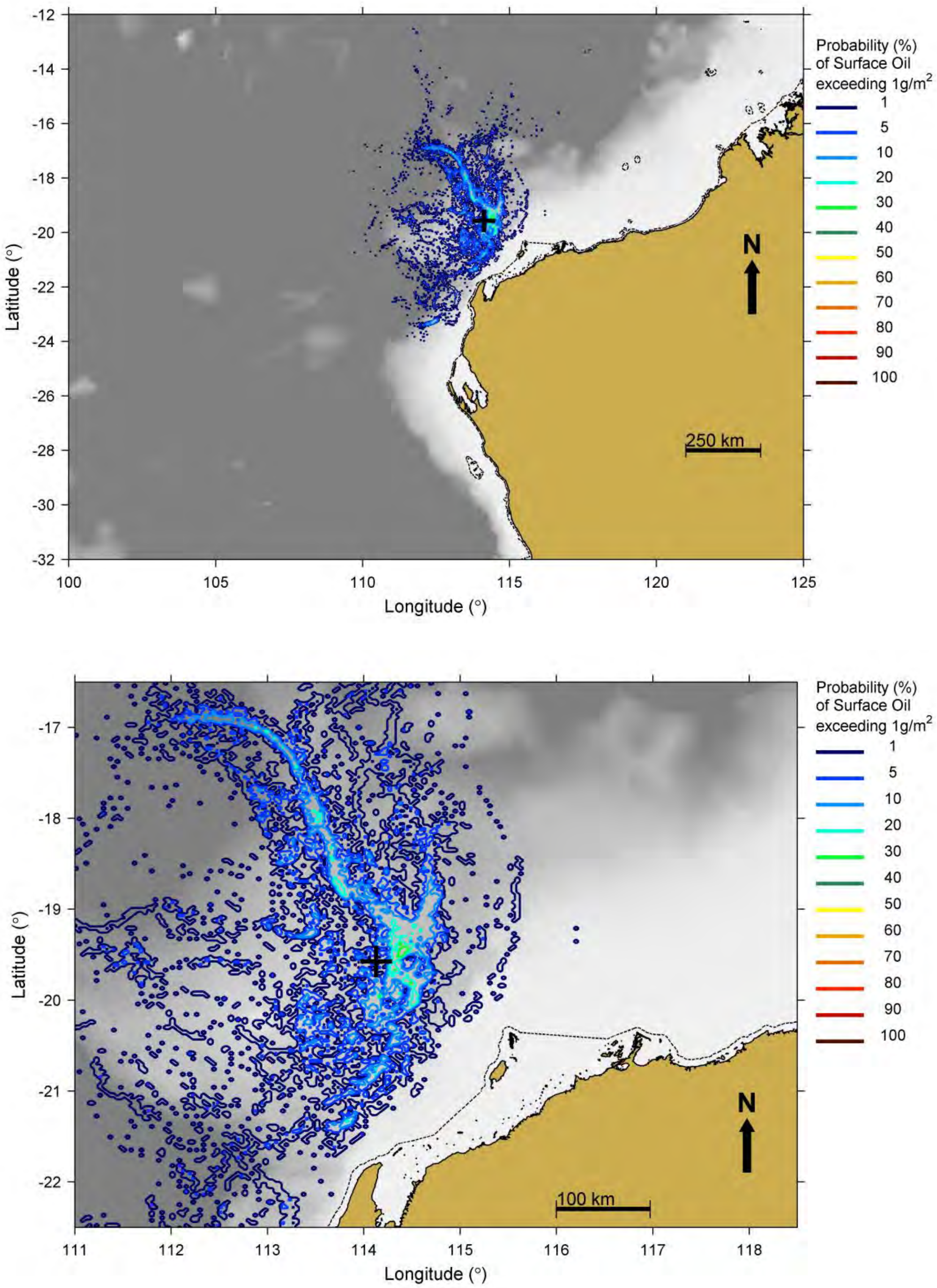


Figure 3-75: Predicted probability of sea surface contact to concentrations above 1 g/m^2 resulting from an 11 week blowout at the seabed at the Chandon Well commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

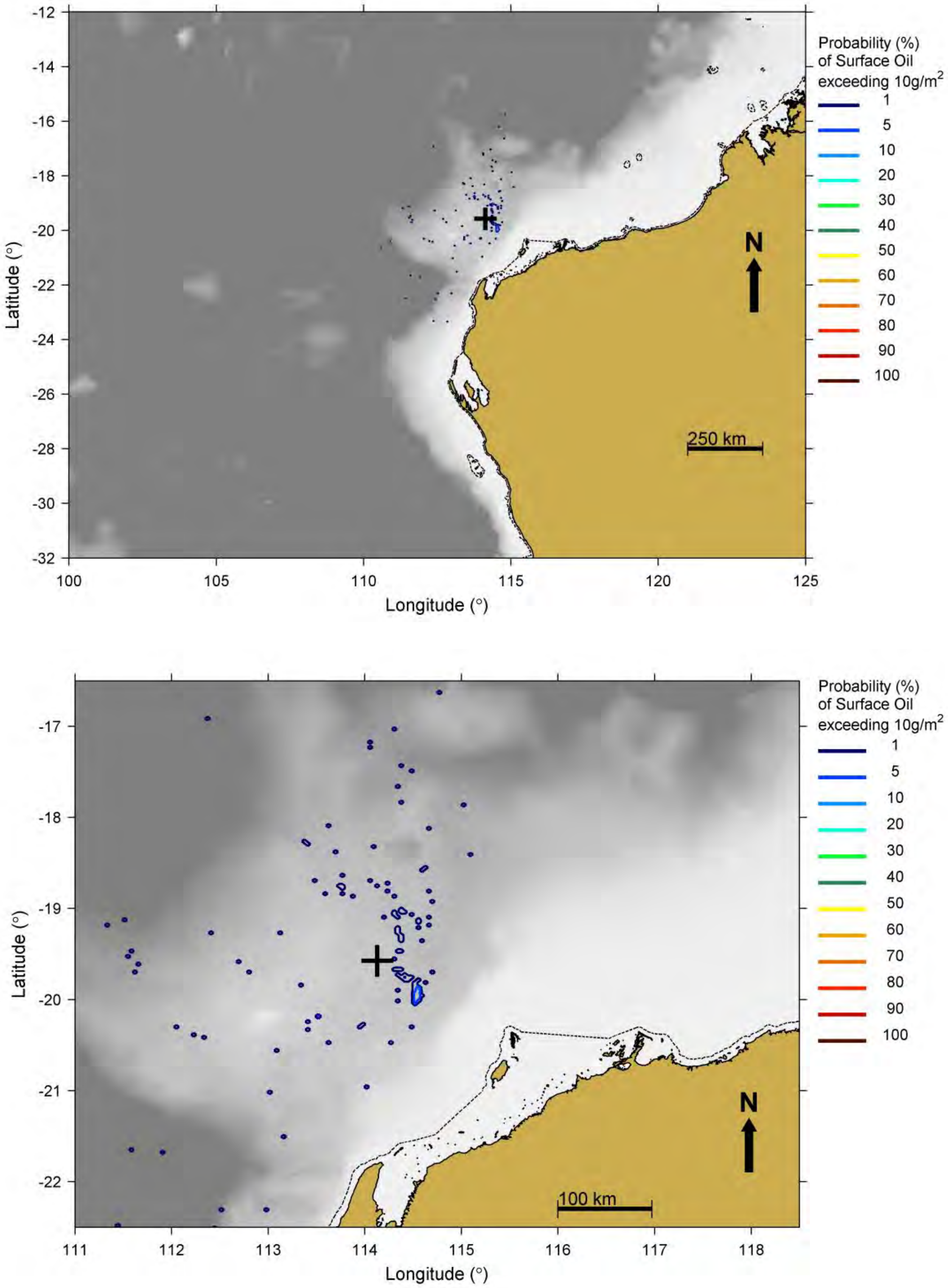


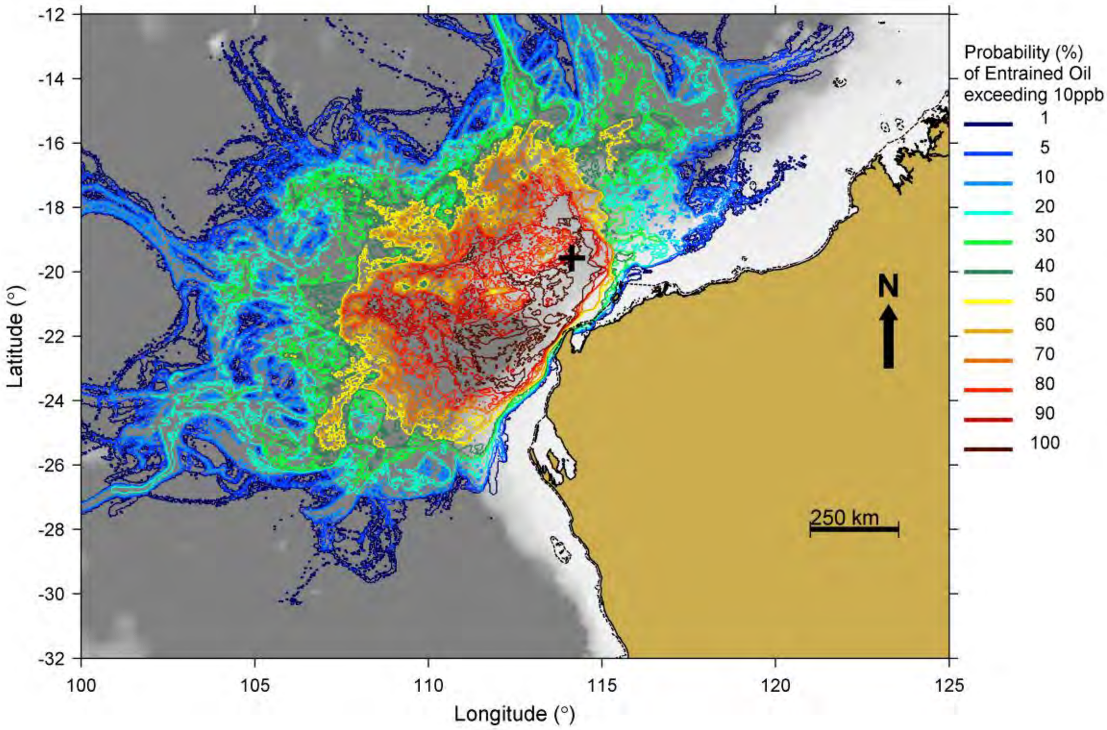
Figure 3-76: Predicted probability of sea surface contact to concentrations above 10 g/m² resulting from an 11 week blowout at the seabed at the Chandon Well commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Entrained Oil

Table 3-43: Summary of risks for entrained oil concentrations in shallow waters adjacent to shorelines, from an 11 week blowout at the seabed at the Chandon Well commencing during spring months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group	Bernier/ Dorre Islands	Abrolhos Islands
Probability (%) of entrained hydrocarbon concentrations > 10 ppb	16	13	6	46	50	NC	43	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 100 ppb	6	3	NC	43	36	NC	30	NC	NC	NC	NC
Probability (%) of entrained hydrocarbon concentrations > 500 ppb	NC	NC	NC	23	23	NC	6	NC	NC	NC	NC
Minimum time to shoreline (days) at >10 ppb	21	16	22	15	10	NC	15	NC	NC	NC	NC
Minimum time to shoreline (days) at >100 ppb	26	28	NC	15	16	NC	15	NC	NC	NC	NC
Minimum time to shoreline (days) at >500 ppb	NC	NC	NC	16	16	NC	15	NC	NC	NC	NC
Mean expected maximum entrained concentration (ppb)	20	< 10	< 10	315	300	NC	130	NC	NC	NC	NC
Maximum entrained hydrocarbon concentration (ppb)	350	155	55	2,220	2,940	NC	855	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold



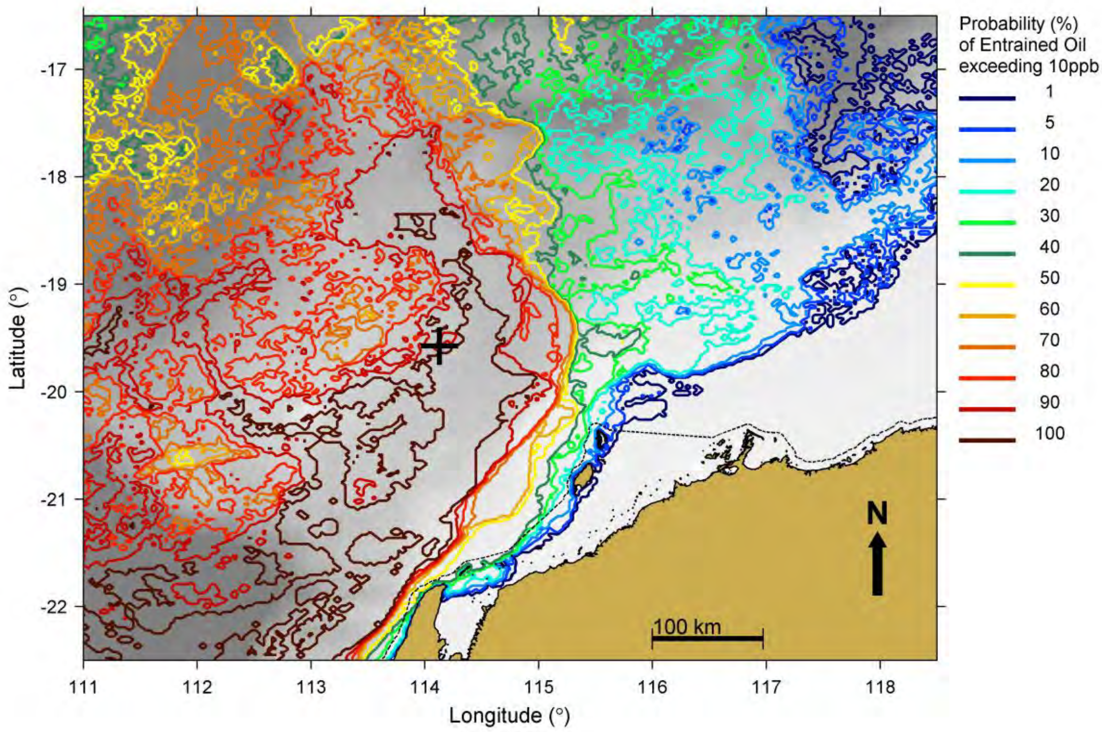


Figure 3-77: Predicted probability of entrained concentrations above 10 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

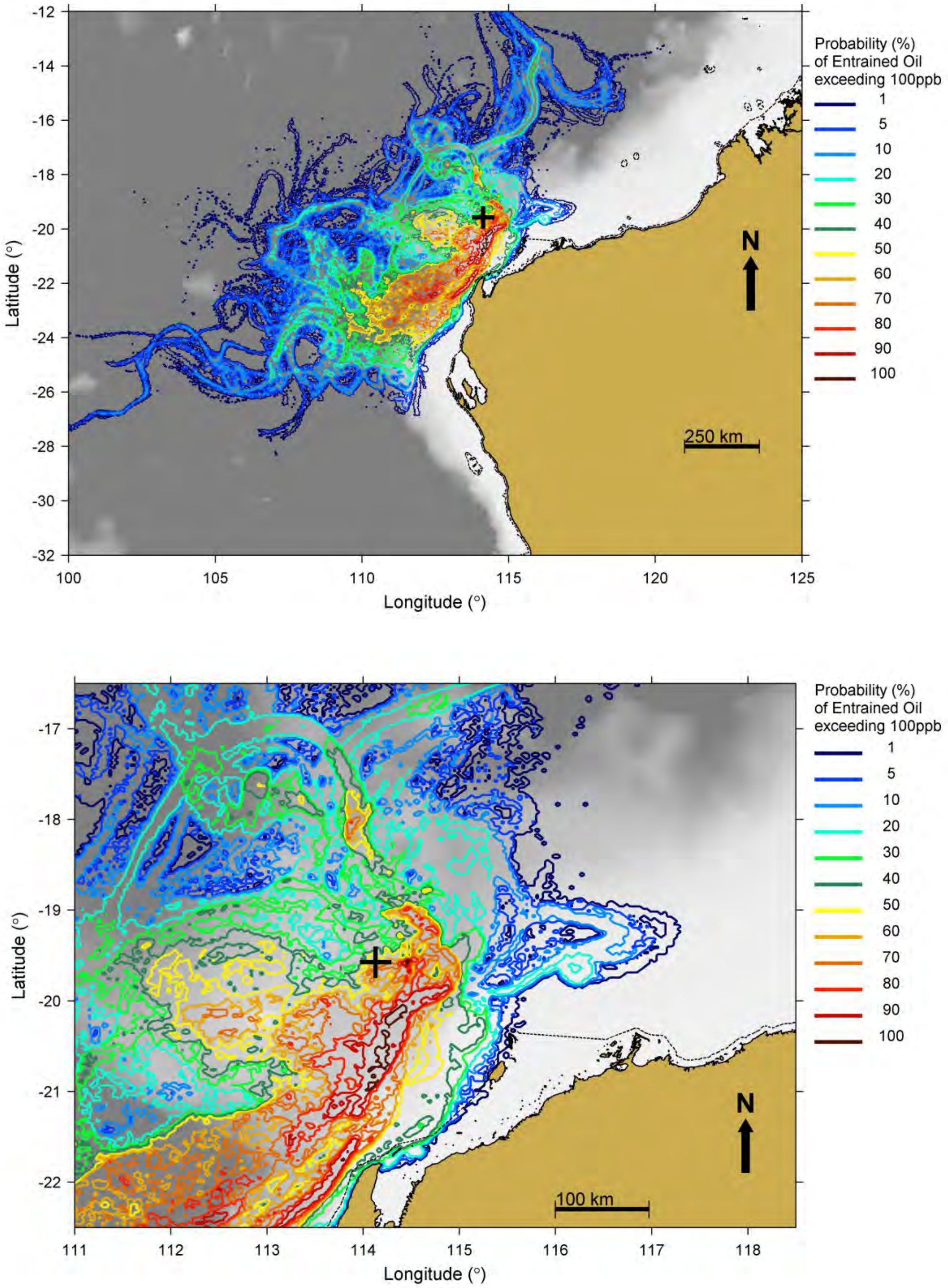
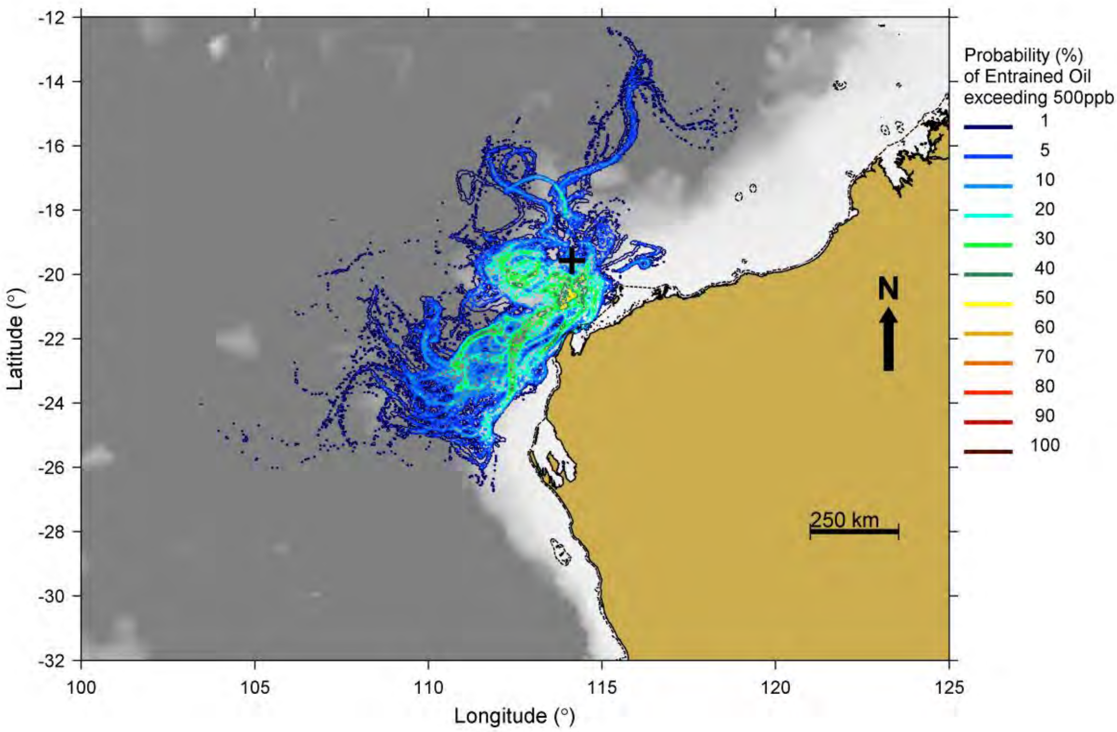


Figure 3-78: Predicted probability of entrained concentrations above 100 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.



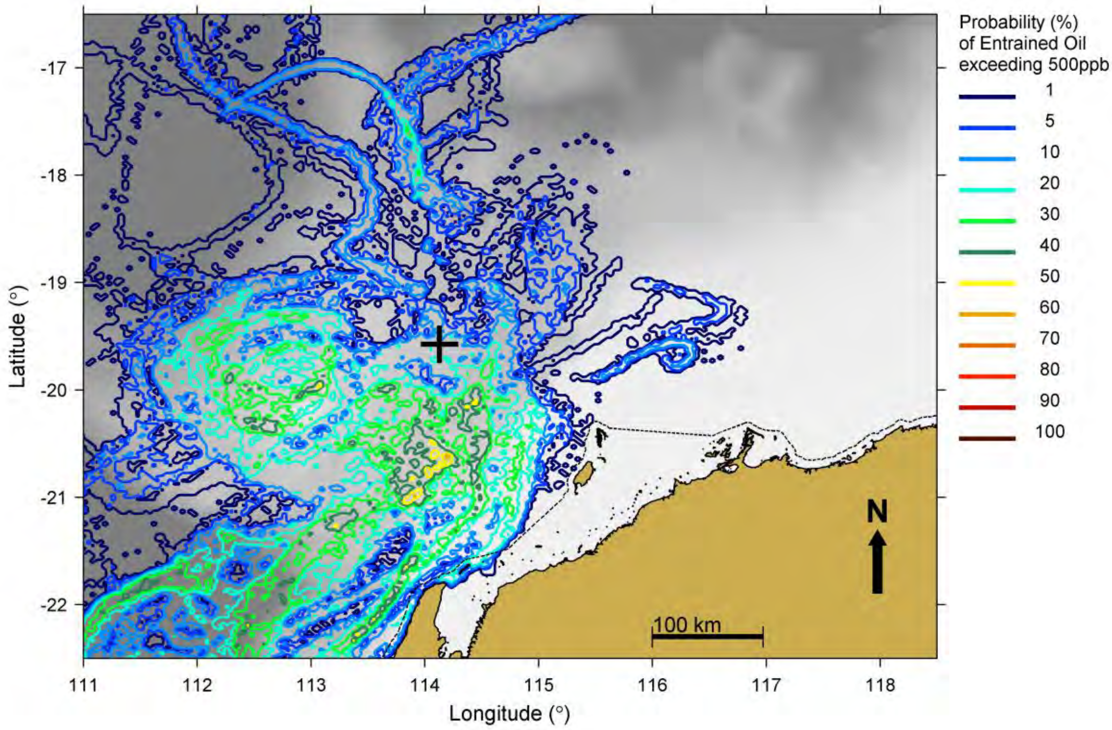


Figure 3-79: Predicted probability of entrained concentrations above 500 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during spring months. Bottom panel has been enlarged for viewing results. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

Dissolved Aromatic Hydrocarbons

Table 3-44: Summary of risks for dissolved aromatic concentrations in shallow waters adjacent to shorelines, from an 11 week blowout at the seabed at the Chandon Well commencing during spring months.

	Barrow Island	Montebello Islands	Lowendal Islands	Muiron Islands	Ningaloo Coast	Dampier Archipelago	Southern Island Group	Middle Island Group	Northern Island Group	Bernier/ Dorre Islands	Abrolhos Islands
Probability (%) of dissolved aromatic concentrations > 5 ppb	NC	NC	NC	23	23	NC	23	NC	NC	NC	NC
Probability (%) of dissolved aromatic concentrations > 50 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Probability (%) of dissolved aromatic concentrations > 500 ppb	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mean expected maximum aromatic concentration (ppb)	NC	NC	NC	< 5	6	NC	< 5	NC	NC	NC	NC
Maximum dissolved aromatic concentration (ppb)	NC	NC	NC	25	30	NC	15	NC	NC	NC	NC

NC: No contact to shoreline predicted for specified threshold

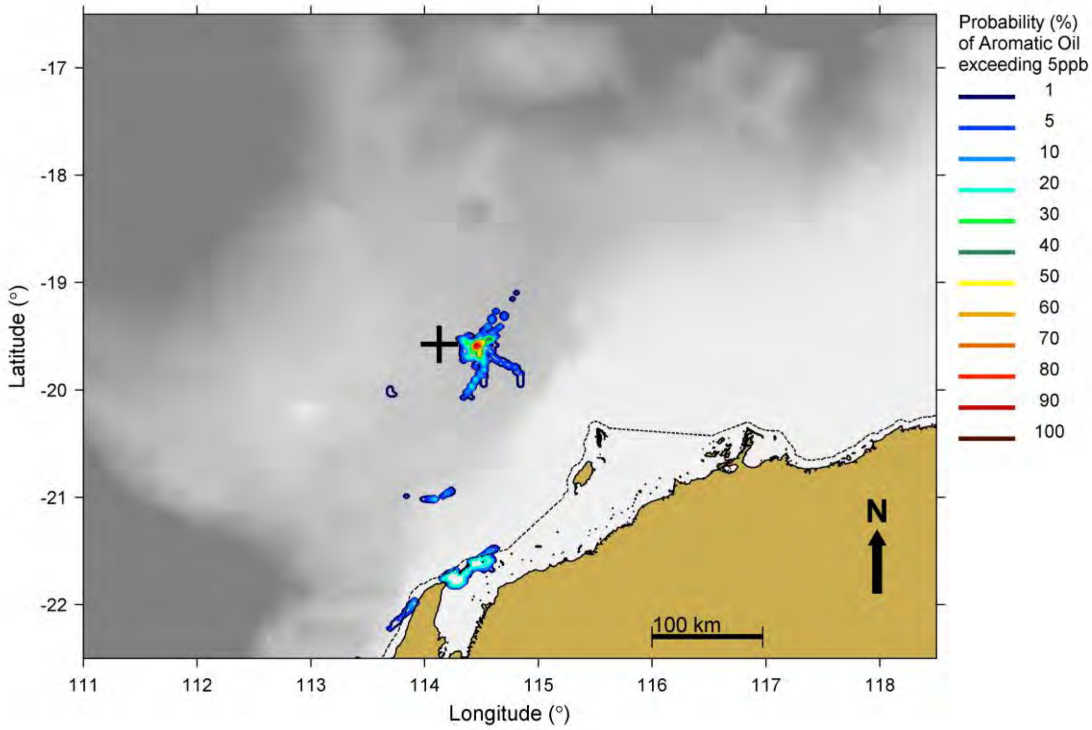


Figure 3-80: Predicted probability of dissolved aromatic hydrocarbons above 5 ppb resulting from an 11 week blowout at the seabed at the Chandon Well commencing during spring months. Black dashed contour indicates the Commonwealth/State jurisdictional boundary.

4 CONCLUSIONS AND RECOMMENDATIONS

The main findings of this modelling study are:

- Large scale drift currents will have a significant influence on the trajectory of any oil spilled at the modelled release sites, irrespective of the seasonal conditions. The prevailing drift currents will determine the trajectory of oil that is entrained beneath the water surface.

- Interactions with the prevailing wind will add additional variation in the trajectory of spilled oil and in the case of the long-term blowout scenarios, marked variation in the prevailing drift current and wind conditions would be expected over the duration of the release. This would be expected to increase the spread of oil during any single event.

- Modelling indicated aromatics > 5 ppb is unlikely to be present in the water column or on shorelines at any time in the diesel and pipeline rupture scenarios.

- Surface oil > 1 g/m^2 is also unlikely to contact any shorelines during any season as a result of the diesel and pipeline rupture scenarios.

- A 1% probability of contact by entrained oil > 10 ppb is predicted at Ningaloo Coast during spring in the 80 m^3 diesel scenario. Entrained oil > 10 ppb was not forecast to contact any shorelines in the 2.5 m^3 scenario.

- For both pipeline rupture scenarios, probabilities < 30% were indicated for surface oil > 1 g/m^2 to occur in surface waters. The 1% probability contour does not extend further than 300 km from the release site during each of the seasons.

- Entrained oil is predicted to drift towards the south-southwest to southwest in both pipeline scenarios during all seasons. Drift towards the north-northwest is also likely for the Chandon Manifold rupture (summer, winter and spring) and for the Jansz PTS rupture (winter and spring).

- For the Chandon Manifold rupture, a 1% probability for shoreline contact by entrained oil > 10 ppb is forecast for Ningaloo Coast during spring, with an earliest time to shoreline of 13 days, indicating that the entrained oil is likely to have lost highly soluble components. A 1% probability is also predicted for this shoreline during summer in the Jansz PTS rupture scenario, with a minimum time to shoreline of 12 days. No other shorelines are predicted to be contacted.

- Maximum short-term concentrations along Ningaloo Coast could potentially reach 60 ppb from a rupture of the Chandon Manifold and 25 ppb from a rupture of the Jansz PTS during spring and summer respectively.

- For the 11 week blowout scenario, there is a low probability of surface oil > 10 g/m^2 in waters around the blowout in any season. Surface oil of > 1 g/m^2 is likely to travel with trajectories to the southwest or northwest for blowouts commencing in summer or winter, though almost any direction is possible. Drift is most likely to be towards the northeast or west-southwest in the autumn scenario and towards the north-northwest for the spring scenario, with shorter trajectories to the south-southwest also possible in spring. For all seasons there is a low probability (<20%) of surface oil > 1 g/m^2 travelling more than 300 km from the blowout site.

- A maximum probability of 3% was forecasted for shoreline contact by surface oil > 1 g/m² along shorelines of Ningaloo Coast during the winter scenario, with an earliest arrival time of 29 days, indicating that the oil is likely to be composed of highly weathered wax components. No other shoreline contact by surface oil > 1 g/m² is likely.

- Maximum short-term surface concentrations were calculated to be low for all locations, with the highest being Murion Islands in summer (60 g/m²) and spring (47 g/m²). Short-term concentrations are also forecasted for Ningaloo Coast during winter (26 g/m²) autumn (33 g/m²) and summer (43 g/m²) and Southern Island Group during spring (13 g/m²).

- For the blowout scenario, entrained oil > 10 ppb is highly likely to be transported to the south-southwest to southwest for all of seasons. Likely transport to the west and north were also indicated for winter. Shorter trajectories to the west and northwest (summer) to the north (spring) were also forecast to be highly likely.

- A highest probability of 70% was predicted for entrained oil > 10 ppb to reach waters bordering the Ningaloo Coast in the autumn scenario, with a minimum time to shoreline of 11 days. Lower probabilities were predicted for this shoreline for the summer (40%), winter (36%) and spring (50%) scenarios. Earliest times for shoreline contact were calculated to be 10 days for each of these three seasons.

- During each of the seasons, the potential for contact at > 10 ppb was indicated for the Muiron Islands and Southern Island Group at probabilities of 23 – 46% and 16 – 43%, respectively.

- For contact by entrained oil > 100 ppb, highest probabilities were calculated for the Muiron Islands (43%) and Ningaloo Coast (36%) during spring. These probabilities were reduced to 23% for each shoreline for contact above 500 ppb.

- Highest potential short-term entrained oil concentrations forecast at Ningaloo Coast were 2.9 ppm in spring and 2 ppm in summer. Potential concentrations at the Muiron Islands were forecasted as highest during for spring (2.2 ppm), while highest concentrations at the Southern Island Group were forecasted for winter (2.1 ppm).

- Modelling forecasts aromatics > 5 ppb are most likely to occur in a small region immediately to the east of the blowout location for each of the seasons.

- Probabilities for shoreline contact by aromatics > 5 ppb are forecasted at 23% for Ningaloo Coast, Muiron Islands and Southern Island Group in the spring scenario, with a maximum short-term concentration of 30 ppb along Ningaloo Coast.

- No sedimentation of residual condensate or diesel was indicated by the modelling for any season.

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APPENDIX 2

APASA Comparison of 2005 and 2012 Modelling Studies

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Technical Note

TO:	Tyron Miley, RPS Group	**DATE:**	11th February 2013
FROM:	Scott Langtry, APASA	**REFERENCE:**	J0199
RE:	Review of the 2004/2005 and 2011/2012 oil spill modelling studies for the Gorgon Expansion project.		

Review

Asia-Pacific ASA (APASA) were requested by RPS to review the methods, assumptions and conclusions from two separate assessments that have been undertaken by APASA to quantify exposure risks related to potential oil spills associated with the Gorgon Development (APASA 2005, 2012). Findings from both assessments have been presented by RPS in the document "*Assessment of Environmental Risk: Hydrocarbon Spill. Gorgon Gas Development, Fourth Train Proposal – Chandon Gas Field*" to represent potential risks for the Gorgon Gas Development, with the breakdown delineated by spill scenario (Table 1, Table 2).

Table 1. Spill scenarios assessed in the 2004/2005 study

Spill Source	Release Location	Hydrocarbons Modelled	Volume	Duration
Feed Gas Pipeline rupture	14 km west of Barrow Island (seabed)	Gorgon condensate	1621,000 L	4.5 hours
Feed Gas Pipeline rupture	200 m west of Barrow Island (seabed)	Gorgon condensate	1621,000 L	4.5 hours
Refuelling accident	Feed Gas Pipeline route – 10 km west of Barrow Island (surface)	Diesel	2,500 L	< 1 hour
Refuelling accident	Feed Gas Pipeline route – 5 km west of Barrow Island (surface)	Diesel	2,500 L	< 1 hour
Refuelling accident	Feed Gas Pipeline route – 2.5 km west of Barrow Island (surface)	Diesel	2,500 L	< 1 hour
Refuelling accident	Adjacent MOF	Diesel	100 L to 10,000 L	< 1 hour
Spill from grounded tanker	Adjacent to tanker terminal	Gorgon condensate	10,000 L to 100,000 L	1 to 24 hrs
Spill from grounded tanker	Adjacent to tanker terminal	Light crude oil	10,000 L to 100,000 L	1 to 24 hrs
Spill from grounded tanker	Adjacent to tanker terminal	Bunker fuel oil	10,000 L to 100,000 L	1 to 24 hrs

Table 2. Spill scenarios assessed in the 2011/2012 study

Spill Source	Release Location	Hydrocarbons Modelled	Volume	Duration
Well blowout	Chandon Well (1,200 m depth at seabed)	Chandon condensate	28,756,500 L	11 weeks
Flowline rupture	Chandon Manifold Intrafield Flowline Tie-in (1,200 m depth at seabed)	Chandon condensate	200,000 L	3 hours
Flowline rupture	Jansz PTS Intrafield Flowline Tie-in (1,345 m depth at seabed)	Chandon condensate	200,000 L	3 hours
Refuelling accident	Chandon field (surface)	Diesel	80,000 L	6 hours
Refuelling accident	Chandon field (surface)	Diesel	2,500 L	< 1 hour

The scenarios addressed in the 2004/2005 assessment (APASA 2005) were all for short term releases with the assessment concentrating on spills that might occur either adjacent to Barrow Island (offshore from the pipeline crossing on the west side or at the MOF or Tanker Terminal on the east side) or out along the proposed route of the Feed Gas Pipeline at a distance not exceeding 14 km. The latter included assessment for small diesel refuelling accidents associated with the construction phase as well as discharge of condensate from the proposed Feed Gas pipeline.

Scenarios addressed in the 2011/2012 assessment (APASA 2012) were for locations within the Chandon or Jansz Production fields, which lie about 100 – 150 km north-west of Barrow Island. These included simulations for short term releases at the production field location (both diesel fuel spills and seabed discharges of condensate) as well as simulation of long-term blowouts, from seabed level, at the production field.

Review of the methodology applied to each study confirms that the major difference in the methodology between the assessments was in the specification of the metocean forcing applied to calculate spill trajectories (Table 3). The 2004/2005 study calculated spill trajectories due to wind and tide driven circulation only, applying a high resolution hydrodynamic model with barotropic forcing. This hydrodynamic model was successfully validated against a series of current measurements from sites around Barrow Island and extending offshore along the pipeline route, indicating that the representation of current forcing was appropriate for spills within the region of interest to that study.

In contrast, the 2011/2012 assessment considered release sites positioned in > 1200 m water, where effects of wind shear and mesoscale drift currents are known to be the more significant contribution to circulation. These drift currents, which are generated by large scale gradients of density and sea height and the influence of sustained wind forcing, are most significant in deeper water (>100-200 m) along the North West Shelf and will therefore have the greatest potential to influence the trajectory of spills at the offshore production location or along the pipeline route in > 100 – 200 m depth. Consequently, the 2011/2012 risk assessment made use of current estimates that combined barotropically-forced current data with inputs representing mesoscale drift currents. Drift current data were sourced from a hindcast of the mesoscale drift currents over the study area from the HYCOM ocean analysis and combined with estimates for the tidal currents by vector addition. This approach allowed for increased tidal influence over shallow areas.

Mesoscale drift currents will have little or no consequence for the trajectory of oil that is spilled over the shallow shelf surrounding Barrow Island and the adjacent islands (Montebello and Lowendal Islands), where water circulation is dominated by strong tidal currents. Thus, the current forcing applied in the 2004/2005 study remains valid for the scenarios assessed in that study, which all involved discharges of relatively small volumes of volatile oil types close to Barrow Island because spill trajectories are not forecasted to extend into deeper locations where mesoscale drift currents would have a significant influence on current forcing. The scenarios from the 2004/2005 study that considered the deepest releases (Feed Gas Pipeline rupture 14 km west of Barrow Island) would place the location in water depths < 35 m where mesoscale drift currents are unlikely to be significant.

Table 3: Metocean forcing applied to the 2004/2005 and 2011/2012 studies

	2004/2005 spill risk assessment	2011/2012 spill risk assessment
Floating oil	Vector of the wind and surface current	Vector of the wind, surface current and mesoscale drift current
Entrained and dissolved components	wind and tide driven current	Current due to tide, wind and mesoscale drift current

Other methodologies and assumptions were consistent across the studies. Both studies applied the same three-dimensional oil spill trajectory and fates model (SIMAP) and similar assumptions were applied to the oil types. Both used the same characteristics for diesel oil while similar densities, viscosities and volatilities were assumed for the condensate that might be spilled. The major difference in the latter assumptions being that the 2004/2005 study assumed that a lower proportion of the condensate would resist evaporation (2.6% compared to 9%; Table 4 & Table 5).

Both studies assessed risks for floating oil, physically entrained oil and dissolved aromatic hydrocarbons.

The studies applied the same minimum thresholds for the calculation of exposure events for entrained oil (10, 100, 500 ppb) and dissolved aromatic hydrocarbons (5, 50, 500 ppb), although the 2004/2005 study adopted a more conservative lower threshold for oil films on the water surface (0.3 g/m^2 compared to 1 g/m^2). These thresholds represent different concentrations along the range at which oil films will appear as a thin sheen with bright rainbow colours. Thus, outcomes of the modelling should remain valid. Moreover, differences in the thresholds have been documented and discussed in the Assessment summary.

Where relevant for sub-sea discharge scenarios, both studies considered the influence of the discharge situation on the size distribution of the condensate droplets that would be generated and the consequence of this size distribution for the trajectory and fate of the condensate. The 2011/2012 study applied a blowout model to estimate the droplet size-distribution for blowout and pipeline ruptures in deep water. For the 2004/2005 study, small droplet sizes (median < 300 µm) were assumed based on engineering advice regarding the discharge pressures. This assumption remains relevant for the scenarios considered.

In conclusion, review of the summary document: *Assessment of Environmental Risk: Hydrocarbon Spill Gorgon Gas Development, Fourth Train Proposal – Chandon Gas Field*, and the modelling studies as documented by APASA (2005, 2012) indicates that the methods, assumptions and results of the 2004/2005 and 2011/2012 spill modelling studies have been applied appropriately in the Assessment Summary.

Table 4: Characteristics of the condensate used in the 2004/2005 study

Oil type	**Initial density (kg/m^3) at 15 °C**	**Viscosity (cP) (20 °C)**	**Component**	**Volatiles (%)**	**Semi-volatiles (%)**	**Low Volatility (%)**	**Residual (%)**
			BP (°C)	<180	180-265	265 - 380	>380
Gorgon Condensate	748.0	1.4	**% of total**	72.90	14.00	10.50	2.60
				NON-PERSISTENT			PERSISTENT

Table 5: Characteristics of the condensate used in the 2011/2012 study

Oil type	**Initial density (kg/m^3) at 15 °C**	**Viscosity (cP) (20 °C)**	**Component**	**Volatiles (%)**	**Semi-volatiles (%)**	**Low Volatility (%)**	**Residual (%)**
			BP (°C)	<180	180-265	265 - 380	>380
Chandon Condensate	736.1	0.566	% of total	73.25	10.18	7.47	9.09
				NON-PERSISTENT			PERSISTENT

References

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APPENDIX 3

Calculated Probabilities

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APPENDIX 3: Calculated Probabilities

Calculated Annualised Probabilities

Calculation of annualised probabilities for APASA (2012) modelled spill scenarios (i.e. well blowout, pipeline rupture at Chandon Manifold Tie-in and Gorgon (Jansz PTS) Tie-in, and 2.5 m^3 and 80 m^3 diesel spill at Chandon) are based on the breakdown of the four seasons according to prevailing wind conditions. Summer and winter extend for five months each and autumn and spring extend for one month each (Table 3-1). In order to calculate annualised probabilities it is necessary to calculate the proportion of a year for each season, by dividing the length of the season by the number of months in a full year. For example, the summer and winter seasons of five months each have a proportionate value of 0.417 (5/12), while the autumn and spring seasons each have a proportionate value of 0.083 (1/12). The overall likelihood for each season is multiplied by the corresponding seasonal proportionate value. Therefore the annualised probability of shoreline exposure as a result of a well blowout is:

- summer and winter proportions: $(2.31 \times 10^{-5}) \times 0.417$
- autumn and spring proportions: $(2.31 \times 10^{-5}) \times 0.083$

$(((\[2.31 \times 10^{-5}\] \times 0.417) \times 0.40) + ((\[2.31 \times 10^{-5}\] \times 0.083) \times 0.70) + ((\[2.31 \times 10^{-5}\] \times 0.417) \times 0.36) + ((\[2.31 \times 10^{-5}\] \times 0.083) \times 0.50)) = 9.63 \times 10^{-6}$

Table 3-1: Seasonal Proportional Values (APASA 2012)

Season	Duration	Months	Proportion
Summer	5 months	Nov-March	0.417
Autumn	1 month	April	0.083
Winter	5 months	May-Sept	0.417
Spring	1 month	Oct	0.083

Calculation of annualised probabilities for APASA (2005) modelled spill scenarios (i.e. feed gas pipeline ruptures, refuelling accidents along the pipeline route and at the MOF, and spills from grounded tankers) are based on the breakdown of the prevailing wind conditions into three seasons. Summer extends for six months, winter for four months and a combined transitional period extends for two months (Table 3-2). As for the APASA (2012) modelled scenarios, the overall likelihood for each season is multiplied by the corresponding seasonal proportionate value.

Table 3-2: Seasonal Proportional Values (APASA 2005)

Season	Duration	Months	Proportion
Summer	6 months	Oct-March	0.5
Transition	2 months	April-Sept	0.167
Winter	4 months	May-August	0.33

Probability of a Well Blowout – Foundation Project and the Fourth Train Proposal Comparison

Taken from the industry databases (OGP 2010) the probability of a single well blowout is 0.0000231.

Therefore the probability of not having a blowout is 1 – 0.0000231 = 0.9999769.

The Gorgon Foundation Project encompassed 25 wells, while the Forth Train Proposal contains an additional 16 wells, resulting in a total of 41 wells.

Foundation Project = 25 wells

- The probability of not having a blowout is: (1 – 0.0000231)^25 = 0.9994227.
- The probability of having at least one well blowout is: 1 – 0.9994227 = 0.0005773 or 0.06%.

Fourth Train Proposal = 16 wells

- The probability of not having a blowout is: (1 – 0.0000231)^16 = 0.9996304
- The probability of having at least one well blowout is: 1 – 0.9996304 = 0.0003696 or 0.04%

Foundation Project plus Fourth Train Proposal = 41 wells

- The probability of not having a blowout is: (1 – 0.0000231)^41 = 0.9990533.
- The probability of having at least one well blowout is: 1 – 0.9990533 = 0.0009467 or 0.09%

While the increase in the number of wells increases the likelihood of having at least one blowout by 50%, the resulting likelihood is still very small (less than 0.1%).

Appendix E: Environmental Baseline

Appendix E1: Key Foundation Project Survey, Audit and Environmental Reporting

Key Foundation Project Survey, Audit and Environmental Reporting

Key Environmental Baseline Sources

The environmental baseline of this PER/Draft EIS has been informed by desktop research and the results of environmental surveys, including those undertaken by the approved Foundation Project impact assessment and subsequent Baseline Reports and Monitoring Programs undertaken in accordance with the pre-approved survey scopes and methods under the Ministerial Conditions for the Foundation Project. This appendix provides an overview of the key surveys and monitoring and audit programs that have been undertaken on Barrow Island, including the areas that have the potential to be impacted by the Fourth Train Proposal.

Information on survey methodologies can be found in publicly available documents, including:

- Gorgon Gas Development and Jansz Feed Gas Pipeline Terrestrial and Subterranean Baseline State and Environmental Impact Report (Chevron Australia 2014)
- Gorgon Gas Development and Jansz Feed Gas Pipeline: Coastal and Marine Baseline State and Environmental Impact Report (Chevron Australia 2011, Revision 4)
- Additional Construction Laydown and Operations Support Area (Additional Support Area): Environmental Review, Assessment on Proponent Information (API) Category A (Chevron Australia 2013).

These reports are available from

- http://www.chevronaustralia.com/our-businesses/gorgon/environmental-responsibility/environmental-approvals; or
- http://www.epa.wa.gov.au/EIA/EPAReports/Pages/1499-GorgonGasDevelopment.aspx?pageID=3278&url=EIA/EPAReports.

Terrestrial Flora and Vegetation

There is substantial information on the flora and vegetation of Barrow Island. An Annotated Bibliography of the Natural History of Barrow Island 1622–2004 (Smith *et al.* 2006) identified 110 reports and publications on Barrow Island's flora and vegetation. Flora surveys have been undertaken across Barrow Island since the 1960s.

Historically, Beard (1975) mapped the vegetation of the entire Pilbara Region at a scale of 1:1 000 000. On Barrow Island, Buckley (1983) classified the vegetation into broad units based on analysis of the presence or absence of 218 taxa in 175 quadrats and five transects, and mapped this at a scale of 1:20 000 across Barrow Island (with selected areas mapped using 1:10 000 aerial imagery). Trudgen (1989) recorded detailed flora information in quadrats at 41 Impact Sites and 13 Reference Sites to compare the vegetation in undisturbed areas to that in areas being revegetated after disturbance. Mattiske (1993) established more than 100 quadrats for vegetation mapping at a scale of 1:25 000 and assessed the revegetation of seismic lines across Barrow Island. Mattiske (1993) classified plant communities based on major landform types, soil types, and dominant species (including cluster analysis of percentage foliage cover in quadrats). This refined Buckley's (1983) vegetation units. Many of the vegetation types identified by Buckley (1983) and Mattiske (1993) are similar or overlap. Disturbed vegetation (excluding seismic lines) were mapped by National Geographic Information Systems (2001) at a scale of 1:10 000 based on aerial photography interpretation, with an assumption of an average road width of 7.5 m.

Vegetation in the vicinity of the Combined Gorgon Gas Development Footprint was assessed in accordance with EPA Guidance Statement No. 51 (EPA 2004), and mapping of vegetation at the scale of subformation and association has been undertaken across more than 11% of Barrow Island, including the Fourth Train Proposal Footprint. Vegetation was mapped within an area of approximately 1683 ha surrounding the Gas Treatment Plant, Administration and Operations Complex, and Butler Park (Construction Village) on Barrow Island as documented in the Draft EIS/ERMP (Chevron Australia 2005). Vegetation plots were established and surveyed in September and October 2003 and in January 2004. The area where the Gas Treatment Plant is located was resurveyed in April and May 2004 following cyclonic rains, to collect annual species.

Vegetation was characterised by RPS Bowman Bishaw Gorham (RPS BBG 2005) in accordance with Trudgen's (2002) adaptation of Aplin's (1979) modification of Specht's (1970) vegetation classification system. This allowed for species with less than 2% cover to be considered, as is appropriate given the low cover of many strata in the vegetation of more arid areas (Trudgen 2002).

For the onshore Feed Gas System Pipeline System route, a continuous transect at least twice the width of the pipeline easement was surveyed on foot. Pipeline routes were surveyed in April and May 2004. Additional surveys to determine the extent of potentially restricted vegetation units were conducted in July 2004, and January to February 2008.

The coastal dunes at North Whites Beach were surveyed in June 2005 (RPS BBG 2006a). Additional areas of the Onshore Feed Gas Pipeline were surveyed in 2006 as a result of minor realignments (RPS BBG 2006a). Coastal vegetation communities at Whites Beach were surveyed in 2006 to discern vegetation communities along a potential access route for an investigatory drilling program (RPS BBG 2006a).

A development envelope of approximately 36 ha encompassing the Additional Support Area was surveyed in October 2013. The survey was undertaken to identify any Threatened Flora, Threatened Ecological Communities, Priority Ecological Communities, and flora not protected but considered significant on Barrow Island, to assess the type, abundance and location of weeds, and to describe the vegetation and flora within the surveyed area (Astron Environmental Services 2013).

All vegetation associations described during surveys for the Foundation Project on Barrow Island have been grouped into subformations based on familiarity (Astron Environmental Services 2008, 2011, 2013).

Terrestrial Invertebrates

In one of the largest invertebrate surveys conducted in Australia for a single locality, up to 26 taxonomists were consulted for the identification of invertebrates. The invertebrate groups that were targeted during surveys in 2003 and 2004 for input into the Draft EIS/ERMP (Chevron Australia 2005) were:

- Araneae (spiders, in particular trapdoor and wolf spiders)
- Pseudoscorpionida (pseudoscorpions)
- Scorpionida (scorpions)
- Diplopoda (millipedes)
- Pulmonata (camaenid land snails).

The Draft EIS/ERMP (Chevron Australia 2005) documented the method for the 2003 and 2004 surveys as consisting of pitfall trapping and hand foraging, including head-torching, burrow excavation, lifting rocks, peeling bark, and foraging through leaf litter and under Triodia hummocks. Leaf litter and other debris found beneath Triodia clumps were collected and later sieved for cryptic invertebrates. Voucher specimens were collected, preserved, and lodged with the Western Australian Museum for ongoing taxonomic studies.

Various survey methods were again used during surveys in 2006, including pitfall traps, litter searches, plant beating, and night searches with light traps (Majer *et al*. 2008). The Terrestrial and Subterranean Baseline State and Environmental Impact Report (Chevron Australia 2014) contain further methodology information.

Landbirds and Littoral Birds

Quantitative surveys of landbirds across Barrow Island were undertaken by Sedgwick (1978) and Pruett-Jones and O'Donnell (2004). Sedgwick (1978) surveyed across Barrow Island in August 1976 at eight 0.5 ha quadrats. Pruett-Jones and O'Donnell (2004) surveyed across Barrow Island in September and October 2001 at 178 two-hectare quadrats in six major vegetation zones.

Landbirds and littoral birds were also surveyed monthly from September 2003 to October 2004 as part of the preparation of the Foundation Project Draft EIS/ERMP (Chevron Australia 2005). Further littoral bird surveys were conducted along the entire Barrow Island coastline in October 2005, and in February and March 2006 (RPS BBG 2006b). These surveys collected data from 12 coastal regions around Barrow Island.

White-winged Fairy-wren (Barrow Island) Monitoring Program Surveys have been conducted under the White-winged Fairy-wren (Barrow Island) Monitoring Program annually since 2009, timed to coincide with the typical White-winged Fairy-wren (Barrow Island) breeding season. The objectives of this program are to:

- establish a statistically valid ecological monitoring program to detect any Material or Serious Environmental Harm to the ecological elements outside the Terrestrial Disturbance Footprint (TDF)
- collect information on the density of White-winged Fairy-wrens (Barrow Island)
- diagnose observed declines in abundance over time that are attributable to the Foundation Project.

Distance sampling was used to estimate absolute densities within the TDF and Reference Zones. Line transect data were analysed using the software Distance (Thomas *et al.* 2010). Sampling occurs on approximately 400 m transects stratified across vegetation types, and spaced at an appropriate distance apart to maintain independence of observations between transects whilst limiting the distance between them. Six of the transects surveyed as part of the White-winged Fairy-wren (Barrow Island) Monitoring Program partially or wholly intersect with the Additional Support Area (Biota Environmental Sciences 2013).

Terrestrial Mammals

Extensive mammal surveys have been undertaken on Barrow Island. The Western Australia Department of Parks and Wildlife (DPaW), formerly the Department of Environment and Conservation (DEC), has collected information on terrestrial vertebrates on Barrow Island since 1998 using spotlighting transects and five grids (increased to six in 2007) of traps in representative areas around Barrow Island. These data have been captured in a number of reports including: Burbidge *et al.* (1998); Morris *et al.* (1999); Morris *et al.* (2001); Morris *et al.* (2002); Burbidge *et al*. (2003); and Burbidge and Holmes (2006).

The mammal (and reptile) surveys in the vicinity of the Gas Treatment Plant site in November and December 2003, and in October 2004 are detailed in the Draft EIS/ERMP (Chevron Australia 2005). The Feed Gas Pipeline routes, airport extension, and road-widening areas were also surveyed in 2004 for signs of mammal activity, in particular, Boodie warrens.

Since completion of the Draft EIS/ERMP studies in 2005, numerous terrestrial fauna surveys have been conducted. Surveys were conducted in 2005 and 2006 to support realignments in the Onshore Feed Gas Pipeline and the location of the Horizontal Directional Drilling laydown area (RPS BBG 2006c). The methodology used in the mammal (and reptile) survey for the Foundation Project replicated the grid alignment of the DPaW surveys.

Biota Environmental Sciences (2013) provided a site-specific assessment of the terrestrial fauna values of the approximately 36 ha development envelope within the Additional Support Area, particularly in relation to conservation significant species. The assessment included a review of the results of monitoring programs on Barrow Island as well as a field survey over the approximately 36 ha development envelope in October 2013, primarily focused on detecting Boodie warrens but also noting other habitats of the area.

The Barrow Island Spectacled Hare-wallaby (*Lagorchestes conspicillatus conspicillatus*) and Barrow Island Euro (*Macropus robustus isabellinus*) are monitored under the Mammal Distance Sampling Program. Annual surveys have been conducted since 2010. This program aims to collect information on the abundance of these mammal species and associated demographics to diagnose any observed declines in abundance that may be attributable to the Foundation Project (Chevron Australia 2012). Approximately 60 one-kilometre transects were surveyed over a range of habitats in the TDF and Reference Zones. Populations and densities were estimated using distance sampling (Biota Environmental Sciences 2011).

The Mammal Trapping Program primarily monitors the Boodie (*Bettongia lesueur*) and the Barrow Island Golden Bandicoot (*Isoodon auratus barrowensis),* but also monitors the Barrow Island Spectacled Hare-wallaby. Annual surveys have been conducted since 1998, during spring (September to October) (Chevron Australia 2012). The program aims to:

- establish a statistically valid ecological monitoring program to detect any Material or Serious Environmental harm to the significant mammals outside the TDF, before any Material or Serious Environmental Harm manifests outside the TDF
- detect change or loss of significant mammals within the TDF attributable to the Foundation Project.

Herpetofauna (Reptiles and Amphibians)

Records of reptiles and amphibians on Barrow Island have been compiled from a number of sources including:

- 18 pitfall traps, flushing by burning of spinifex, examination of rubbish sites, and ‘stalking’ (Smith 1976)
- flushing by burning of spinifex over an area of 1175 m^2 (Heatwole and Butler 1981)
- targeted surveys with method not recorded (Butler 1970).

Targeted reptile surveys were conducted at the existing Chevron Australia Camp accommodation blocks, airport, Barge (WAPET) Landing, existing oilfield operations base, and the Terminal Tanks on Barrow Island in April 2006 (Biota Environmental Sciences 2006).

The Foundation Project has also collected data from pitfall trapping exercises during the monitoring of mammals (as described above) and from records of any entrapped fauna in trenches and other excavations. Relevant data has also been collected of herpetofauna recorded during vegetation clearance activities and from other opportunistic records or sightings, and supplemented with desktop research.

Subterranean Fauna

Subterranean fauna has been studied on Barrow Island since 1991. Surveys by the Western Australian Museum at 43 sites focused largely on cave fauna. Sampling was undertaken by Chevron Australia in 2002 and 2003 to support the Environmental, Social and Economic Review of the Gorgon Gas Development on Barrow Island (ChevronTexaco Australia 2003).

Subsequent to this, Chevron Australia commissioned a 19-month four-phase survey between November 2004 and July 2006. The last two phases were undertaken after the release of the Draft EIS/ERMP in 2005 (Chevron Australia 2005). This sampling was undertaken at 46 sites for troglofauna and 37 sites for stygofauna.

Four types of boreholes were installed and sampled as part of the survey:

- Halocline bores: Cased holes drilled to the halocline (the interface between the superficial aquifer and deeper saline groundwater) plus 5 m – aimed primarily at stygofauna sampling.
- Subterranean fauna bores: Drilled to 5 m below the top of the superficial freshwater aquifer – primarily stygofauna sampling holes, but the portion of the casing above the watertable was also fully slotted (3 mm slots) to allow for troglofauna sampling. These were the core component of the sampling program and a grid of reference site bores (S1 to S9) was installed to provide transects of data inland from shore.
- Opportunistic troglofauna bores: Uncased holes drilled primarily for geotechnical work (top few metres cased and capped to enable sampling access and prevent blockages) – varying depth (generally less than 5 m), sampled only for troglofauna in this superficial portion of the karst.
- Opportunistic bores (other): Bores of indeterminate origin.

Stygofauna were sampled using the established technique of groundwater bailing with haul nets. Troglofauna were sampled by using custom-built litter traps containing leaf litter material.

Monitoring of subterranean fauna has continued since the approval of the Foundation Project. In 2013 Biota Environmental Sciences (2013a) undertook a site-specific study, using monitoring data from these previous field surveys, to determine the subterranean fauna values within the approximately 36 ha development envelope encompassing the Additional Support Area. Additionally, Humphreys *et al.* (2013) has provided an update of the expanded knowledge of the subterranean fauna of Barrow Island.

Terrestrial Invertebrate Short-range Endemics

The invertebrate groups Araneae, Pseudoscorpionida, Scorpionida, Diplopoda, and Pulmonata were targeted by systematic pit trapping surveys in November and December 2003. Pit trapping was complemented by hand foraging methods, including head-torching, burrow excavation, lifting rocks, peeling bark, and foraging through leaf litter and under Triodia hummocks in late 2003 and in August 2004. This enabled collection of particular spider taxa, camaenid land snails, insects, scorpions, millipedes, centipedes, and pseudoscorpions. Leaf litter and other debris found beneath Triodia clumps were collected and later sieved for cryptic invertebrates.

Voucher specimens were collected, preserved, and lodged with the Western Australian Museum for ongoing taxonomic studies. Land snails were collected for ongoing genetic and evolutionary studies by the University of Western Australia.

Terrestrial Habitat

The Fourth Train Proposal restricts the ecological element of ‘habitat’ to Boodie warrens, termite mounds, and raptor nests. Other aspects of habitat are captured through the characterisation of other ecological elements.

Boodie warrens across Barrow Island were surveyed within fifty 1 km^2 blocks across Barrow Island by Short *et al.* (1989). A total of 658 ha surrounding the Gas Treatment Plant site near Town Point and 550 ha around North Whites Beach were surveyed for Boodie warrens as part of the Foundation Project. Boodie warren surveillance was conducted using transects spaced 50 m apart. If a warren was observed, the position, number of entrances, significant vegetation, and soil type were plotted. Transects totalling 131 km in length were surveyed for Boodie warrens. A PhD student from the University of Western Australia working on Boodies also surveyed for active and inactive warrens across a large section of Barrow Island in 2002, and provided updated data that have been incorporated into Chevron Australia’s Geographical Information System. In 2013 an additional field assessment was undertaken over an approximately 36 ha development envelope encompassing the Additional Support Area and did not identify any Boodie warrens (Biota Environmental Sciences 2013).

Termite mounds have been mapped by Chevron Australia within 500 m of the Foundation Project footprint based on the interpretation of 2005 aerial photo imagery at scale of 1:1000. This area was expanded to include the approximately 36 ha development envelope encompassing the Additional Support Area and the Fourth Train Proposal footprint.

Raptor nests have been mapped by Chevron Australia, based on expert knowledge of Barrow Island and global positioning system coordinates supplied by field staff in 2006 and subsequent surveys.

Marine Benthic Habitats and Fish

The Marine Baseline Program on the east coast of Barrow Island was designed to include sites within the Dredge Management Areas of the Foundation Project, as well as Reference Sites outside these areas that are not at risk of Material or Serious Environmental Harm. Sites were selected based on the dredge management areas, distribution of coral assemblages, level of coral cover, and logistical constraints. The depth of monitoring sites varied between 0.06 ha at the Materials Offloading Facility and 1.54 ha at Dugong Reef, with an average area of 0.70 ha. The Fourth Train Proposal facilities (i.e. Materials Offloading Facility and LNG Jetty) are located within the Area at Risk of Material or Serious Environmental Harm.

Sampling frequency was designed to account for predicted seasonal differences. Table E1-1 lists the ecological elements surveyed in the Marine Baseline Program surveys, the methods used, and the survey dates.

Table E1-1: Marine Baseline Program Surveys: East coast of Barrow Island

Ecological Element	Survey Type/Method	Survey Timings
Hard and soft corals	Mapping	Oct 2008–Mar 2009
	Rapid Visual Assessment (RVA)	Oct 2008–Jan 2009
	Coral size-class frequency transect surveys	Oct 2008–Jan 2009
	Coral growth (photo-quadrats, tagged colonies)	May 2008–data collection ongoing over one Baseline Year
	Coral survival (photo-quadrats, tagged colonies)	May 2008–data collection ongoing over one Baseline Year May 2008–Nov 2009
	Coral recruitment tiles	Mar 2008–Jul 2009
Non-coral benthic macroinvertebrates	Video transects	Nov 2008 Jan 2009 Jul 2009
Macroalgae	Photo-quadrats and biomass	Nov 2008 Jan 2009 Jul 2009
Seagrass	Photo-quadrats and biomass	Nov 2008 Jan 2009 Jul 2009
Mangroves	Analysis of aerial photography Vegetation surveys	Barrow Island aerial photography (2005) Nov 2009
Demersal fish	Baited remote underwater stereo-video (stereo-BRUVs) systems	Oct 2008 Mar 2009

Ecological Element	Survey Type/Method	Survey Timings
	Seine nets, gill nets, throw, and scoop nets in mangroves	Dec 2009

The Marine Baseline Program on the west coast of Barrow Island was designed to include sites that are potentially at risk of Material or Serious Environmental Harm due to the construction and operation of the Offshore Feed Gas Pipeline System in State Waters and the marine component of the shore crossing, as well as Reference Sites that are not at risk of Material or Serious Environmental Harm due to the construction and operation of these Marine Facilities. Where practicable, sampling frequency was designed to account for predicted seasonal differences; for example, the seagrass and macroalgae surveys were conducted over late winter/early spring and summer to capture seasonal differences. Table E1-2 lists the ecological elements surveyed in the Marine Baseline Program surveys, the methods used, and the survey dates.

Table E1-2: Marine Baseline Program Surveys: West coast of Barrow Island

Ecological Element	Survey Type/Method	Survey Timings
Hard and soft corals	Diver transects and photo-quadrats with CPCe analysis	Nov 2008 July 2009 Sep 2009 Mar 2010
Non-coral benthic macroinvertebrates	Video transects Video footage analysis	Nov 2008 Jul 2009 Sep 2009 Mar 2010
Macroalgae	Diver transects and photo-quadrats with CPCe analysis	Nov 2008 Jul 2009 Sep 2009 Mar 2010
Seagrass	Diver transects and photo-quadrats with CPCe analysis	Nov 2008 Jul 2009 Sep 2009 Mar 2010
Demersal fish	Stereo-BRUV systems	Mar 2009 Mar 2010

Coastal Habitats

Field surveys that investigated intertidal and marine ecology and assessed the conservation significance of areas pertaining to the Gorgon Gas Development were undertaken during August 2002, January 2003, and January 2004. The surveys included investigations of the supratidal, intertidal, and marine areas on the east and west coasts, at locations likely to be affected by the development and operation of the proposed Marine Facilities.

Marine Turtles

Investigations into the ecology and biology of marine turtles nesting at Barrow Island have been conducted since 1985 (Green Turtles on the west coast) and 1998 (Flatback Turtles on the east coast). Marine turtle nesting activity on beaches around Barrow Island was surveyed by beach monitoring and track identification during the 2003–2004 and 2004–2005 breeding seasons.

The Foundation Project developed a program to monitor the populations of marine turtles that use the beaches adjacent to the east coast facilities, and to measure and detect changes related to the Flatback Turtle population using Barrow Island to nest. Further details are available in the Long-term Marine Turtle Management Plan (Chevron Australia 2014a).

Flatback Turtle Tagging

Existing data available for the Flatback Turtle Tagging Program include four years of monitoring on Barrow Island (2005–2006 to 2008–2009), four years on Mundabullangana (2005–2006 to 2008–2009), and ten years' DPaW data at Mundabullangana.

The Turtle Tagging Program aims to collect baseline information and to subsequently monitor the populations of marine turtles that use the beaches adjacent to the east coast facilities of Barrow Island to nest. The Program aims to provide:

- data from Barrow Island and Mundabullangana on individual reproductive behaviour, nesting rookery size, demographics, adult turtle nest beach usage, survivorship, and recruitment
- sufficient data for statically valid (greater than 0.8 or an alternative) population modelling analyses
- information regarding variation in abundance, and spatial and temporal distribution of nesting adult Flatback Turtles.

The annual tagging program began in 2005. A capture-mark-recapture program is used to determine population parameters on two Flatback Turtle rookeries that are part of the North West Shelf genetic unit: Barrow Island and Mundabullangana (mainland Reference Site).

Marine Turtle Track Census Program

Existing data available for the Marine Turtle Track Census Program includes data from surveys conducted on Barrow Island for five years (2003–2004 to 2007–2008), a total of three snapshot track census surveys (one in November 2003–2004, two in December 2003–2004 and 2004–2005), and snapshot track survey data for Hawksbill Turtles from 1998 to 2008.

Annual Marine Turtle Track Census Programs have been conducted since 2004 during the peak nesting seasons. The program aims to

- quantify adult marine turtle emergences (using species specific track counts) as a proxy for abundance
- identify spatial and temporal patterns of all adult marine turtle emergencies and nesting activity
- detect any changes in adult marine turtle emergences in the first year of construction (2010–2011) from the baseline levels (2004–2005 to 2009–2010).

Surveys were conducted using census and snapshot methods.

Hatchling Orientation (Fan) Monitoring Program

The Hatchling Orientation (Fan) Monitoring Program has been conducted annually since 2003–2004 on Barrow Island for Flatback Turtle hatchling fan data from the east coast nests.

The ongoing program is designed to specifically address parameters required by the Long-term Marine Turtle Management Plan (Chevron Australia 2014a) relating to hatchling misorientation (offset from most direct line to the ocean) and disorientation (spread) parameters. Monitoring occurs on key Green and Flatback Turtle nesting beaches to detect potential changes that may be attributable to the presence of artificial lighting from Foundation Project construction works at Barrow Island (Pendoley Environmental 2012a).

Flatback Turtle Satellite Tracking Program

The Flatback Turtle Satellite Tracking Program uses satellite tracking and time-depth recording technology to identify internesting migrations and dive behaviour of adult female Flatback

Turtles that nest on the east coast of Barrow Island. Monitoring is conducted during the nesting season (Pendoley Environmental 2012b).

Flatback Turtle Nest Success Program

Flatback Turtle Nest Success Program studies were conducted yearly in 2006–2012 for Flatback Turtles on Barrow Island. This ongoing Nest Success Program monitors the incubation success on Barrow Island and Mundabullangana by monitoring the indices of reproductive output (i.e. clutch size, hatch and emergence success incubation period [duration], egg morphometrics [size and mass], incubation temperature, sand temperature, and hatchling morphometrics [size and mass]).

Protected Marine Species

Information on protected marine species was compiled through:

- desktop reviews of the available literature on marine species
- liaison with Australian Petroleum Production and Exploration Association, Commonwealth Department of Environment and Heritage (now the Department of the Environment), Western Australian Department of Conservation and Land Management (now DPaW and Department of Environment Regulation), Department of Fisheries, Department of Industry and Resources (now Department of Mines and Petroleum, Department of State Development, and Department of Commerce)
- liaison with research personnel (independent researchers, universities, and the Western Australian Museum)
- reviews of existing in-house information and previous surveys undertaken in the region by Bowman Bishaw Gorham, including the North West Shelf Environmental Resource Atlas (Bowman Bishaw Gorham 1995)
- opportunistic observations collected during field surveys and by marine fauna observers for the Foundation Project.

Foundation Project Audit Reporting

Condition 4 of Statement No. 800 and Condition 2 of EPBC Reference: 2003/1294 and 2008/4178 requires Chevron Australia to submit an annual Compliance Assessment Report to address the previous 12-month period. Condition 4 of Statement No. 769 similarly requires that Chevron Australia submit an annual Audit Compliance Report, for the previous 12-month period.

Annual Audit Compliance Reports prepared for the Commonwealth and the State, for the previous 12-month period, are available online at the following location under ‘Reports’: http://www.chevronaustralia.com/our-businesses/gorgon/environmental-responsibility/environmental-approvals

Foundation Project Environmental Performance Reporting

Condition 5.1 of Statement No. 800 and Statement No. 769, and Condition 4 of EPBC Reference: 2003/1294 and 2008/4178 require that Chevron Australia submits an annual Environmental Performance Report to the Western Australian Minister for the Environment and to the Commonwealth Minister of the Environment respectively, for the previous 12-month period.

In addition, under Condition 5.3 of Statement No. 800 and Statement No. 769, and Condition 4.2 of EPBC Reference: 2003/1294 and 2008/4178, every five years from the date of the first annual report, Chevron Australia shall submit to the Western Australian Minister for the Environment an Environmental Performance Report covering the previous five-year period.

Annual Environmental Performance Reports are available online at the following location under ‘Reports’: http://www.chevronaustralia.com/our-businesses/gorgon/environmental-responsibility/environmental-approvals

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Appendix E2: Conservation Significant Species Considered for Assessment in this PER/Draft EIS

Conservation-significant Species Considered for Assessment in this PER/Draft EIS

Introduction

The Fourth Train Proposal will be developed in an area where a number of conservation-significant species protected under Commonwealth and/or Western Australian (State) legislation may potentially be present. The assessment presented in the PER/Draft EIS considers the potential impacts of the Fourth Train Proposal on all species and habitats that are 'likely' or 'possible' to be present in the Fourth Train Proposal Area.

The purpose of this Appendix is to list all conservation-significant species (or their habitat) identified as potentially occurring in the Fourth Train Proposal Area ('Identification Phase') and to determine their likely presence in the vicinity of the Fourth Train Proposal and need for an assessment at the species level.

In accordance with the requirements of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) and the *Environmental Protection Act 1986* (WA) (EP Act), a more detailed assessment of conservation-significant species and their habitats was undertaken for those species considered 'likely' to be present due to the potential for impact by stressors generated as part of the Fourth Train Proposal.

Identification Phase: Identification of Species for Consideration in the PER/Draft EIS

The list of conservation-significant species (under both Commonwealth and State legislation) with the potential to be impacted by the Fourth Train Proposal was identified from:

- initial Fourth Train Proposal Referral process (Chevron Australia 2011, 2011a)
- Attachment 1 of Tailored Guidelines Species List (Department of Sustainability, Environment, Water, Population and Communities [SEWPaC] 2011) (Appendix B3 [Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS])
- EPBC Act Protected Matters Interactive Search Tool and Report
- Department of Parks and Wildlife (DPaW) Current Threatened and Priority Fauna Ranking (dated 10 January 2013)
- status under the *Wildlife Conservation Act 1950* (WA) (Wildlife Conservation Act) and the EPBC Act
- latest baseline studies and technical studies completed for the approved Foundation Project with regards to the flora, fauna, and habitats present on Barrow Island and its surrounding waters
- publicly available scientific data and literature on the geographic extent and presence of the conservation-significant species.

Species were categorised as 'likely', 'possible', or 'unlikely' to be present in the vicinity of the Fourth Train Proposal Footprint using available data/evidence on parameters such as the natural geographic extent/range of the species; abundance and regularity of occurrence; and the presence of critical habitat or biologically important areas for the species (as defined by DotE).

To ensure a focused assessment on conservation-significant species, individual species assessments were only completed on species considered 'likely' to be in the vicinity of the Fourth Train Proposal Footprint and that were listed as migratory, threatened, endangered, or vulnerable in the statutory resources listed above. The exceptions were all the species listed in Attachment 1 of the Tailored Guidelines, for which the SEWPaC has requested an individual assessment be completed (Section 13.3.1.3 [Identification of Species and their Habitats]). Species falling under 'listed marine species' and 'other whales and cetaceans' were considered as part of the general assessment of the Commonwealth Marine Environment and/or marine fauna (Section 10 [Coastal and Nearshore Environment – Impacts and Management] and Section 13 [Matters of National Environmental Significance – Impacts and Management].

All 'possible' species are considered in the general assessment of potential impacts on terrestrial and marine fauna and their habitats in this PER/Draft EIS. Those species considered 'unlikely' to occur were excluded from further assessment in this PER/Draft EIS.

Table E2-1 lists the species that were identified and considered for assessment in this PER/Draft EIS.

Table E2-1: Conservation-significant Species Considered for Assessment in this PER/Draft EIS

Listed Species Protected under State and Commonwealth Legislation	Common Name	Status			Presence within the vicinity of the Fourth Train Proposal Footprint
		WA		Commonwealth	
		Wildlife Conservation Act[1]	DEC[2]	EPBC Act[3]	
Terrestrial Avifauna					
Calidris subminuta	Long-toed Stint	Schedule 3	-	M– Marine	Unlikely
Hirundo rustica	Barn Swallow	Schedule 3	-	M – Marine	Unlikely
Malurus leucopterus edouardi	White-winged Fairy-wren (Barrow Island), Barrow Island Black and White Fairy-wren	Schedule 1	-	V	Likely
Merops ornatus	Rainbow Bee-eater	Schedule 3	-	M – Marine	Unlikely
Neochmia ruficauda	Star Finch	-	Priority 4	E	Unlikely
Terrestrial Mammals					
Bettongia lesueur unnamed subsp.*	Boodie	Schedule 1	-	V	Likely
Hydromys chrysogaster	Rakali or Water-rat	-	Priority 4	-	Likely
*Isoodon auratus barrowensis**	Golden Bandicoot (Barrow Island)	Schedule 1	-	V	Likely
*Lagorchestes conspicillatus conspicillatus**	Spectacled Hare-wallaby (Barrow Island)	Schedule 1	-	V	Likely
*Macropus robustus isabellinus**	Barrow Island Euro	Schedule 1	-	V	Likely
*Petrogale lateralis lateralis**	Black-flanked Rock-wallaby	Schedule 1	-	V	Unlikely
Coastal and Marine Avifauna					
Anous tenuirostris melanops	Australian Lesser Noddy	Schedule 1	-	E – Marine	Possible
Apus pacificus	Fork-tailed Swift	Schedule 3	-	M – Marine	Possible

Listed Species Protected under State and Commonwealth Legislation	Common Name	Status			Presence within the vicinity of the Fourth Train Proposal Footprint
		WA		Commonwealth	
		Wildlife Conservation Act[1]	DEC[2]	EPBC Act[3]	
Ardea (Egretta) garzetta	Little Egret	-	-	Marine	Possible
Ardea (Egretta) alba	Great Egret	-	-	M – Marine	Possible
Ardea (Egretta) sacra	Eastern Reef Egret	Schedule 3	-	M – Marine	Likely
Ardeotis australis	Australian Bustard	-	Priority 4	-	Possible
Arenaria interpres	Ruddy Turnstone	Schedule 3	-	M – Marine	Likely
Calidris acuminata	Sharp-tailed Sandpiper	Schedule 3	-	M – Marine	Likely
Calidris alba	Sanderling	Schedule 3	-	M – Marine	Likely
Calidris canutus	Red Knot	Schedule 3	-	M – Marine	Likely
Calidris ferruginea	Curlew Sandpiper	Schedule 1	-	V – M-Marine	Likely
Calidris ruficollis	Red-necked Stint	Schedule 3	-	M – Marine	Likely
Calidris tenuirostris	Great Knot	Schedule 1	-	V – M-Marine	Possible
Charadrius leschenaultii	Greater Sand Plover	Schedule 3	-	M – Marine	Likely
Charadrius mongolus	Lesser Sand Plover	Schedule 1	-	E – M – Marine	Likely
Charadrius veredus	Oriental Plover	Schedule 3	-	M – Marine	Possible
Chlidonias leucopterus	White-winged Black Tern	Schedule 3	-	M – Marine	Likely
Haliaeetus leucogaster	White-bellied Sea-Eagle	Schedule 3	-	M – Marine	Likely
Thalassarche chlororhynchos	Atlantic Yellow-nosed Albatross	-	-	V–M – Marine	Possible
Falco cenchroides	Nankeen Kestrel	-	-	Marine	Possible

Listed Species Protected under State and Commonwealth Legislation	Common Name	Status			Presence within the vicinity of the Fourth Train Proposal Footprint
		WA		Commonwealth	
		Wildlife Conservation Act[1]	DEC[2]	EPBC Act[3]	
Fregata ariel	Lesser Frigatebird	Schedule 3	-	M – Marine	Possible
Glareola maldivarum	Oriental Pratincole	Schedule 3	-	M – Marine	Possible
Haematopus fuliginosus	Sooty Oystercatcher	-	-	-	Likely
Hirundapus caudacutus	White-throated Needletail	Schedule 3	-	M – Marine	Possible
Hirundo neoxena	Welcome Swallow	-	-	Marine	Possible
Larus novaehollandiae	Silver Gull	-	-	Marine	Likely
Limosa lapponica	Bar-tailed Godwit	Schedule 3	-	M – Marine	Likely
Limosa limosa	Black-tailed Godwit	Schedule 3	-	M – Marine	Possible
Macronectes giganteus	Southern Giant Petrel	-	Priority 4	E –M – Marine	Possible
Motacilla flava	Yellow Wagtail	Schedule 3	-	M – Marine	Unlikely
Numenius madagascariensis	Eastern Curlew	Schedule 1	-	V – Marine	Possible
Numenius minutus	Little Curlew	Schedule 3	-	M – Marine	Possible
Numenius phaeopus	Whimbrel	Schedule 3	-	M - Marine	Possible
Oceanites oceanicus	Wilson's Storm Petrel	Schedule 3	-	M – Marine	Possible
Onychoprion anaethetus (previously *Sterna anaethetus)*	Bridled Tern	Schedule 3	-	M – Marine	Likely
Pandion cristatus	Osprey	-	-	M – Marine	Likely
Pelecanus conspicillatus	Australian Pelican	-	-	Marine	Unlikely

Listed Species Protected under State and Commonwealth Legislation	Common Name	Status			Presence within the vicinity of the Fourth Train Proposal Footprint
		WA		Commonwealth	
		Wildlife Conservation Act[1]	DEC[2]	EPBC Act[3]	
Pluvialis fulva	Pacific Golden Plover	Schedule 3	-	M – Marine	Likely
Pluvialis squatarola	Grey Plover	Schedule 3	-	M – Marine	Likely
Pterodroma mollis	Soft-plumaged Petrel	-	-	V – Marine	Possible
Puffinus pacificus	Wedge-tailed Shearwater	Schedule 3	-	M – Marine	Likely
Sterna albifrons	Little Tern	-	-	M – Marine	Likely
Sterna bergii	Crested Tern	-	-	Marine	Possible
Sterna bengalensis	Lesser Crested Tern	Schedule 3	-	M – Marine	Likely
Sterna caspia	Caspian Tern	Schedule 3	-	M – Marine	Likely
Sterna dougallii	Roseate Tern	Schedule 3	-	M – Marine	Likely
Sterna hirundo	Common Tern	Schedule 3	-	M – Marine	Likely
Sternula nereis nereis	Fairy Tern (Australian)	Vulnerable		V	Likely
Stiltia maldivarum	Oriental Pratincole	-	-	M-Marine	Possible
Sula dactylatra bedouti	Masked Booby	Schedule 3	-	M – Marine	Possible
Sula leucogaster	Brown Booby	Schedule 3	-	M – Marine	Possible
Tringa brevipes	Grey-tailed Tattler	-	-	M – Marine	Likely
Tringa glareola	Wood Sandpiper	Schedule 3	-	M – Marine	Possible
Tringa hypoleucos	Common Sandpiper	-	-	M – Marine	Possible
Tringa nebularia	Common Greenshank	Schedule 3	-	M – Marine	Likely

Listed Species Protected under State and Commonwealth Legislation	Common Name	Status			Presence within the vicinity of the Fourth Train Proposal Footprint
		WA		Commonwealth	
		Wildlife Conservation Act[1]	DEC[2]	EPBC Act[3]	
Tringa stagnatilis	Marsh Sandpiper	Schedule 3	-	M – Marine	Possible
Xenus cinereus (Tringa terek)	Terek Sandpiper	Schedule 3	-	M – Marine	Possible
Fish					
Acentronura larsonae	Helen's Pygmy Pipehorse	-		Marine	Possible
Bulbonaricus brauni	Braun's Pughead Pipefish, Pug-headed Pipefish	-	-	Marine	Possible
Campichthys tricarinatus	Three-keel Pipefish	-	-	Marine	Possible
Carcharias taurus (west coast population)	Grey Nurse Shark	Schedule 1	-	V	Possible
Carcharodon carcharias	Great White Shark	Schedule 1	-	V – M	Unlikely
Choeroichthys brachysoma	Pacific Short-bodied Pipefish, Short-bodied Pipefish	-	-	Marine	Possible
Choeroichthys latispinosus	Muiron Island Pipefish	-	-	Marine	Possible
Choeroichthys suillus	Pig-snouted Pipefish	-	-	Marine	Possible
Corythoichthys flavofasciatus	Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish	-	-	Marine	Possible
Cosmocampus banneri	Roughridge Pipefish	-	-	Marine	Possible
Doryrhamphus dactyliophorus	Banded Pipefish, Ringed Pipefish	-	-	Marine	Possible
Doryrhampus excisus	Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish	-	-	Marine	Possible
Doryrhampus janssi	Cleaner Pipefish, Janss' Pipefish	-	-	Marine	Possible

Listed Species Protected under State and Commonwealth Legislation	Common Name	Status			Presence within the vicinity of the Fourth Train Proposal Footprint
		WA		Commonwealth	
		Wildlife Conservation Act[1]	DEC[2]	EPBC Act[3]	
Doryrhamphus multiannulatus	Many-banded Pipefish	-	-	Marine	Likely
Doryrhamphus negrosensis	Flagtail Pipefish, Masthead Island Pipefish	-	-	Marine	Possible
Festucalex scalaris	Ladder Pipefish	-	-	Marine	Possible
Filicampus tigris	Tiger Pipefish	-	-	Marine	Possible
Halicampus brocki	Brock's Pipefish	-	-	Marine	Possible
Halicampus grayi	Mud Pipefish, Gray's Pipefish	-	-	Marine	Possible
Halicampus nitidus	Glittering Pipefish	-	-	Marine	Possible
Halicampus spinirostris	Spiny-snout Pipefish	-	-	Marine	Possible
Haliichthys taeniophorus	Ribboned Pipehorse, Ribboned Seadragon	-	-	Marine	Possible
Hippichthys penicillus	Beady Pipefish, Steep-nosed Pipefish	-	-	Marine	Unlikely
Hippocampus angustus	Western Spiny Seahorse, Narrow-bellied Seahorse	-	-	Marine	Possible
Hippocampus histrix	Spiny Seahorse, Thorny Seahorse	-	-	Marine	Possible
Hippocampus kuda	Spotted Seahorse, Yellow Seahorse	-	-	Marine	Possible
Hippocampus planifrons	Flat-face Seahorse	-	-	Marine	Possible
Hippocampus spinosissimus	Hedgehog Seahorse	-	-	Marine	Possible
Isurus oxyrinchus	Shortfin Mako	-	-	M	Possible
Isurus paucus	Longfin Mako Shark	-	-	M	Possible

Listed Species Protected under State and Commonwealth Legislation	Common Name	Status			Presence within the vicinity of the Fourth Train Proposal Footprint
		WA		Commonwealth	
		Wildlife Conservation Act[1]	DEC[2]	EPBC Act[3]	
Manta Bostris	Giant Manta Ray	-	-	M	Likely
Micrognathus micronotopterus	Tidepool Pipefish			Marine	Possible
Phoxocampus belcheri	Black Rock Pipefish	-	-	Marine	Likely
*Pristis clavata**	Dwarf Sawfish	-	Priority 1	V	Possible
Pristis zijsron	Green Sawfish	Schedule 1	-	V	Possible
*Rhincodon typus**	Whale Shark	-	-	V – M	Likely
Solegnathus hardwickii	Pallid Pipehorse, Hardwick's Pipehorse	-	-	Marine	Possible
Solegnathus lettiensis	Gunther's Pipehorse, Indonesian Pipefish	-	-	Marine	Possible
Solenostomus cyanopterus	Robust Ghostpipefish, Blue-finned Ghost Pipefish	-	-	Marine	Possible
Solenostomus paegnius	Rough-snout Ghost Pipefish	-	-	Marine	Possible
Syngnathoides biaculeatus	Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish	-	-	Marine	Possible
Trachyrhamphus bicoarctatus	Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish	-	-	Marine	Possible
Trachyrhamphus longirostris	Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish	-	-	Marine	Possible

Listed Species Protected under State and Commonwealth Legislation	Common Name	Status			Presence within the vicinity of the Fourth Train Proposal Footprint
		WA		Commonwealth	
		Wildlife Conservation Act[1]	DEC[2]	EPBC Act[3]	
Marine Mammals					
Balaenoptera acutorostrata	Common Minke Whale			Cetacean	Possible
Balaenoptera bonaerensis	Antarctic Minke Whale, Dark-shoulder Minke Whale	-	-	M – Cetacean	Unlikely
Balaenoptera borealis	Sei Whale	Schedule 1	-	V – M – Cetacean	Unlikely
*Balaenoptera edeni**	Bryde's Whale	-	-	M – Cetacean	Likely
*Balaenoptera musculus**	Blue Whale	Schedule 1	-	E – M – Cetacean	Likely
Feresa attenuata	Pygmy Killer Whale	-	-	Cetacean	Possible
Globicephala macrorhynchus	Short-finned Pilot Whale	-	-	Cetacean	Possible
Grampus griseus	Risso's Dolphin	-	-	Cetacean	Likely
Kogia breviceps	Pygmy Sperm Whale	-	-	Cetacean	Possible
Kogia simus	Dwarf Sperm Whale	-	-	Cetacean	Possible
Lagenodelphis hosei	Fraser's Dolphin, Sarawak Dolphin	-	-	Cetacean	Possible
Balaenoptera physalus	Fin Whale	Schedule 1	-	V – M – Cetacean	Possible
*Megaptera novaeangliae**	Humpback Whale	Schedule 1	-	V – M – Cetacean	Likely
Mesoplodon densirostris	Blainville's Beaked Whale, Dense-beaked Whale	-	-	Cetacean	Possible
Orcinus orca	Orca	-	-	M – Cetacean	Possible

Listed Species Protected under State and Commonwealth Legislation	Common Name	Status			Presence within the vicinity of the Fourth Train Proposal Footprint
		WA		Commonwealth	
		Wildlife Conservation Act[1]	DEC[2]	EPBC Act[3]	
Pseudorca crassidens	False Killer Whale	-	-	Cetacean	Possible
*Physeter macrocephalus**	Sperm Whale	-	Priority 4	M – Cetacean	Possible
Delphinus delphis	Common dolphin, Short-beaked Common Dolphin	-	-	Cetacean	Likely
Lagenorhynchus obscurus	Dusky Dolphin	-	-	M -Cetacean	Possible
*Orcaella heinsohni**	Irrawaddy Dolphin/ Australian Snubfin Dolphin	-	Priority 4	M – Cetacean	Likely
Peponocephala electra	Melon-headed Whale	-	-	Cetacean	Possible
*Sousa chinensis**	Indo–Pacific Humpback Dolphin	-	Priority 4	M – Cetacean	Likely
Tursiops aduncus	Indian Ocean Bottle-nose Dolphin /Spotted Bottlenose Dolphin (Arafura/Timor Sea populations)	-	-	M -Cetacean	Likely
Stenella longirostris	Spinner Dolphin		Priority 4	Cetacean	Likely
Stenella attenuata	Spotted Dolphin	-	-	Cetacean	Possible
Stenella coeruleoalba	Striped Dolphin, Euphrosyne Dolphin	-	-	Cetacean	Possible
Steno bredanensis	Rough-toothed Dolphin	-	-	Cetacean	Likely
Ziphius cavirostris	Cuvier's Beaked Whale, Goose-beaked Whale	-	-	Cetacean	Possible
*Dugong dugon**	Dugong	Schedule 4	Listed under other specially	M – Marine	Likely

Listed Species Protected under State and Commonwealth Legislation	Common Name	Status			Presence within the vicinity of the Fourth Train Proposal Footprint
		WA		Commonwealth	
		Wildlife Conservation Act[1]	DEC[2]	EPBC Act[3]	
			protected fauna		
Eubalaena australis	Southern Right Whale	Schedule 1	-	V – M – Cetacean	Unlikely
Stenella longirostris	Long-snouted Spinner Dolphin	-	-	Cetacean	Likely
Tursiops truncatus	Bottlenose dolphin	-	-	Cetacean	Likely
Marine Reptiles					
Acalyptophis peronii	Horned Seasnake			Marine	
*Aipysurus apraefrontalis**	Short-nosed Sea Snake	Schedule 1 (Critically Endangered)	-	Marine – Critically Endangered	Possible
Aipysurus duboisii	Dubois' Seasnake	-	-	Marine	Possible
Aipysurus eydouxii	Spine-tailed Seasnake	-	-	Marine	Unlikely
Aipysurus laevis	Olive Sea Snake	-	-	Marine	Likely
Astrotia stokesii	Stokes' Seasnake	-	-	Marine	Possible
*Caretta caretta**	Loggerhead Turtle	Schedule 1	-	E – M – Marine	Likely
*Chelonia mydas**	Green Turtle	Schedule 1	-	V – M – Marine	Likely
*Dermochelys coriacea**	Leatherback Turtle, Leathery Turtle	Schedule 1	-	V – M – Marine	Possible
Disteira kingii	Spectacled Seasnake	-	-	Marine	Possible
Disteira major	Olive-headed Seasnake	-	-	Marine	Possible

Listed Species Protected under State and Commonwealth Legislation	Common Name	Status			Presence within the vicinity of the Fourth Train Proposal Footprint
		WA		Commonwealth	
		Wildlife Conservation Act[1]	DEC[2]	EPBC Act[3]	
Emydocephalus annulatus	Turtle-headed Seasnake	-	-	Marine	Possible
Ephalophis greyi	North-western Mangrove Seasnake	-	-	Marine	Unlikely
*Eretmochelys imbricata**	Hawksbill Turtle	Schedule 1	-	V – M – Marine	Likely
Hydrophis czeblukovi	Fine-spined Seasnake	-	-	Marine	Likely
Hydrophis elegans	Elegant Seasnake	-	-	Marine	Possible
Hydrophis ornatus	Ornate Seasnake	-	-	Marine	Possible
Lepidochelys olivacea	Olive Ridley Turtle	Schedule 1	-	E – M – Marine	Unlikely
*Natator depressus**	Flatback Turtle	Schedule 1	-	V – M – Marine	Likely
Pelamis platurus	Yellow-bellied Seasnake	-	-	Marine	Possible
Subterranean Fauna					
Amphipoda *Nedsia fragilis*	-	Schedule 1	V	-	Possible
Amphipoda *Nedsia humphreysi*	-	Schedule 1	V	-	Possible
Amphipoda *Nedsia hurlberti*	-	Schedule 1	V	-	Likely
Amphipoda *Nedsia sculptilis/macrosculptilis*	-	Schedule 1	V	-	Possible
Amphipoda *Nedsia straskraba*	-	Schedule 1	V	-	Possible
Amphipoda *Nedsia urifimbriata*	-	Schedule 1	V	-	Possible
Eleotridae *Milyeringa veritas**^	Blind Gudgeon	Schedule 1	-	V	Likely

Listed Species Protected under State and Commonwealth Legislation	Common Name	Status			Presence within the vicinity of the Fourth Train Proposal Footprint
		WA		Commonwealth	
		Wildlife Conservation Act[1]	DEC[2]	EPBC Act[3]	
Synbranchidae *Ophisternon candidum*[#]	Blind Cave Eel	Schedule 1		V	Likely
Ramphotyphlops longissimus	Blind Snake	-	Priority 2	-	Possible
Schizomida Draculoides bramstokeri	-	Schedule 1	V	-	Likely
Spirobolida Speleostrophus nesiotes	-	Schedule 1	V	-	Likely

1 *Status under the* Wildlife Conservation Act 1950 *(WA) [Wildlife Conservation (Specially Protected Fauna) Notice 2012 (2) dated 6 November 2012]:*

Schedule 1: Fauna that is rare or is likely to become extinct

Schedule 3: Migratory birds protected under an international agreement

Schedule 4: Other specially protected fauna (for reasons other than those mentioned in Schedules 1, 2, and 3).

2 *DPaW Current Threatened and Priority Fauna Ranking (January 2013 version)*

Priority One: Taxa with few, poorly known populations on threatened lands. Taxa that are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority Two: Taxa with few, poorly known populations on conservation lands. Taxa that are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority Four: Taxa in need of monitoring. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.

3 *Status under the EPBC Act: V = Vulnerable; E = Endangered; CE = Critically Endangered; M = Migratory (matters of NES) and in the EPBC Act Protected Matters Report: the Listed Marine Species and Whales and other Cetaceans*

* *Attachment 1 SEWPaC Tailored Guidelines Species List (Appendix B3 [Commonwealth (Tailored Guidelines) Requirements for the Contents of this Draft EIS])*

^ *The taxonomy of the Blind Gudgeon has recently been revised, with* M. veritas *no longer considered present on Barrow Island. The very similar* M. justitia*, or Barrow Cave Gudgeon, is described by Larson* et al. *(2013) as occurring within the groundwater on Barrow Island.*

[#] *The single blind eel (*Ophisternon *sp.) found on Barrow Island has not been identified to species level but, given the wide range of* Ophisternon candidum *in stygal ecosystems in the Pilbara, is taken to be* Ophisternon candidum *for the purposes of conservation status (Humphreys* et al. *2013)*

1.1 References

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Appendix E3: Restricted Distribution Flora Species on Barrow Island

Restricted Distribution Flora Species on Barrow Island

Species	Classification	Known Abundance on Barrow Island	Known Habitat (s) of Occurrence on Barrow Island	Rarity Classification
Abutilon otocarpum	SPF1	Few populations. One known population has been removed.	1 Habitat Only – Flats	Very Likely to be Rare
Acacia colei subsp. colei	SPF1	One population - Near F24	1 Habitat Only - Drainage line	Very Likely to be Rare
Acacia robeorum	SPF3	One population - North of Airstrip	1 Habitat Only - Flats	Very Likely to be Rare
Acacia trudgeniana	SPF1	Few populations - L21 - South-west corner	1 Habitat Only - Limestone	Likely to be Rare
Acanthocarpus robustus	SPF3	One population - John Wayne country	1 Habitat Only - Coastal	Very Likely to be Rare
Acacia sp. (sclerosperma complex) (CO2-FO10)	SPF1	One known population	1 Habitat Only - Drainage line	Very Likely to be Rare
Calandrinia remota	SPF2	Few populations - Camp-Base Road - Flats south-west of airstrip - Drainage line across Whites Beach Road	3 Habitats - Limestone - Flats - Drainage	Unlikely to be Rare
Commelina ciliata	SPF2	Population status unknown	Habitat preference unknown	Insufficient data
Cyperus bifax	SPF1	Few populations	2 Habitats - Drainage	Very Likely to be Rare

Species	Classification	Known Abundance on Barrow Island	Known Habitat (s) of Occurrence on Barrow Island	Rarity Classification
			- Claypans	
Cyperus iria	SPF1	Few populations	2 Habitats - Drainage - Claypans	Very Likely to be Rare
Dolichandrone heterophylla	SPF3	One population - North of Q37	1 Habitat Only - Limestone	Likely to be Rare
Dysphania kalpari	SPF3	Few populations	1 Habitat Only - Coastal Limestone	Very Likely to be Rare
Dysphania pumilio	SPF2	Several populations	1 Habitat Only - Flats	Possibly Rare
Eremophila forrestii subsp. Forrestii	SPF3	One population - East of Triangle Pit	1 Habitat Only - Flats (Valley Floor)	Very Likely to be Rare
Erythrina vespertilio	SPF1	Few to several populations	1 Habitat Only - Flats	Likely to be Rare
Eucalyptus xerothermicams	SPF1	Few populations - 3 main populations plus scattered trees	1 Habitat Only - Limestone: Drainage within Limestone	Very Likely to be Rare
Ficus aculeata	SPF1	One population - North of G64	1 Habitat Only - Limestone	Likely to be Rare
Ficus virens var. virens	SPF3	Several populations	1 Habitat Only - Limestone (Restricted Areas Only)	Likely to be Rare
Gossypium australe	SPF1	Few to several populations	1 Habitat Only - Limestone (Mainly Drainage within Limestone)	Likely to be Rare
Grevillea pyramidalis subsp. leucadendron	SPF1	Few populations	2 Habitats - Flats - Limestone (Fringe with Flats only)	Likely to be Rare

Species	Classification	Known Abundance on Barrow Island	Known Habitat (s) of Occurrence on Barrow Island	Rarity Classification
Heliotropium inexplicitum	SPF3	Population status unknown - 1 specimen in WA Herbarium	1 Habitat Only – Flats (Coastal)	Very Likely to be Rare
Herissantia crispa	SPF2	Population status unknown – 2 records but no specimens	Habitat preference unknown	Insufficient data
Isotropis atropurpurea	SPF1	Few populations	1 Habitat Only - Limestone - Flats	Likely to be Rare
Lechenaultia aff.?subcymosa	SPF1	Few populations	1 Habitat Only - Limestone	Likely to be Rare
Mallotus dispersus	SPF3	Few populations (unconfirmed) - Valley of Giants - Y53	1 Habitat Only - Limestone	Likely to be Rare
Melaleuca cardiophylla	SPF4	Many populations	3 or More Habitats - Limestone - Flats - Drainage	Very Unlikely to be Rare
Nicotiana rosulata subsp. rosulata	SPF3	Few populations	1 Habitat Only - Limestone (Coastal Only)	Very Likely to be Rare
Peripleura arida	SPF2	Population status unknown – 2 specimens in WA Herbarium, no habitat details	Habitat preference unknown	Insufficient data
Peripleura obovata	SPF2	Several populations	1 Habitat Only – Limestone	Unlikely to be Rare
Rhagodia latifolia subsp. latifolia	SPF3	Few populations	2 Habitats - Coastal - Limestone (coastal)	Likely to be rare
Rhagodia latifolia subsp.?recta	SPF2	Population status not known – No specimen in WA Herbarium	Habitat preference unknown	Insufficient data

Species	Classification	Known Abundance on Barrow Island	Known Habitat (s) of Occurrence on Barrow Island	Rarity Classification
Santalum murrayanum	SPF3	Population status not known − No specimen in WA Herbarium	Habitat preference unknown	Insufficient data
Scaevola cf aemula	SPF2	Population status not known	Habitat preference unknown	Insufficient data
Senna planitiicola	SPF2	Few to several populations	2 Habitats − Claypans (edges) − Limestone (drainage within limestone)	Possibly Rare
Sporobolus mitchellii	SPF1	One population only	1 Habitat Only − Limestone (sunken cave)	Likely to be Rare
Tecticornia indica subsp. julacea	SPF3	One population only	1 Habitat Only − Tidal flats	Very Likely to be Rare
Ventilago viminalis	SPF1	Two populations	1 Habitat Only − Limestone	Likely to be Rare
Whiteochloa airoides	SPF1	Two populations − Flacourt Bay − Barrells	1 Habitat Only − Coastal	Very Likely to be Rare

Appendix E4: Detected Non-Indigenous Terrestrial Species Currently on Barrow Island

Detected Non-Indigenous Terrestrial Species Currently on Barrow Island

Common Name	Scientific Name	Distribution
Animals – Invertebrates		
Daddy Long-legs Spider	*Crossopriza lyoni*	Cosmopolitan, commensal with human habitation and only collected at Chevron Australia Camp
Giant Daddy Long Legs Spider	*Artema atlanta*	Cosmopolitan, commensal with human habitation and only collected at Chevron Australia Camp
Spitting Spider	*Dictis striatipes*	Commensal with human habitation; only collected from disturbed sites and considered benign
Urban Wall Spider	*Oecobius navus*	Cosmopolitan, commensal with human habitation and only collected at the WA Oil Base and the Chevron Australia Camp
American Cockroach	*Periplaneta americana*	Cosmopolitan, commensal with human habitation
Brown Banded Cockroach	*Supella longipalpa*	Cosmopolitan, commensal with human habitation
Carpet Beetle	*Attagenus* sp.	Cosmopolitan, commensal with human habitation
Dermestid Beetle	*Dermestes haemorrhoidalis*	Cosmopolitan, stored products pest and highly dependent on human habitation; only collected near the Chevron Australia Camp
Black Larder Beetle	*Dermestes ater*	Cosmopolitan, commensal with human habitation
Beetle	*Leucohimatium arundinaceum*	Restricted distribution and only collected at disused rubbish tip
Red-legged Ham Beetle	*Necrobia rufipes*	Cosmopolitan, stored products pest and highly dependent on human habitation; only collected near the Chevron Australia Camp
Confused Flour Beetle	*Tribolium confusum*	Cosmopolitan, commensal with human habitation
Cannibal Ant	*Cerapachys longitarsus*	Only collected from the Chevron Australia Camp
Black Crazy Ant	*Paratrechina longicornis*	Generally found at disturbed and rehabilitated sites. Suggested presence on Barrow Island for some time
Tomato Mirid	*Nesidiocoris tenuis*	Restricted distribution, highly mobile with periodic detection
Cowpea Aphid	*Aphis craccivora*	Found in native vegetation
Cotton Aphid	*Aphis gossypii*	Found in native vegetation

Common Name	Scientific Name	Distribution
Delicate Slater	*Porcellionides pruinosus*	Not common; only collected at the Chevron Australia Camp and considered benign
Indian Meal Moth	*Plodia interpunctella*	Found around accommodation
Diamondback Moth	*Plutella xylostella*	Found around accommodation
Booklouse	*Liposcelis bostrychophila*	Cosmopolitan, commensal with human habitation
Booklouse	*Liposcelis entomophilus*	Cosmopolitan, commensal with human habitation
Booklouse	*Dorypteryx domestica*	Cosmopolitan, commensal with human habitation
Tomato Thrips	*Frankliniella schultzei*	Widespread agricultural pest on Barrow Island. Subject to long-distance wind dispersal
Grey Silverfish	*Ctenolepisma longicaudata*	Putative species. Cosmopolitan
Red-backed Spider	*Latrodectus hasseltii*	Putative species. Found in native environment
Springtail	*Hypogastrura* sp. Cf. *vernalis*	Putative species. Found in native environment
Springtail	cf. *Isotoma viridis*	Putative species. No record relating to location of detection
Springtail	*Mesophorura* sp.	Putative species. Widespread over Barrow Island
Sneaking Ant	*Cardiocondyla nuda*	Putative species. Feeds on thrips, so likely to be widespread
Flower Bug	*Montandoniola* sp.	Putative species. Cosmopolitan
Moth Fly	*Psychoda alternata*	Cosmopolitan, commensal with human habitation
Cigarette Beetle	*Lasioderma serricorne*	Cosmopolitan, commensal with human habitation
Flora Weed Species		
Buffel Grass	*Cenchrus ciliaris*	Located at disturbed sites and currently under control
Milk Thistle/Sowthistle	*Sonchus oleraceus*	Although difficult to differentiate between the two *Sonchus* sp., Milk Thistle is currently being controlled at all known locations
Black Berry Nightshade	*Solanum nigrum*	Currently being controlled at all known locations
Fleabane	*Conzya sp.*	Currently being controlled at all known locations
Whorled Pigeon Grass	*Setaria verticillata*	Limited distribution at Whites Beach. Responsibility for control under review.
Watermelon	*Citrullus lanatus*	Not detected since Gorgon Construction activities commenced.
Tomato	*Lycopersicon esculentum*	Currently being controlled at all known locations
Prickly Sowthistle	*Sonchus asper*	Although difficult to differentiate from *Sonchus oleraceus* (Milk Thistle), Prickly Sowthistle is currently being controlled at all known locations

Common Name	Scientific Name	Distribution
Coast Button Grass	*Dactyloctenium aegyptium*	Isolated detection in 2011. Not recorded since, following control activities.
Kapok	*Aerva javanica*	Isolated detection in 2011. Not recorded since, following control activities.
Couch Grass	*Cynodon dactylon*	Limited distribution. Removed in 2009 and not detected since 2010.
Green Fat Hen	*Chenopodium murale*	Not detected since Gorgon Construction Activities commenced
Stinking Passion Flower	*Passiflora foetida var. hispida*	Not detected since Gorgon Construction Activities commenced
Annual Ryegrass	*Lolium rigidum*	Not detected since Gorgon Construction Activities commenced
Spiked Malvastrum	*Malvastrum americanum*	Considered naturalised. Not subject to control
Common Poppy	*Papaver somniferum*	Not detected since Gorgon Construction activities commenced. Considered eradicated.
Doublegee	*Emex australis*	Not detected since Gorgon Construction activities commenced. Considered eradicated.
Common Centaury	*Centaurium erythraea*	Identified by Buckley in 1980 and again by Mattiske in 1993. Records are considered to be unconfirmed. Not detected since Gorgon Construction activities commenced.
Jersey Cudweed	*Helichrysum luteoalbum*	Not detected since Gorgon Construction activities commenced. Considered eradicated.
Caltrop	*Tribulus terrestris*	Not detected since Gorgon Construction activities commenced. Considered eradicated.
Capeweed	*Arctotheca calendula*	Recorded on the flora list compiled by Butler for the Environmental Review in 1980. Records are considered to be unconfirmed.
Purslane	*Portulaca oleracea*	Identified by Buckley and Butler. Records are considered to be unconfirmed. Not detected since Gorgon Construction activities commenced.
Speedy Weed	*Flaveria trinervia*	Recorded by W. H. Butler in 1973, with a specimen lodged in WA Herbarium (190). Formerly *Flaveria australasica*, a pre-European introduction is now considered naturalised. Not subject to control
Common Lantana	*Lantana camara*	Isolated detection in 1969. Not detected since Gorgon Construction activities commenced. Considered eradicated.
Flora Weed Species – Native (Mainland WA) Introductions		
Coolabah	*Eucalyptus victrix*	Limited distribution throughout WA Oil Base. Not currently subject to control
Pituri	*Duboisia hopwoodii*	Pituri was recorded by Butler and Buckley, and again by Mattiske in 1996. Records are considered to be unconfirmed. Not detected since Gorgon Construction activities commenced.
Tuart	*Eucalyptus gomphocephala*	Not detected since Gorgon Construction activities commenced. Considered eradicated.
Miniritchie	*Acacia grasbyi*	Not detected since Gorgon Construction activities commenced. Considered eradicated.
Coral Gum	*Eucalyptus torquata*	Limited distribution around the Chevron Australia Camp oval. Last recorded in 2012

Common Name	Scientific Name	Distribution
River Gum	*Eucalyptus camaldulensis*	No confirmed locations of River Gum populations on Barrow Island have been established.

Appendix F: Environmental Risk Assessment

Appendix F1: Risk Assessment Consequence Criteria

Risk Assessment Consequence Criteria

Environmental and Social Factors	6 INCIDENTAL	5 MINOR	4 MODERATE	3 MAJOR	2 SEVERE	1 CATASTROPHIC
Terrestrial Environment						
Soil and Landform [1]	**Degradation and Contamination** Localised and short-term soil contamination or degradation of soil integrity or specific soil characteristic(s).	**Degradation and Contamination** Localised and long-term or widespread and short-term soil contamination or degradation/loss of soil integrity or specific soil characteristic(s).	**Degradation and Contamination** Localised and irreversible or widespread long-term soil contamination or degradation/loss of soil integrity or specific soil characteristic(s).	**Degradation and Contamination** Significant, widespread, and persistent soil contamination or degradation/loss of soil integrity or specific soil characteristic(s).	**Degradation and Contamination** Significant and persistent soil contamination or degradation of soil integrity or loss of specific soil characteristic(s) across the whole of Barrow Island.	**Degradation and Contamination** Significant, widespread, and persistent soil contamination or degradation of soil integrity/loss of specific soil characteristic(s) on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region).
	Recharge Patterns Localised and short-term disturbance to recharge patterns that can be readily remediated.	**Recharge Patterns** Localised and long-term or widespread and short-term disturbance to recharge patterns.	**Recharge Patterns** Localised and irreversible disturbance to surface/ groundwater recharge patterns.	**Recharge Patterns** Significant, widespread, and persistent disturbance to surface/ groundwater recharge patterns.	**Recharge Patterns** Significant and persistent change in surface/ groundwater recharge patterns across the whole of Barrow Island.	**Recharge Patterns** Significant, widespread, and persistent change in recharge patterns on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region).
	Landforms and Habitat Localised and short-term disturbance to well-represented landforms that can be readily remediated.	**Landforms and Habitat** Localised and long-term or widespread and short-term disturbance to well-represented landforms. Localised and short-term disturbance to a sensitive habitat.	**Landforms and Habitat** Localised and irreversible or widespread long-term loss of well-represented landform habitats. Localised and long-term disturbance to a sensitive habitat.	**Landforms and Habitat** Significant, widespread, and persistent changes to well-represented landform habitats, or widespread, long-term disturbance to sensitive habitats.	**Landforms and Habitat** Significant and persistent losses of well-represented or unique/ sensitive landform habitats across the whole of Barrow Island.	**Landforms and Habitat** Significant, widespread, and persistent loss of well-represented and unique landform habitats on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region)

Environmental and Social Factors	6 INCIDENTAL	5 MINOR	4 MODERATE	3 MAJOR	2 SEVERE	1 CATASTROPHIC
Surface and Groundwater Quality	**Surface and Groundwater Quality** Localised and short-term reduction in surface and groundwater quality that can be readily remediated.	**Surface and Groundwater Quality** Localised, but long-term reduction in surface and groundwater quality. Widespread short-term reduction in surface and groundwater quality that can be remediated.	**Surface and Groundwater Quality** Localised and irreversible reduction in surface and groundwater quality. Widespread long-term reduction in surface and groundwater quality, requiring significant remediation efforts.	**Surface and Groundwater Quality** Significant, widespread, and persistent reduction in surface and groundwater quality.	**Surface and Groundwater Quality** Significant and persistent reduction in surface and groundwater quality across the whole of Barrow Island.	**Surface and Groundwater Quality** Significant, widespread, and persistent reduction in surface and groundwater quality on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region).
Air Quality	**Air Quality Standards [2]** Localised, short-term, and minor exceedance of air quality standards.	**Air Quality Standards [2]** Minor, localised, and long-term or minor widespread, short-term exceedance of air quality standards. Major, localised, and short-term exceedance of air quality standards.	**Air Quality Standards [2]** Minor, widespread, and long-term exceedance of air quality standards. Major, widespread, and short-term exceedance of air quality standards.	**Air Quality Standards [2]** Significant, widespread, and long-term exceedance of air quality standards, resulting in minor, but persistent reduction in air quality across multiple locations on Barrow Island.	**Air Quality Standards [2]** Significant and persistent reduction in air quality standards across the whole of Barrow Island.	**Air Quality Standards [2]** Significant and persistent reduction in air quality on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region).
Restricted Flora and Vegetation Associations	**Abundance and Structure** Localised and short-term decrease in abundance or impact on vegetation association structure. Sublethal physiological impacts. **Viability** Localised and short-term reduction in taxon or vegetation association viability.	**Abundance and Structure** Localised and long-term or widespread and short-term decrease in abundance or impact on vegetation association structure. **Viability** Localised and long-term or widespread and short-term reduction of taxon or vegetation association viability.	**Abundance and Structure** Localised and irreversible or widespread and long-term decrease in abundance or impact on vegetation association structure. **Viability** Localised and irreversible or widespread and long-term reduction of viability of taxon or vegetation association on Barrow Island.	**Abundance and Structure** Significant, widespread, and persistent decrease in abundance of flora or impact on vegetation association structure. **Viability** Significantly reduced viability of taxon or vegetation association across multiple locations on Barrow Island.	**Abundance and Structure** Loss of a significant portion of the entire taxon on Barrow Island or significant and persistent disruption to vegetation association abundance and structure. **Viability** Near extinction of taxon or vegetation association on Barrow Island.	**Abundance and Structure** Extinction on Barrow Island, and/or significant and persistent decrease in abundance of flora or loss of effective vegetation association structure on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region). **Viability** Extinction on Barrow Island, and/or significantly reduced viability (near extinction) on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region).

Environmental and Social Factors	6 INCIDENTAL	5 MINOR	4 MODERATE	3 MAJOR	2 SEVERE	1 CATASTROPHIC
General Flora and Vegetation Associations	**Abundance and Structure** Localised and short-term decrease in abundance or impact on vegetation association structure. Sublethal physiological impacts. **Viability** Localised and short-term reduction of taxon or vegetation association viability.	**Abundance and Structure** Widespread and short-term or localised and long-term decrease in abundance or impact on vegetation association structure. Sublethal to lethal physiological impacts. **Viability** Localised and long-term or widespread and short-term reduction of taxon or vegetation association viability.	**Abundance and Structure** Widespread and long-term decrease in abundance or impact on vegetation association structure. **Viability** Localised and irreversible reduction in viability or widespread and long-term reduction of viability of taxon or vegetation association.	**Abundance and Structure** Significant, widespread, and persistent decrease in abundance or impact on vegetation association structure. **Viability** Significant and persistent reduction in viability of taxon or vegetation association across multiple locations on Barrow Island.	**Abundance and Structure** Extinction of taxon on Barrow Island or significant and persistent disruption to vegetation association and structure. **Viability** Extinction of the entire taxon or vegetation association on Barrow Island.	**Abundance and Structure** Extinction of taxon or vegetation association or loss of effective vegetation association structure on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region). **Viability** Extinction/near extinction of taxon or vegetation association on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region).
Listed Fauna, including Listed Subterranean Fauna (listed and threatened species)	**Behaviour** Short-term behavioural impact to protected fauna within local area. **Abundance** Localised and short-term decrease in abundance. **Population Viability** Localised and short-term reduction of local population, no lasting effects on the whole population.	**Behaviour** Long-term behavioural impact to protected fauna within local area or widespread short-term behavioural impact to protected fauna. **Abundance** Localised and long-term or widespread, and short-term decrease in abundance. **Population Viability** Localised and long-term or widespread and short-term reduction in population viability.	**Behaviour** Widespread and long-term behavioural impact to fauna. **Abundance** Localised and irreversible or widespread and long-term decrease in abundance. **Population Viability** Localised and irreversible reduction in viability of population or widespread and long-term reduction of viability on Barrow	**Behaviour** Significant and persistent change in fauna behaviour across multiple locations on Barrow Island. **Abundance** Significant, widespread, and persistent decrease in abundance. **Population Viability** Significantly reduced population viability across multiple locations on Barrow Island.	**Behaviour** Significant and persistent change in fauna behaviour across the whole of Barrow Island. **Abundance** Permanent loss of a significant portion of the entire population on Barrow Island (near extinction). **Population Viability** Near extinction of taxon on Barrow Island.	**Behaviour** Significant and persistent change in fauna behaviour on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region). **Abundance** Extinction on Barrow Island, and/or significant reduction in abundance on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region). **Population Viability** Extinction on Barrow Island, and/or significantly reduced viability on a regional scale (i.e. Barrow Island,

Environmental and Social Factors	6 INCIDENTAL	5 MINOR	4 MODERATE	3 MAJOR	2 SEVERE	1 CATASTROPHIC
			Island.			Lowendal and Montebello Islands and/or the Pilbara Region).
General Fauna, including General Subterranean Fauna (not listed/ threatened species)	**Behaviour** Short-term behavioural impact to fauna within local area. **Abundance** Localised and short-term decrease in abundance. **Population Viability** Localised and short-term reduction of population viability, no lasting effects on the whole population.	**Behaviour** Long-term behavioural impact to fauna within local area or widespread and short-term behavioural impact. **Abundance** Localised and long-term or widespread and short-term decrease in abundance. **Population Viability** Localised and long-term or widespread short-term reduction in population viability.	**Behaviour** Widespread and long-term behavioural impact to fauna. **Abundance** Localised and irreversible or widespread and long-term decrease in population abundance. **Population Viability** Localised and irreversible or widespread and long-term reduction of population viability.	**Behaviour** Significant and persistent change in fauna behaviour across multiple locations on Barrow Island. **Abundance** Significant and persistent changes in population abundance across multiple locations on Barrow Island. **Population Viability** Significantly reduced population viability across multiple locations on Barrow Island.	**Behaviour** Significant and persistent change in fauna behaviour across the whole of Barrow Island. **Abundance** Permanent loss of the entire population on Barrow Island (extinction). **Population Viability** Extinction of taxon/population on Barrow Island.	**Behaviour** Significant and persistent change in fauna behaviour on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region). **Abundance** Extinction on Barrow Island, and significant and permanent reduction in abundance on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region). **Population Viability** Extinction or near extinction on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region).
Marine Environment						
Marine Water Quality	**Marine Water Quality** Localised and short-term and minor reduction in water quality.	**Marine Water Quality** Minor reduction in water quality, which is widespread and short-term or localised and long-term. Significant, localised, and short-term reduction in water quality.	**Marine Water Quality** Minor and long-term reduction in water quality across multiple locations, but outside marine conservation reserves [3] around Barrow Island.	**Marine Water Quality** Significant and persistent reduction in water quality across multiple locations around Barrow Island, including marine conservation reserves [3], but outside marine parks [3].	**Marine Water Quality** Significant and persistent reduction in water quality across multiple locations around Barrow Island including marine conservation reserves [3] and marine parks [3].	**Marine Water Quality** Significant, persistent and widespread reduction in water quality on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region).

Environmental and Social Factors	6 INCIDENTAL	5 MINOR	4 MODERATE	3 MAJOR	2 SEVERE	1 CATASTROPHIC
Foreshore and Seabed (subtidal and intertidal)	**Seabed/Sediment Contamination** Localised contamination of low toxicity, or disturbance that can readily be remediated. **Benthic Substrate** Localised and short-term impact on benthic substrate characteristics.	**Seabed/Sediment Contamination** Localised contamination or disturbance requiring long-term remediation efforts. Widespread contamination or disturbance that can be readily remediated. **Benthic Substrate** Localised and long-term or widespread and short-term changes in benthic substrate characteristics.	**Seabed/Sediment Contamination** Localised and irreversible or widespread and long-term contamination or disturbance outside marine conservation reserves [3] around Barrow Island. **Benthic Substrate** Localised and irreversible or widespread and long-term changes in benthic substrate characteristics outside marine conservation reserves [3] around Barrow Island.	**Seabed/Sediment Contamination** Significant and persistent contamination or disturbance across multiple locations around Barrow Island, including marine conservation reserves [3], but outside marine parks [3]. **Benthic Substrate** Significant and persistent change in benthic substrate characteristics across multiple locations around Barrow Island, including marine conservation reserves [3], but outside marine parks [3].	**Seabed/Sediment Contamination** Significant and persistent contamination or disturbance across multiple locations around Barrow Island including marine conservation reserves [3] and marine parks [3]. **Benthic Substrate** Significant and persistent change in benthic substrate characteristics across multiple locations around Barrow Island including marine conservation reserves [3] and marine parks [3].	**Seabed/Sediment Contamination** Significant, persistent, and widespread contamination or disturbance on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region). **Benthic Substrate** Significant, widespread, and persistent change in benthic substrate characteristics on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region).
Restricted and Significant Benthic Primary Producer Communities	**Abundance** Localised and short-term decrease in abundance or impact on communities and habitats. **Viability** Localised and short-term reduction in community/ taxon viability.	**Abundance** Widespread and short-term or localised and long-term decrease in abundance or impact on communities and/or habitats. **Viability** Localised and long-term or widespread and short-term reduction in community/ taxon viability.	**Abundance** Widespread and long-term or localised and irreversible decrease in abundance or impact on communities outside marine conservation reserves [3] around Barrow Island. **Viability** Localised and irreversible or widespread, long-term reduction of community/ taxon viability outside marine conservation reserves [3] around Barrow Island.	**Abundance** Significant and persistent decrease in abundance or impact on a communities and/or habitats around Barrow Island, including marine conservation reserves [3], but outside marine parks [3]. **Viability** Significant and persistent reduction in community/ taxon viability around Barrow Island, including marine conservation reserves [3], but outside marine parks [3].	**Abundance** Significant and persistent decrease in abundance of communities/ habitats across multiple locations around Barrow Island including marine conservation reserves [3] and marine parks [3]. **Viability** Significantly and permanently reduced viability of taxon or community (near extinction) around Barrow Island including marine conservation reserves [3] and marine parks [3].	**Abundance** Significant and persistent reduction in abundance of communities/ habitats on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region). **Viability** Extinction of communities and habitats around Barrow Island and significantly reduced viability on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands or the Pilbara Region).

Environmental and Social Factors	6 INCIDENTAL	5 MINOR	4 MODERATE	3 MAJOR	2 SEVERE	1 CATASTROPHIC
General Taxa and Communities (Flora)	**Abundance** Localised and short-term decrease in abundance or impact on communities and/or habitats. **Viability** Localised and short-term reduction in community/ taxon viability.	**Abundance** Widespread and short-term or localised and long-term decrease in abundance or impact on communities and/or habitats. **Viability** Localised and long-term or widespread and short-term reduction in community/ taxon viability.	**Abundance** Localised and irreversible or widespread and long-term decrease in abundance or impact on communities outside marine conservation reserves [3] around Barrow Island. **Viability** Localised and irreversible or widespread and long-term reduction of community/ taxon viability outside marine conservation reserves [3] around Barrow Island.	**Abundance** Significant and persistent decrease in abundance or impact on communities and/or habitats around Barrow Island, including marine conservation reserves [3], but outside marine parks [3]. **Viability** Significant and persistent reduction in community/ taxon viability in multiple locations around Barrow Island, including marine conservation reserves [3], but outside marine parks [3].	**Abundance** Significant and persistent decrease in abundance of communities/ habitats across multiple locations around Barrow Island including marine conservation reserves [3] and marine parks [3]. **Viability** Extinction on Barrow Island, including marine conservation reserves [3] and marine parks [3].	**Abundance** Significant and persistent reduction in abundance of communities/ habitats on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region). **Viability** Extinction or near extinction on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region).
Listed Species or Evolutionary Significant Units	**Behaviour** Localised and short-term behavioural impact. **Abundance** Localised and short-term decrease in abundance.	**Behaviour** Widespread and short-term or localised and long-term behavioural impact. **Abundance** Localised and long-term or widespread and short-term decrease in abundance.	**Behaviour** Widespread and long-term behavioural impact. **Abundance** Localised and irreversible or widespread and long-term decrease in species abundance outside marine conservation reserves [3] around Barrow Island.	**Behaviour** Significant and persistent change in species behaviour in multiple locations around Barrow Island, including marine conservation reserves [3], but outside marine parks [3]. **Abundance** Significant and persistent decrease in species abundance in multiple locations around Barrow Island, including marine conservation reserves [3], but outside marine parks [3].	**Behaviour** Significant and persistent change in species behaviour across multiple locations around Barrow Island including marine conservation reserves [3] and marine parks [3]. **Abundance** Significant and persistent reduction in species abundance across multiple locations around Barrow Island including marine conservation reserves [3] and marine parks [3].	**Behaviour** Significant and persistent change in species behaviour on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region). **Abundance** Significant and persistent reduction in species abundance on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region).

Environmental and Social Factors	6 INCIDENTAL	5 MINOR	4 MODERATE	3 MAJOR	2 SEVERE	1 CATASTROPHIC
	Population Viability Localised and short-term reduction in population viability.	**Population Viability** Localised and long-term or widespread and short-term reduction in population viability.	**Population Viability** Localised and irreversible or widespread and long-term reduction of population viability outside marine conservation reserves [3] around Barrow Island.	**Population Viability** Significant and persistent reduction in population viability in multiple locations around Barrow Island, including marine conservation reserves [3], but outside marine parks [3].	**Population Viability** Significantly and permanently reduced population viability (near extinction) across multiple locations around Barrow Island including marine conservation reserves [3] and marine parks [3].	**Population Viability** Extinction of population around Barrow Island and/or significantly reduced viability on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region).
General Species and Communities (not listed/ threatened) (Fauna)	**Behaviour** Localised and short-term behavioural impact. **Abundance** Localised and short-term decrease in abundance. **Population Viability** Localised and short-term reduction in population viability.	**Behaviour** Widespread and short-term or localised and long-term behavioural impact. **Abundance** Localised and long-term or widespread and short-term decrease in abundance. **Population Viability** Localised and long-term or widespread and short-term reduction in population viability.	**Behaviour** Widespread and long-term behavioural impact. **Abundance** Localised and irreversible or widespread and long-term decrease in species abundance outside marine conservation reserves [3] around Barrow Island. **Population Viability** Localised and irreversible or widespread and long-term reduction of population viability outside marine conservation reserves [3] around Barrow Island.	**Behaviour** Significant and persistent change in species behaviour in multiple locations around Barrow Island, including marine conservation reserves [3], but outside marine parks [3]. **Abundance** Significant and persistent decrease in species abundance in multiple locations around Barrow Island, including marine conservation reserves [3], but outside marine parks [3]. **Population Viability** Significant and persistent reduction in population viability in multiple locations around Barrow Island, including marine conservation reserves [3], but outside marine parks [3].	**Behaviour** Significant and persistent change in species behaviour across multiple locations around Barrow Island including marine conservation reserves [3] and marine parks [3]. **Abundance** Significant and persistent loss of species abundance across Barrow Island including marine conservation reserves [3] and marine parks [3]. **Population Viability** Extinction on Barrow Island and/or significantly reduced viability (near extinction) on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region).	**Behaviour** Significant and persistent change in species behaviour on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region). **Abundance** Significant and persistent loss of species abundance on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region). **Population Viability** Extinction or near extinction on a regional scale (i.e. Barrow Island, Lowendal and Montebello Islands and/or the Pilbara Region).

Environmental and Social Factors	6 INCIDENTAL	5 MINOR	4 MODERATE	3 MAJOR	2 SEVERE	1 CATASTROPHIC
Social, Cultural and Economic Factors						
Workforce and Public Health and Safety	No measureable impacts on workforce and/or public health and safety	Low -level, short-term inconvenience or symptoms. No measurable physical effects. No medical treatment.	Objective but reversible. Disability/impairment and/or medical treatment injuries requiring hospitalisation.	Moderate irreversible disability or impairment (<30%) to one or more persons.	Single fatality or severe irreversible disability or impairment (>30%) to one or more persons.	Short- or long-term health effects leading to multiple fatalities or significant irreversible human health effects.
Social or Economic Impacts	No measureable socio-economic impacts	Local, small-scale, easily reversible change on local and regional economy social and economic characteristics, infrastructure and/or values of Shires of Roebourne and Ashburton or Barrow Island. Community can easily adapt or cope with change.	Short-term, recoverable, or positive changes to social and economic characteristics, infrastructure, and/or values of the Pilbara Region or Barrow Island. Community has significant capacity to adapt and cope with or promote change.	Medium-term, recoverable, or positive changes to social and economic characteristics, infrastructure, and/or values of the Pilbara Region or Barrow Island. Community has some capacity to adapt and cope with or promote change.	Long-term, but recoverable or positive changes to social and economic characteristics, infrastructure, and/or values of Western Australia, the Pilbara Region or Barrow Island. Limited capacity within community to adapt and cope with or promote change.	Irreversible change to social and economic characteristics, infrastructure, and/or values of Western Australia, the Pilbara Region or Barrow Island. No capacity of community to adapt and cope with change.

[1] Landform habitats on Barrow Island could include any of the following: creeks or dry creek beds, rocky outcrops, vegetated sand dunes, tidal flats, valleys, escarpments, and exposed limestone ridges, etc.

[2] Air Quality Standards refer to the Ambient Air Quality Standards for common atmospheric pollutants (i.e. nitrogen dioxide, photochemical oxidants, sulfur dioxide and particulate matter) as listed in the Ambient Air Quality National Environmental Protection Measure (National Environment Protection Council 2003) and the National Occupational Health and Safety Commission's Exposure Standards for Atmospheric Contaminants (i.e. benzene, toluene, ethyl benzene, xylenes, and hydrogen sulfide) in the Occupational Environment and the National Exposure Standards (as amended by Safe Work Australia 1995), and supplemented by criteria adopted by the New South Wales (NSW) Department of Environment and Conservation (DEC)'s Approved Methods for Modelling and Assessment of Air Pollutants in New South Wales (NSW DEC 2005).

[3] Marine Conservation Reserves are defined in the WA DEC Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves (DEC 2007) as inclusive of the following:

- *The Barrow Island Marine Park and the Montebello Islands Marine Park (highest conservation status)*
- *Barrow Island Marine Management Area (high conservation status) north and south of Barrow Island and to the limit of the state coastal waters to the west, the Lowendal Nature Reserve to the north of Barrow Island, and the Bandicoot Bay Conservation Area (for benthic primary producer habitat) on the south end of Barrow Island.*

References

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Safe Work Australia. 1995. *Adopted Exposure Standards for Atmospheric Contaminants in the Occupational Environment [NOHSC:1003(1995)].* Department of Education, Employment and Workplace Relations, Office of Safe Work Australia, Canberra, Australian Capital Territory.

Appendix F2: Consolidated Risk Assessment Results

Consolidated Risk Assessment Results: Impacts to atmosphere

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Risk	Change introduced by Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
Air Quality													
1	Air quality	Atmospheric emissions (except dust)	Reduction in air quality, resulting in exceedance(s) in air quality criteria	During construction of the Fourth Train Proposal emissions of atmospheric pollutants and air toxics including NOx, SOx, particulates, CO and NMVOCs from activities or infrastructure such as machinery, marine vessels, vehicles and equipment with combustion engines, spraying/painting with primer, welding and coating, power generation, shipboard incineration and flaring during well completion or workover.	LOW	Same emissions types and sources as Foundation Project. Volumes emitted likely to be the same or less than Foundation Project (due to scale of activity). Will be short duration during construction phase and occurring over several widely dispersed sites. Impact is not expected to be any different or greater than that of the Foundation Project so no change to risk.	6	4	LOW	6	4	LOW	_
2	Air quality	Atmospheric emissions (except dust)	Reduction in air quality, resulting in exceedance(s) in air quality criteria	Emissions of atmospheric pollutants and air toxics including NOx, SOx, particulates, CO and NMVOCs from the operation of the Fourth Train Proposal including commissioning and start-up, operational process emissions (such as flaring), supporting utilities and subsidiary infrastructure and vehicles.	LOW	Fourth Train Proposal emissions types will be the same as those expected for the Foundation Project but will be only a third of that predicted for the Foundation Project. Incremental risk is therefore same or lower than Foundation Project.	6	4	LOW	6	3	LOW	_
3	Air quality	Atmospheric emissions (except dust)	Contribution of VOCs to regional ozone formation. Potential exceedance of local occupational health exposure standards under certain weather conditions.	Emission of VOCs produced during operation of the gas treatment plant, including acid gas venting and loading of additional condensate produced by the Fourth Train Proposal	LOW	Fourth Train Proposal will generate additional condensate loading activities but incrementally, these are predicted to be a third less than those anticipated for the Foundation Project. No change in risk	6	4	LOW	6	3	LOW	_
4	Air quality	Fire	Reduction in air quality from smoke and particulates of fire	Smoke and particulates generated by fire caused by accidental ignition during construction activities, such as hot works (cutting, welding, grinding), sparks from vehicle exhausts and personnel smoking.	LOW	Increase in the number of ignition sources.	5	4	LOW	5	4	LOW	_
9	Air quality	Dust	Reduction in air quality, resulting in exceedance(s) in air quality criteria	Construction activities including clearing and earthworks, additional vehicle movements on unsealed roads, installation of the onshore Feed Gas Pipeline System and concrete batching.	LOW	Additional clearing and earthworks, and an additional onshore Feed Gas Pipeline System. Majority of roads that will be used will be sealed by the time work on the Fourth Train Proposal begins.	6	5	TRIVIAL	_	_	–	_

Consolidated Risk Assessment Results: Impacts to the Terrestrial Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change introduced by Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
	Soils and landforms												
1	Soils and landforms	Vegetation clearing and earthworks	Change in physical landform from earthworks and from wind, water erosion Change in natural drainage regimes (at shore crossing site) Degradation of areas vulnerable to wind and water erosion (e.g. dune systems around shore crossing site, shore end of the onshore pipeline, open trenches, open site areas and drainage channels)	Vegetation clearing, stripping and storage of topsoil Earthworks within the Foundation Project footprint, and over up to 10 ha of previously uncleared land	MEDIUM	Approximately 10 ha of additional land clearing and earthworks at shore crossing. Up to 10 ha of additional re-clearing and earthworks at the Foundation horizontal directional drilling site (area already subject to Foundation Project earthworks). Up to 32 ha of additional earthworks at the Additional Support Area (area already cleared and levelled). Impacts on landform affect shore crossing sites and Additional Support Area. Extended duration of construction	6	2	LOW	5	1	MEDIUM	_
2	Soils and landforms	Vegetation clearing and earthworks	Loss and/or compaction of topsoil and change in soil vertical profile and physical characteristics	Vegetation clearing, stripping and storage of topsoil Excavation, re-filling of foundations, pipeline trench	LOW	Approximately 10 ha of additional land affected at shore crossing. Up to 10 ha of additional re-clearing and earthworks at the Foundation horizontal directional drilling site (area already subject to Foundation Project earthworks). Approximately 50 ha of additional earthworks mainly within the existing approved Foundation Project Gas Treatment Plant site (area already cleared and levelled). Up to 32 ha of additional earthworks at the Additional Support Area (area already cleared and levelled). Additional trenching along Feed Gas Pipeline System RoW. Extended duration of construction	5	5	LOW	5	5	LOW	_
3	Soils and landforms	Fire	Change in soil quality resulting from runoff containing nutrients and chemicals	Runoff from water and foam used for fire control during construction or operation of terrestrial facilities	-	Extended duration of construction activities that have potential to ignite fire Additional inventory of combustible materials Extension of physical footprint by approximately 10 ha	5	6	TRIVIAL	_	_	_	Likelihood of this impact occurring considered 'rare' based on experience from Foundation Project and mitigation measures in place
4	Soils and landforms	Spills and leaks	Contamination of soil	Precommissioning leaks and spills, including loss of saline water during hydrotesting of Feed Gas Pipeline System pipestring or LNG tank, hydraulic fluids	LOW	Additional Feed Gas Pipeline System Additional LNG tank	5	5	LOW	5	5	LOW	_
5	Soils and landforms	Spills and leaks	Contamination of soil	Unplanned discharge of drill cuttings or fluids to the environment from frac-out from drilling activities onshore	LOW	Extended duration of construction activities	6	2	LOW	6	2	LOW	This impact did not occur (in the terrestrial environment) for the Foundation Project

Consolidated Risk Assessment Results: Impacts to the Terrestrial Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change introduced by Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
6	Soils and landforms	Spills and leaks	Contamination of soil	Unplanned loss of potentially contaminated stormwater to the terrestrial environment because capacity of stormwater drains is exceeded	LOW	Extended duration of construction activities Footprint increasing by approximately 10 ha	5	3	LOW	5	3	LOW	
7	Soils and landforms	Spills and leaks	Contamination of soil	Unplanned loss from equipment (e.g. hydraulic fluids, oil and grease, diesel), during construction activities (e.g. during refuelling and from paint and joint coating spills for onshore pipeline construction)	LOW	Extended duration of construction activities Construction work adjacent to operational Foundation Project	6	4	LOW	6	4	LOW	No change in type or inventory of hazardous substances anticipated
8	Soils and landforms	Spills and leaks	Contamination of soil	Unplanned loss from the storage, handling and disposal of solid and liquid wastes	MEDIUM	Extended duration of construction activities Footprint over which impacts could occur increased by approximately 10 ha	5	4	LOW	5	4	LOW	No change in the type of hazardous substances required/generated for the Fourth Train Proposal Assessment assumes use of the Foundation Project's Waste Transfer Station on Barrow Island
9	Soils and landforms	Spills and leaks	Contamination of soil	Unplanned loss from the storage, handling and use of fuels and chemicals during construction	MEDIUM	Extended duration of construction activities	5	3	LOW	4	3	MEDIUM	_
10	Soils and landforms	Spills and leaks	Contamination of soil	Spills and leaks during operations from: # Transfer, storage, handling and use of additional fuel, chemicals and wastes # Failure of new plant equipment #Failure of drainage system	MEDIUM	Inventory of hazardous substances will increase by approximately 33% once operational Construction work adjacent to operational Foundation Project	4	3	MEDIUM	4	3	MEDIUM	_
	Subterranean Fauna												
11	Subterranean fauna	Vegetation clearing and earthworks	Smothering and/or loss of subterranean fauna and habitat due to sedimentation of aquifer from high-sediment run-off or due to loss of injected concrete to the karst	Excavation of foundations, drains and underground utilities at the Gas Treatment Plant site Excavation of material at the Additional Support Unit Earthworks at the Feed Gas Pipeline System RoW and shore crossings Runoff of sediment from exposed surfaces into karst	MEDIUM	Approximately 10 ha of clearing and earthworks additional for the shore crossing Up to 10 ha of additional re-clearing and earthworks at the Foundation horizontal directional drilling site (area already subject to Foundation Project earthworks) Up to approximately 50 ha of additional earthworks mainly within the existing approved Foundation Project Gas Treatment Plant site (area already cleared and levelled) Up to 32 ha of additional earthworks at the Additional Support Area (area already cleared and levelled). Approximately 15 ha of additional re-clearing and trenching along Feed Gas Pipeline System RoW Extended duration of construction activities	2	6	LOW	2	5	MEDIUM	Subsequent to the Foundation Project risk assessment, geotechnical work for the Foundation Project determined that the likelihood of this impact occurring is considered rare because the aquifer beneath the Gas Treatment Plant site is contiguous and subterranean fauna are not considered to be limited to one place. Therefore, risk from Fourth Train Proposal is lower

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Consolidated Risk Assessment Results: Impacts to the Terrestrial Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change introduced by Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
12	Subterranean fauna	Noise and vibration	Loss of subterranean fauna and habitat	Rupture of subsurface karst lenses or partial collapse of karst formation from activities such as drilling and blasting during construction	HIGH	Extended duration of construction activities Amount of blasting for the Fourth Train Proposal will be considerably less than for the Foundation Project. Additional drilling may be required if a 3rd LNG tank is installed	6	4	LOW	6	4	LOW	Foundation Project risk covered all the earthworks, blasting and piling required for the entire Gas Treatment Plant site. The area that may require activities such as blasting and drilling for the Fourth Train Proposal site will be considerably smaller
13	Subterranean fauna	Physical presence	Reduced groundwater recharge under Fourth Train Proposal infrastructure at Gas Treatment Plant affecting subterranean humidity and free water - and consequently loss of stygofauna and/or troglofauna	Additional impermeable surfaces and drainage in Fourth Train Proposal area at the Gas Treatment Plant during both construction and operations	MEDIUM	Approximately 10 ha of additional handstand for shore crossing Up to approximately 50 ha of additional compacted area/hardstand will be added at the Gas Treatment Plant site	6	2	LOW	5	1	MEDIUM	_
14	Subterranean fauna	Spills and leaks	Contamination of subterranean habitats (soil, surface water and/or groundwater) and associated acute toxicity to troglofauna and/or stygofauna	During construction, accidental release of hydrocarbons, chemicals or construction-related wastes, refuelling of equipment, transfer and storage or fuels and waste	MEDIUM	Extended duration of construction activities Footprint over which impact could occurring increasing by approximately 10 ha Construction work adjacent to operational Foundation Project	5	4	LOW			MEDIUM	No change in the type of hazardous substances required/generated for the Fourth Train Proposal
15	Subterranean fauna	Spills and leaks	Contamination of subterranean habitats (soil, surface water and/or groundwater) and associated acute toxicity to troglofauna and/or stygofauna	Once operational, accidental release of hydrocarbons, chemicals or wastes from: # Transfer, storage, handling and use of additional fuel, chemicals and wastes # Failure of new plant equipment or pipelines # Failure of drainage system	MEDIUM	Inventory of hazardous substances will increase by approximately 33% once operational	4	3	MEDIUM	4	3	MEDIUM	_
16	Subterranean fauna	Suppression of Dust	Loss of troglofauna and stygofauna due to contamination of groundwater and/or change in groundwater levels	Use of treated effluent (including treated sewage), fresh water, recycled water and/or seawater for dust suppression	MEDIUM	Extended duration of construction during which dust suppression may be required Area potentially subject to dust suppression increased by approximately 10 ha	6	5	TRIVIAL	_	_	_	Foundation Project risk assessment assumed use of seawater for dust suppression. However, in practice, very little sea water was used for the Foundation Project; where sea water was used, its use was restricted to the Gas Treatment Plant site inwards of a 50 m buffer zone. Also, many of the roads that will be used by Fourth Train Proposal are now sealed
17	Subterranean fauna	Unplanned CO_2 migration	Acidification of groundwater with potential loss of stygofauna and/or asphyxiation of troglofauna from settlement of CO_2 above the water table	Unplanned CO_2 migration or release to the surface or near surface environment during operations from deep faults within the Dupuy formation	LOW	Approximately 2% increase in the rate of injection of reservoir CO_2 into the Dupuy Formation to the approved Foundation Project	5	6	TRIVIAL	_	_	_	Detailed in the PER/Draft EIS due to regulator interest

Consolidated Risk Assessment Results: Impacts to the Terrestrial Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change introduced by Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
Surface and ground water													
18	Surface and groundwater	Vegetation clearing and earthworks	Sedimentation of natural drainage systems	Vegetation clearing and earthworks associated with construction of Terrestrial Facilities (shore crossings, Feed Gas Pipeline System, Additional Support Area earthworks, and additional infrastructure at Gas Treatment Plant sites)	**MEDIUM**	Approximately 10 ha of clearing and earthworks additional for the shore crossing Up to 10 ha of additional re-clearing and earthworks at the Foundation horizontal directional drilling site (area already subject to Foundation Project earthworks). Up to approximately 50 ha of additional earthworks mainly within the existing approved Foundation Project Gas Treatment Plant site (area already cleared and levelled) Up to 32 ha of additional earthworks at the Additional Support Area (area already cleared and levelled). Approximately 15 ha of additional re-clearing and trenching along Feed Gas Pipeline System RoW. Extended duration of construction activities	6	3	**LOW**	6	3	**LOW**	_
19	Surface and groundwater	Fire	Change in surface water and groundwater quality resulting from runoff containing nutrients and chemicals	Runoff from water or foam used for fire control	_	Extended duration of construction activities that have potential to ignite fire Additional inventory of combustible materials Extension of physical footprint by approximately 10 ha	5	6	**TRIVIAL**	_	_	_	Likelihood of this impact occurring considered 'rare' based on experience from Foundation Project and mitigation measures in place
20	Surface and groundwater	Physical presence	Disturbance/alteration of natural drainage patterns (resulting in change in groundwater infiltration, increased runoff, and recharge rates)	Additional impermeable surfaces and drainage in the Fourth Train Proposal area of Gas Treatment Plant (both construction and operations phase)	**MEDIUM**	approximately 10 ha of additional handstand for shore crossing Up to approximately 50 ha of additional compacted area/hardstand will be added at the Gas Treatment Plant site	6	2	**LOW**	5	1	**MEDIUM**	_
21	Surface and groundwater	Spills and leaks	Contamination of groundwater	Precommissioning leaks and spills, including loss of saline water during hydrotesting of Feed Gas Pipeline System pipestring or LNG tank, hydraulic fluids.	**LOW**	Additional Feed Gas Pipeline System Additional LNG tank	5	4	**LOW**	5	4	**LOW**	_
22	Surface and groundwater	Spills and leaks	Contamination of groundwater	Unplanned loss of potentially contaminated stormwater to the terrestrial environment because capacity of stormwater drains is exceeded	**LOW**	Extended duration of construction activities Footprint increasing by approximately 10 ha	5	3	**LOW**	5	3	**LOW**	_

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Consolidated Risk Assessment Results: Impacts to the Terrestrial Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change introduced by Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
23	Surface and groundwater	Spills and leaks	Contamination of groundwater	During construction, accidental release of hydrocarbons, chemicals or construction-related wastes, refuelling of equipment, transfer and storage or fuels and waste	MEDIUM	Extended duration of construction activities Footprint over which impacts could occur increased by approximately 10 ha Construction work adjacent to operational Foundation Project	6	3	LOW	4	3	MEDIUM	No change in the type of hazardous substances required/generated for the Fourth Train Proposal Assessment assumes use of the Foundation Project's Waste Transfer Station on Barrow Island
24	Soils and landforms	Spills and leaks	Surface water and groundwater contamination	Unplanned loss from the storage, handling and use of fuels and chemicals during construction	MEDIUM	Extended duration of construction activities Construction work adjacent to operational Foundation Project	5	3	LOW			MEDIUM	_
25	Surface and groundwater	Spills and leaks	Surface water and groundwater contamination	Spills and leaks during operations from: # Transfer, storage, handling and use of additional fuel, chemicals and wastes # Failure of new plant equipment # Failure of drainage system	MEDIUM	Inventory of hazardous substances will increase by approximately 33% once operational	4	3	MEDIUM	4	3	MEDIUM	_
26	Surface and groundwater	Suppression of Dust	Increase in groundwater levels and mounding	Use of treated effluent (including treated sewage), fresh water, recycled water and/or seawater for dust suppression	MEDIUM	Extended duration of construction during which dust suppression may be required Area potentially subject to dust suppression increased by approximately 10 ha This stressor was considered for the Foundation Project because of the intention to use sea water for dust suppression. However, in practice, very little sea water was used for the Foundation Project; where sea water was used, its use was restricted to the Gas Treatment Plant site inwards of a 50 m buffer zone	6	5	TRIVIAL	_	_	_	Foundation Project risk assessment assumed use of seawater for dust suppression. However, in practice, very little sea water was used for the Foundation Project; where sea water was used, its use was restricted to the Gas Treatment Plant site inwards of a 50 m buffer zone. Also, many of the roads that will be used by Fourth Train Proposal are now sealed.
	Terrestrial fauna												
27	Terrestrial fauna	Artificial light	Behavioural changes to terrestrial fauna (not turtles) including disruption of foraging, breeding and other nocturnal fauna activity Change in community structure in area affected by light spill because seabirds (e.g. silver gull)/other predators are attracted by insects etc around lighting	Artificial lighting used at terrestrial construction sites	LOW	Extended duration of construction activities (and period of light generation at shore crossing and along Feed Gas Pipeline System onshore route) Additional light at the Gas Treatment Plant site	6	2	LOW	6	2	LOW	_

Consolidated Risk Assessment Results: Impacts to the Terrestrial Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change introduced by Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
28	Terrestrial fauna	Artificial light	Behavioural changes to terrestrial fauna (not turtles) including disruption of foraging, breeding and other nocturnal fauna activity Change in community structure in area affected by light spill because seabirds (e.g. silver gull)/other predators are attracted by insects etc around lighting	Artificial lighting used at the Gas Treatment Plant site during operations	LOW	Additional long-term light sources at the Gas Treatment Plant site	5	3	LOW	5	3	LOW	_
29	Terrestrial fauna	Atmospheric emissions (except dust)	Sub lethal or toxic effects on fauna from inhalation of pollutants and ingestion of pollutants on vegetation or in water	Operational emissions including: # Low levels of vehicle and equipment exhaust emissions (NOx, SOx) # Additional combustion and fugitive emissions of SO_x, NO_x, CO_2, CO, CH_4, H_2S, BTEX and particulates from Fourth Train Proposal infrastructure # Gas leak through pipeline or equipment failure # Additional flaring (e.g. during commissioning, start-up and process upsets) # Unscheduled start-up and shut-down of gas processing facility # Equipment failure resulting in emissions of H_2S and BTEX	LOW	Extended duration of construction activities Emissions during the construction activities of the Fourth Train Proposal will be comparatively smaller than for Foundation Project Additional operational emissions (increased by a factor of approximately 33%)	5	4	LOW	5	4	LOW	_
30	Terrestrial fauna	Vegetation clearing and earthworks	Death or displacement of fauna from removal of habitat (Excludes interaction with machinery - see under "Physical Interaction")	Removal of vegetation and topsoil	LOW	Approximately 10 ha of additional land clearing and earthworks at shore crossing Up to 10 ha of additional re-clearing and earthworks at the Foundation horizontal directional drilling site Delay to reinstatement at the Additional Support Area (area already cleared and levelled) Approximately 15 ha of additional re-clearing along Feed Gas Pipeline System RoW	6	4	LOW	6	4	LOW	There are no Boodie warrens to be removed. Termite mounds present within the Fourth Train Proposal shore crossing site

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Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change introduced by Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
31	Terrestrial fauna	Vegetation clearing and earthworks	Displacement and loss of individual short-range endemics	Removal of vegetation and topsoil	HIGH	Extended duration of construction activities No additional clearing at the Gas Treatment Plant site Approximately 10 ha of additional land clearing at shore crossing Up to 10 ha of additional re-clearing at the Foundation horizontal directional drilling site Delay to reinstatement at the 32 ha Additional Support Area (area already cleared and levelled) Approximately 15 ha of additional re-clearing along Feed Gas Pipeline System RoW) Clearing within 332 ha for Foundation Project and Fourth Train Proposal	5	5	LOW	5	5	LOW	High impact for Foundation Project attributed to clearing and earthworks for the Gas Treatment Plant. No additional clearing required at Gas Treatment Plant site for the Fourth Train Proposal
32	Terrestrial fauna	Creation of heat and/or cold	Injury or death to avifauna (flying through heat plume) or to reptiles (attracted to the heat) Attraction of fauna to cryogenic/cold equipment at the Gas Treatment Plant	Additional use of ground flares during Fourth Train Proposal commissioning, start-up in the event of upset conditions	LOW	Increased use of Foundation Project's ground flare by approximately 30% compared to Foundation Project	6	5	TRIVIAL	–	–	–	Commissioning will be short term (approximately 6 months); start ups will be occasional and short-term (few days) Ground Flare s45c ranked heat as a low risk
33	Terrestrial fauna	Fire	Fauna injury and/or death; loss/change in habitat and associated change in fauna community composition	Industrial fire that spreads to adjacent vegetation	MEDIUM	Potential increased consequence of fire during construction at Gas Treatment Plant site while Foundation Project is operational Extended duration of construction activities that have the potential to ignite fire Additional inventory of combustible materials	5	4	LOW	5	4	LOW	
34	Terrestrial fauna	Fire	Injury or mortality to fauna; loss or change in habitat and associated change in fauna community composition	Accidental wildfire spreading into the surrounding vegetation due to hot works activities (e.g. welding, grinding) or machinery	MEDIUM	Extended duration of construction activities that have the potential to ignite fire	5	2	MEDIUM	5	2	MEDIUM	Fire events have been successfully managed
35	Terrestrial fauna	Introduction and/or spread of Non-indigenous Terrestrial Species	Death or out-competition of native fauna resulting in change in community structure and/or species abundance	Carriage of Non-indigenous Terrestrial Species on the topsides of vessels using the Materials Offloading Facility/WAPET Landing or contained within cargo	LOW	Increased number of vessels and cargo	4	4	LOW	4	4	LOW	Best practice quarantine management; there have been no successful introductions to-date
36	Terrestrial fauna	Introduction and/or spread of Non-indigenous Terrestrial Species	Death or out-competition of native fauna resulting in change in community structure and/or species abundance	Carriage of Non-indigenous Terrestrial Species on the topsides of LNG and condensate vessels	MEDIUM	Increased number of vessels	4	3	MEDIUM	4	3	MEDIUM	_

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Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change introduced by Fourth Train Proposal	Residual Impact: Incremental C	Incremental L	Incremental R	Additional C	Additional L	Additional R	Comments
37	Terrestrial fauna	Noise and vibration	Disturbance to or displacement of terrestrial fauna and potential behavioural changes affecting local population abundance and distribution (e.g. impacts on White-winged Fairy wren)	Construction of terrestrial facilities including: Earthworks, vehicle movements and operation of machinery and equipment, Cutting and grinding and Pipeline trenching	MEDIUM	Extended duration of construction activities which will be occurring at the same time as Foundation Project operation	6	2	LOW	6	1	MEDIUM	The Terrestrial and Subterranean Environment Protection Plan (2010) lists this as medium risk. However, the assessment included impacts associated with seismic survey. The Public Environment Review (2008) risk assessment did not include blasting and seismic survey noise and was used for the Foundation Project risk assessment
38	Terrestrial fauna	Noise and vibration	Disturbance to or displacement of terrestrial fauna and potential behavioural changes affecting local population abundance and distribution (e.g. impacts on White-winged Fairy wren)	Additional noise from operational Gas Treatment Plant	MEDIUM	Additional noise sources added	6	1	MEDIUM	5	1	MEDIUM	_
39	Terrestrial fauna	Physical interaction	Fauna injury and/or death	Use of equipment and machinery and additional vehicle movements during construction of terrestrial infrastructure Clearing of vegetation	MEDIUM	Extended duration of construction phase Additional vehicle movements during construction Increased area over which clearing takes place (approximately 10 ha)	5	1	MEDIUM	5	1	MEDIUM	_
40	Terrestrial fauna	Physical interaction	Entrapment and drowning of fauna	Open trench prior to installation of the Feed Gas Pipeline System (including during a rain event)	LOW	Extended duration of construction activities	6	5	LOW	6	5	LOW	
41	Terrestrial fauna	Physical interaction	Fauna injury and/or death	Additional operational vehicle movements	MEDIUM	Small increase in number of operational vehicle movements	4	4	LOW	4	3	MEDIUM	_
42	Terrestrial fauna	Physical interaction	Entrapment and subsequent death or injury of mobile fauna resulting in an associated change in fauna community composition	Excavation of foundations, drains, underground utilities, Feed Gas Pipeline footprint etc	LOW	Extended duration of construction activities Extent of excavated area for the Fourth Train Proposal less than the Foundation Project	6	4	LOW	6	4	LOW	Gas Treatment Plant site is fenced, reducing the risk of entrapment.
43	Terrestrial fauna	Spills and leaks	Poisoning, injury or drowning of mobile fauna attracted to a pool collected in a claypan	Spill or leak of hydrotest water, containing biocides and corrosion inhibitors, to the onshore environment	_	Extended duration of construction activities	5	5	LOW	5	5	LOW	
44	Terrestrial fauna	Spills and leaks	Creation of small 'mud pools' in which fauna could become trapped	Unplanned discharge of drill cuttings or fluids to the environment during construction - Frac-out from drilling activities onshore	LOW	_	6	2	LOW	6	2	LOW	_
45	Terrestrial fauna	Spills and leaks	Smothering, acute or chronic toxicity to habitat and/or individual fauna	During construction, accidental release of hydrocarbons, chemicals or construction-related wastes, refuelling of equipment, transfer and storage or fuels and waste	LOW	Extended duration of construction activities Extension of physical footprint within which this impact could occur by approximately 10 ha Construction work adjacent to operational Foundation Project	5	5	LOW	5	5	LOW	_

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Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change introduced by Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
46	Terrestrial fauna	Spills and leaks	Smothering, acute or chronic toxicity to habitat and/or individual fauna from contamination of habitat (soil or water) or from ingestion, asphyxiation etc	Once operational, accidental release of hydrocarbons, chemicals or wastes from: # Transfer, storage, handling and use of additional fuel, chemicals and wastes # Failure of new plant equipment or pipelines # Failure of drainage system	LOW	Inventory of hazardous substances will increase by approximately 33% once operational	4	4	LOW	4	4	LOW	_
47	Terrestrial fauna	Unplanned CO_2 migration	Asphyxiation of fauna in low-lying areas (e.g. fauna burrows)	Unplanned CO_2 migration or release to the surface or near surface environment from deep faults within the Dupuy formation	LOW	Approximately 2% increase in the rate of injection of reservoir CO_2 into the Dupuy Formation to the approved Foundation Project	5	6	TRIVIAL	–	–	–	
	Terrestrial flora and vegetation associations												
48	Terrestrial flora and vegetation communities	Atmospheric emissions (except dust)	Physiological effects on flora and vegetation communities from the deposition of pollutants resulting in: # Change in taxon dominance due to nitrogen enrichment and soil acidity # Alteration of community composition # Increased growth due to uptake of nitrogen or CO_2	Construction-phase vehicle and equipment exhaust emissions (NO_x, SO_x, particulates etc)	LOW	Extension of duration of construction period Additional emissions (although volumes likely to be less than that generated during Foundation Project construction due to smaller scope of Fourth Train Proposal)	5	4	LOW	5	4	LOW	_
49	Terrestrial flora and vegetation communities	Atmospheric emissions (except dust)	Physiological effects on flora and vegetation communities from the deposition of pollutants resulting in: # Change in taxon dominance due to nitrogen enrichment and soil acidity # Alteration of community composition # Increased growth due to uptake of nitrogen or CO_2	Additional combustion and fugitive emissions of SO_x, NO_x, CO_2, CO, CH_4, H_2S, VOCs and particulates from the Fourth Train Proposal infrastructure Gas leak through additional pipeline or equipment failure Additional flaring and venting during commissioning and start-up	LOW	Additional emissions	5	4	LOW	5	4	LOW	_
50	Terrestrial flora and vegetation communities	Vegetation clearing and earthworks	Loss of flora and vegetation communities including restricted species and communities Habitat disturbance or loss, including impacts from erosion	Clearance of up to 10 ha of flora and vegetation for the terrestrial component of the shore crossing site and Feed Gas Pipeline System footprint. Approximately 25 ha of re-clearing at Foundation Project horizontal directional drilling site and Feed Gas Pipeline RoW, to 332 ha for Foundation Project and Fourth Train Proposal Stripping, stockpiling, laying guidewires	HIGH	Approximately 10 ha of additional land clearing at shore crossing Up to 10 ha of additional re-clearing at the Foundation horizontal directional drilling site Delay to reinstatement at the 32 ha Additional Support Area Approximately 15 ha of additional re-clearing along Feed Gas Pipeline System RoW	5	4	MEDIUM	5	4	MEDIUM	High ranking from the Foundation Project is based on clearance of restricted flora and vegetation from the Gas Treatment Plant site. Additional impact risk ranking is based on restricted vegetation associations impacted by both the Fourth Train Proposal and the Foundation Project

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Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change introduced by Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
51	Terrestrial flora and vegetation communities	Vegetation clearing and earthworks	Loss of vegetation including restricted vegetation community or species	Vegetation clearing for Feed Gas Pipeline System footprint	LOW	No change - clearance of Feed Gas Pipeline System footprint was already assessed for the approved Foundation Project	6	4	LOW	6	4	LOW	_
52	Terrestrial flora and vegetation communities	Vegetation clearing and earthworks	Loss or damage to flora/vegetation through pooling of water following rain	Excavation, creation of channels and barriers and change in local hydrological flow patterns	_	Extended duration of construction activities Extent of excavated area for the Fourth Train Proposal less than the Foundation Project	6	2	LOW	6	2	LOW	_
53	Terrestrial flora and vegetation communities	Vegetation clearing and earthworks	Wind erosion of topsoil with consequent loss of seedbank	Clearance of up to ~ 10 ha of flora and vegetation for the terrestrial component of the shore crossing site. Approximately 25 ha of re-clearing at Foundation Project horizontal directional drilling site and Feed Gas Pipeline RoW, to 332 ha for Foundation Project and Fourth Train Proposal. Stripping and stockpiling of topsoil	_	Approximately 10 ha of additional vegetation clearance required (at shore crossing site), approximately 25 ha of re-clearing at Foundation Project horizontal directional drilling site and Feed Gas Pipeline RoW, to 332 ha for Foundation Project and Fourth Train Proposal Extended duration of construction activities	5	3	LOW	5	3	LOW	_
54	Terrestrial flora and vegetation communities	Vegetation clearing and earthworks	Washout of sediments with consequent smothering and loss of vegetation, loss of seed bank and change in drainage Potential to impact priority ecological communities	Clearance of up to 10 ha of flora and vegetation for the terrestrial component of the shore crossing site. Approximately 25 ha of re-clearing at Foundation Project horizontal directional drilling site and Feed Gas Pipeline RoW, to 332 ha for Foundation Project and Fourth Train Proposal. Stripping and stockpiling of topsoil	_	Extended duration of construction activities Extent of excavated area for the Fourth Train Proposal less than the Foundation Project	6	2	LOW	6	2	LOW	_
55	Terrestrial flora and vegetation communities	Creation of dust	Reduction in plant growth from deposition of dust on flora and vegetation	Vegetation clearing, earthworks, vehicle and machinery movements, concrete batching, stockpiling, pipeline trenching	LOW	Extension of footprint by approximately 10 ha Extended duration of construction activities	6	5	TRIVIAL	_	_	_	
56	Terrestrial flora and vegetation communities	Creation of dust	Reduction in plant growth from deposition of dust on flora and vegetation	Additional vehicle movements along unsealed roads	LOW	Extended duration of construction activities Small additional number of vehicle movements during operation	6	5	TRIVIAL	_	_	_	Many of the roads that will be used have been sealed and dust suppression is undertaken
57	Terrestrial flora and vegetation communities	Creation of heat and/or cold	Burning of vegetation around ground flare area	Additional use of ground flares during Fourth Train Proposal commissioning, start-up in the event of upset conditions	LOW	Additional use of ground flares during commissioning, start-up and in the event of an upset	5	6	TRIVIAL	_	_	_	Operation of the ground flare may potentially impact the vegetation from time to time, with potential for superheated air being pressed on to the surrounding environment during high wind speeds under emergency flaring conditions, however the probability of this occurring is low at approximately one to two times in lifetime of the Project

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Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change introduced by Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
58	Terrestrial flora and vegetation communities	Fire	Loss of native flora and alteration to vegetation community composition and/or reduction in topsoil quality and associated loss of seed bank	Accidental wildfire spreading into the surrounding vegetation due to hot works activities (e.g. welding, grinding) or machinery	MEDIUM	Extended duration of construction activities that have the potential to ignite fire	5	1	MEDIUM	5	1	MEDIUM	Fire events have been successfully managed
59	Terrestrial flora and vegetation communities	Introduction and/or spread of Non-indigenous Terrestrial Species	Spread of weeds on Barrow Island causing out-competition of native vegetation, a change in vegetation community structure or loss of restricted flora communities	Movement of vehicles, personnel and equipment to, from and around worksites; movement of topsoil to storage sites	LOW	Extended duration of construction activities during which increased movement of vehicles, personnel and equipment occurs	4	4	LOW	4	4	LOW	_
60	Terrestrial flora and vegetation communities	Introduction and/or spread of Non-indigenous Terrestrial Species	Death or out-competition of native flora resulting in change in community structure and/or species abundance	Import of rocks and/or stabilisation material from the mainland to be used for pipeline stabilisation as it approaches Barrow Island. Rocks and stabilisation material could harbour seeds and spores of Non-indigenous Terrestrial Species which could be blown onto, or float over to Barrow Island	_	Extended duration of construction activities during which rocks and/or stabilisation materials are imported	3	5	LOW	3	5	LOW	_
61	Terrestrial flora and vegetation communities	Introduction and/or spread of Non-indigenous Terrestrial Species	Death or out-competition of native flora resulting in change in community structure and/or species abundance	Carriage of seeds or spores of Non-indigenous Terrestrial Species on the topsides of vessels using the Materials Offloading Facility/WAPET Landing or contained within cargo	LOW	Extended duration of construction activities during which increased movement of vessels, personnel and equipment occurs	4	4	LOW	4	4	LOW	Best practice quarantine management; there have been no successful introductions to-date
62	Terrestrial flora and vegetation communities	Introduction and/or spread of Non-indigenous Terrestrial Species	Death or out-competition of native flora resulting in change in community structure and/or species abundance	Carriage of seeds or spores of Non-indigenous Terrestrial Species on the topsides of additional visiting LNG and condensate tankers	MEDIUM	Extended duration of construction activities during which increased movement of vessels, personnel and equipment occurs	4	3	MEDIUM	4	3	MEDIUM	_
63	Terrestrial flora and vegetation communities	Physical interaction	Loss of vegetation communities or conservation significant flora outside the Fourth Train Proposal Footprint	Vehicles driving off tenure	LOW	Additional vehicle and personnel movements during construction and operation	6	5	TRIVIAL	_	_	_	Off tenure areas will have access strictly limited. Therefore, likelihood of flora and vegetation communities being significantly damaged from vehicles driving off tenure is remote
64	Terrestrial flora and vegetation communities	Spills and leaks	Disturbance to coastal dune vegetation either from erosion or smothering of vegetation	Unplanned discharge of drill cuttings or fluids to the environment during construction - Frac-out from drilling activities onshore	LOW	Extended duration of construction phase	6	4	LOW	6	4	LOW	_
65	Terrestrial flora and vegetation communities	Spills and leaks	Spill to claypan environment causing impact to flora and vegetation communities	Spill or leak of hydrotest water, containing biocides and corrosion inhibitors, to the onshore environment	_	_	5	5	LOW	5	5	LOW	
66	Terrestrial flora and vegetation communities	Spills and leaks	Loss of vegetation and or reduced plant growth (Secondary impact from contamination of soils, surface water and/or groundwater)	During construction, accidental release of hydrocarbons, chemicals or construction-related wastes, refuelling of equipment, transfer and storage or fuels and waste	LOW	Extended duration of construction phase Extension of physical footprint within which this impact could occur by approximately 10 ha Construction work adjacent to operational Foundation Project	6	4	LOW	6	4	LOW	Assumed that there will be an operational waste transfer station (with adequate drainage) on Barrow Island in time for Fourth Train Proposal construction start

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							Incremental			Additional			
							C	L	R	C	L	R	
67	Terrestrial flora and vegetation communities	Spills and leaks	Loss of vegetation and or reduced plant growth (secondary impact from contamination of soils, surface water and/or groundwater)	Once operational, accidental release of hydrocarbons, chemicals or wastes from: # Transfer, storage, handling and use of additional fuel, chemicals and wastes # Failure of new plant equipment or pipelines # Failure of drainage system	**LOW**	Inventory of hazardous substances will increase by approximately 33% once operational	5	3	**LOW**	5	3	**LOW**	_
68	Terrestrial flora and vegetation communities	Unplanned CO_2 migration	Change in vegetation community composition	Unplanned CO_2 migration or release to the surface or near surface environment from deep faults within the Dupuy formation	**LOW**	Approximately 2% increase in the rate of injection of reservoir CO_2 into the Dupuy Formation to the approved Foundation Project	5	6	**TRIVIAL**	_	_	_	

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Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
Foreshore													
1	Foreshore	Vegetation Clearing and earthworks	Change in natural drainage pattern reducing sediment supply; loss of coastal dune vegetation	Site levelling or excavation activities at the horizontal directional drilling site	–	FTP will result in further vegetation clearing and earthworks (but this is inland of the foreshore area)	6	5	TRIVIAL	–	–	–	Activities are not anticipated to alter drainage patterns which could result in impacts to stability or integrity of the foreshore. Clearing of vegetation is inland of the foreshore area
2	Foreshore	Physical presence	Disturbance to existing vegetation and localised erosion of the dune	Laying of temporary water winning infrastructure across dune zone and intertidal area; placement of clump weights to secure pipeline	LOW	FTP will result in additional presence of infrastructure, but this will be temporary. The infrastructure will be removed at the end of construction activities	6	6	TRIVIAL	–	–	–	No change to dune vegetation is anticipated. Weight clumps will be placed to avoid any scattered dune vegetation encountered
3	Foreshore	Spills and leaks	Contamination of sediments above the high water mark affecting sediment quality (physical and chemical)	Rupture or leak of condensate from live Feed Gas Pipeline System e.g. from anchoring during shore crossing activities, or once the Feed Gas Pipeline System for the Fourth Train Proposal is operational	–	Additional leak or rupture source with the Feed Gas Pipeline System for the Fourth train Proposal in place	3	5	LOW	3	5	LOW	Rupture at close proximity has the potential to affect the foreshore if the spill or leak occurs under severe weather conditions or during spring tidal events. The nature of condensate indicates that it will be rapidly volatilised leaving little in the way of residue on the surface of the sediment
4	Foreshore	Spills and leaks	Contamination of sediments above the high water mark affecting sediment quality (physical and chemical)	Marine vessel collision or grounding during mobilisation of equipment, materials and supplies to Barrow Island during construction and operation (oil type: diesel or heavy fuel oil Marine vessel refuelling incident)	LOW	Increased likelihood of a spill or leak occurring with additional construction activities, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	3	5	LOW	3	5	LOW	Risk assessment assumes vessel grounding is close to Barrow Island. It is unlikely to affect foreshore (given its position above high water) unless under severe weather conditions and spring tides where spray may reach this area
5	Foreshore	Spills and leaks	Contamination of sediments above the high water mark affecting sediment quality (physical and chemical)	Condensate or LNG vessel grounding at the LNG Jetty (oil type: bunker fuel oil)	–	Additional source of a spill or leak with additional condensate and LNG vessel activity around Barrow Island	3	5	LOW	3	5	LOW	It is unlikely to affect foreshore (given its position above high water) unless under severe weather conditions and spring tides where spray may reach this area. However, medium ranking assigned due to the severity of the potential environmental consequence of sediment contamination if a bunker fuel oil spill did occur
6	Foreshore	Spills and leaks	Contamination of sediments above the high water mark affecting sediment quality (physical and chemical)	Condensate or LNG vessel grounding at the LNG Jetty (oil type: crude oil or condensate)	–	Additional LNG and condensate vessels frequenting the LNG Jetty on the east coast of Barrow Island	5	5	LOW	5	5	LOW	–
7	Foreshore	Spills and leaks	Impact on the integrity and stability of sediment above the high water mark (physical changes due to collapse of the drill hole and release of drill cuttings and fluids)	Frac-out (unplanned discharge) of drill cuttings or fluids from drilling activities	–	Additional source of a spill or leak affecting a new geographical area	5	6	TRIVIAL	–	–	–	Frac-out unlikely in the foreshore area due to the distance between the horizontal directional drilling and the surface of the foreshore (approximately 10 m)

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							Incremental			Additional			
							C	L	R	C	L	R	
	Marine benthic primary producer habitats												
8	Marine benthic primary producer habitats	Discharges to sea	Acute or chronic exposure to contaminants resulting in reduction in health status or death of BPPH	Marine vessel related discharges including discharge of treated sewage, greywater; brine; cooling water; putrescibles and deck drainage	MEDIUM	Additional frequency of discharge and additional loads of nutrients and chemicals to the marine environment. Additional areas potentially exposed to discharges	6	3	LOW	6	3	LOW	Dispersive nature of receiving environment and temporary and localised discharges are unlikely to affect BPPH above localised changes. MARPOL regulations prohibit putrescibles within State Water and sewage must be treated. There is limited BPPH in the shore crossing area as marine vessels will be beyond the pavement; dispersive nature of the marine environment will reduce concentration exposure
9	Marine benthic primary producer habitats	Discharges to sea	Smothering of benthic primary producer habitats off the west coast of Barrow Island	Planned loss of drilling fluids and cuttings into the coastal and nearshore environment from the horizontal directional drilling exit	MEDIUM	Additional drill cuttings and fluids released off the west coast of Barrow Island affecting a new geographical area of BPPH	6	4	LOW	6	4	LOW	There is limited benthic primary producer habitats in the shore crossing area to be impacted upon and therefore risk ranking for Fourth Train Proposal is reduced
10	Marine benthic primary producer habitats	Introduction and/or spread of Marine Pests	Loss of native benthic primary producer habitats, and/or a change in community structure due to competition from Marine Pests or parasites	Movement of vessels carrying Marine Pests on their wet-sides Discharge of ballast and bilge water from LNG and condensate vessels	MEDIUM	Increased number of vessels	4	3	MEDIUM	4	3	MEDIUM	During the operations phase - no operational control of vessels outside Port Limits which increases the risk from LNG and condensate vessels
11	Marine benthic primary producer habitats	Introduction and/or spread of Marine Pests	Loss of native benthic primary producer habitats, and/or a change in community structure due to competition from Marine Pests or parasites	Movement of vessels carrying Non-indigenous Terrestrial Species and/or Marine Pests on their wet-sides Discharge of ballast and bilge water from logistics vessels Mobilisation of vessels and equipment, vessel discharges including ballast and bilge water and possible installation of guidewires for the shore crossing site	LOW	Increased number of vessels	3	5	LOW	3	5	LOW	Best practice quarantine management; there have been no successful introductions to-date
12	Marine benthic primary producer habitats	Physical presence	Permanent loss and replacement of benthic primary producer habitat where pipeline and stabilisation material is laid Introduction of contaminants from infrastructure	Installation of, and permanent presence of, the Feed Gas Pipeline System Presence of barge accommodation and barge laydown	LOW	Additional infrastructure present on the west coast of Barrow Island. Additional infrastructure present on the east coast	5	5	LOW	5	5	LOW	Risk assessment assumes the impact is limited to where the pipeline system is laid. Stabilisation material is inert and not considered a contamination source. BPPH unlikely to be present on the east coast given the area longside the MOF and/WAPET landing will have been disturbed by Foundation Project construction activities
13	Marine benthic primary producer habitats	Seabed disturbance	Loss or degradation of benthic primary producer habitat in the contact area	Grooming of the seabed in preparation for the sinking of barge accommodation and barge laydown for Fourth Train Proposal construction Anchoring of floatel accommodation (option) during construction	–	Additional seabed area affected (however, magnitude and extent of area impacted will be less)	5	6	TRIVIAL	–	–	–	Area is within an area likely to be disturbed by Foundation Project construction activities, so unlikely to be in a natural state or to contain substantial BPPH

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Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
14	Marine benthic primary producer habitats	Seabed disturbance	Loss or degradation of benthic primary producer habitat during preparation for Feed Gas Pipeline System Smothering of benthic primary producer habitats from sediment settlements	Feed Gas Pipeline System preparation activities; pipe-lay activates and stabilisation activities	LOW TO MEDIUM	Additional geographical area affected with the preparation and pipe-lay activities	5	4	LOW	5	4	LOW	Horizontal directional drilling exit point is beyond the main limestone pavement which supports BPPH. This choice of technique has avoided the main area where BPPH is found. BPPH found beyond the pavement is limited and not considered extensive
15	Marine benthic primary producer habitats	Physical presence	Loss or degradation of benthic primary producer habitat over which the pipeline system is laid	Laying and long-term presence of the Feed Gas Pipeline System onto the seabed	LOW	Additional area of seabed affected (however, magnitude and extent of area impacted will be less)	5	3	LOW	5	3	LOW	_
16	Marine benthic primary producer habitats	Seabed disturbance	Loss or degradation of benthic primary producer habitat in the contact area	Anchoring of vessels, laying and stabilising pipe (up to approximately 400m beyond the shore crossing breakout points) directly on the seabed, accidental vessel grounding, use of dynamic positioning on vessels (thrusters), dropped objects, laying the initial water winning line and guidewires, span correction	LOW	Additional area impacted by anchoring off the west coast of Barrow Island	5	4	LOW	5	4	LOW	Horizontal directional drilling exit point is beyond the main limestone pavement which supports BPPH. This choice of technique has avoided the main area where BPPH is found. BPPH found beyond the pavement is limited and not considered extensive. Marine vessels will predominantly be operating beyond the pavement area, impact on BPPH will be cursorary. BPPH that do exist off North Whites Beach are naturally exposed to a high-energy turbid environment
17	Marine benthic primary producer habitats	Spills and leaks	Acute or chronic exposure to contaminants resulting in reduction in health status or death of BPPH	Unplanned spill of hydrocarbons or chemicals to the marine environment from the failure of storage, refuelling or handling equipment	LOW	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	6	3	LOW	6	3	LOW	_
18	Marine benthic primary producer habitats	Spills and leaks	Acute or chronic exposure to contaminants resulting in reduction in health status or death of BPPH	Rupture or leak of condensate from live Feed Gas Pipeline System e.g. from anchoring during shore crossing activities, or once the Feed Gas Pipeline System for the Fourth Train Proposal is operational	LOW TO MEDIUM	Additional source of a spill or leak from a rupture occurring when crossing over a live Foundation Project pipeline during construction or operation of the Fourth Train Proposal potentially affecting a new geographical area	3	5	LOW	3	5	LOW	Risk assessment based on worst case (spill or leak being lost close to shore - approximately 200 m west of Barrow Island) Risk assessment assumes volume of condensate lost is limited to the volume of the pipeline. Probability of the event occurring is considered very low. Condensate will rapidly volatise, reducing exposure risk. subtidal BPPH will to some degree be buffered by the water column
19	Marine benthic primary producer habitats	Spills and leaks	Acute or chronic exposure to contaminants resulting in reduction in health status or death Smothering of benthic primary producer habitats (e.g. scleractinian corals and other benthic primary producer habitats reliant on light)	Leak from Materials Offloading Facility during transportation (no storage)	_	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	4	4	LOW	4	4	LOW	Risk assessment based on the long term impacts on coastal habitats Risk assessment assumed the worst case of a spill during the marine turtle peak hatchling time

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							Incremental			Additional			
							C	L	R	C	L	R	
20	Marine benthic primary producer habitats	Spills and leaks	Metabolic impacts on inter-tidal and shallow and subtidal BPPH - physical smothering of BPPH resulting in a reduction in species abundance and/or taxon dominance	Marine vessel collision or grounding during mobilisation of equipment, materials and supplies to Barrow Island during construction. Condensate or LNG vessel grounding at the LNG Jetty; condensate; re-fuelling incident (oil types: diesel; crude oil or condensate)	LOW	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	5	3	LOW	5	3	LOW	Risk assessment based on release of bunker fuel oil as this generates the more severe consequences Limited inter-tidal corals / poorly developed BPPH communities on the east coast of Barrow Island. Any impact is expected to be short-term and at local to widespread scale
21	Marine benthic primary producer habitats	Spills and leaks	Metabolic impacts on intertidal and shallow tidal benthic primary producer habitats resulting in a reduction in species abundance and/or taxon dominance resulting	Condensate or LNG vessel grounding at the LNG Jetty (oil type: bunker fuel oil)	MEDIUM	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	3	4	MEDIUM	3	4	MEDIUM	
22	Marine benthic primary producer habitats	Spills and leaks	Physical impacts (smothering or abrasion) to benthic primary producer habitats; metabolic impacts due to energy reductions from reduced light penetration	Planned release of drill cuttings or fluids to the coastal and nearshore environment as a result of frac-out	LOW	Additional source of a spill or leak affecting a new geographical area	6	2	LOW	6	2	LOW	_
23	Marine benthic primary producer habitats	Spills and leaks	Metabolic impacts on inter-tidal and shallow and subtidal BPPH - physical smothering of BPPH resulting in a reduction in species abundance and/or taxon dominance	Condensate or LNG vessel grounding at the LNG Jetty (oil type: crude oil or condensate).	–	Additional source of a spill or leak potentially affecting a new geographical area	5	5	LOW	5	5	LOW	Condensate - highly volatile, so will evaporate rapidly into the atmosphere
	Marine fauna												
24	Marine fauna	Artificial light	Alter foraging and breeding activity in seabirds, fish and dolphins Disorientation of marine fauna such as birds Increased incidents of marine fauna interactions with vessels and equipment Creation of greater concentration of adaptable species leading to increased mortality of food source	Artificial light emissions from construction activities; logistic and support vessels associated with shore crossing site and pipe-lay preparation and laying activities by marine vessels	LOW	Additional construction activities on the west of Barrow Island at the horizontal directional drilling site requiring artificial light sources and navigational/security/work lighting on marine vessels involved in preparation and laying of the Feed Gas Pipeline System. New geographical area potentially affected	6	4	LOW	6	4	LOW	No long-term stationary sources of artificial light. Lighting sources on the west coast will be temporary and for the duration of construction only. Management actions from the Long-term Marine Turtle Management Plan will be applied during construction

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							C	L	R	C	L	R	
25	Marine fauna	Artificial light	Attraction of marine fauna such as seabirds, shorebirds, pelagic fish and sharks, resulting in: # increased incidents of interactions with vessels and equipment # greater concentration of adaptable species leading to increased mortality of food source # disorientation of certain marine bird species (e.g. localised populations of wedge-tailed shearwater)	Artificial lighting during construction activities at the shore crossing site (horizontal directional drilling site) and pipe-lay preparation and laying activities by marine vessels.	LOW	Additional construction activities on the west of Barrow Island at the horizontal directional drilling site requiring artificial light sources and navigational/security/work lighting on marine vessels involved in preparation and laying of the Feed Gas Pipeline System. New geographical area potentially affected	6	2	LOW	6	2	LOW	Activity should only be conducted over a short term period during construction. West coast is not considered to provide important habitat to non-breeding migratory birds, impacts are considered unlikely. Any foraging is likely to be during the day by individuals and as such impact from light is not foreseen
26	Marine fauna	Artificial light	Behavioural changes of marine turtles or hatchlings (disorientation; repulsion; attraction) leading to potential mortality from increased predation or reduced health. Attraction resulting in increased incidents of interactions with vessels and equipment and disruption to marine turtle nesting and hatchling survival	Artificial lighting during construction activities on west coast (horizontal directional drilling; pipelay) and east coast (gas treatment plant); and the operations phase (product loading associated lighting for condensate and LNG vessels).	LOW TO MEDIUM	Additional construction activities on the west of Barrow Island at the horizontal directional drilling site requiring artificial light sources and navigational/security/work lighting on marine vessels involved in preparation and laying of the Feed Gas Pipeline System. New geographical area potentially affected. additional marine vessels); additional construction lighting on east coast (Gas Treatment Plant); Additional LNG and condensate loading operations on LNG Jetty and on vessels. Artificial task lighting used for safe operation of the Materials Offloading Facility/WAPET Landing during construction and operation of the Fourth Train Proposal.	4	3	MEDIUM	4	2	MEDIUM	Risk ranking depends on seasonality (ranked on worst case season scenario) - Where practicable, work schedule for shore crossing activities to avoid peak turtle nesting season to reduce risk to Low. Scenario in Public Environmental Review (2008): confusion of turtle hatchling behaviour when primary wave front cue for swimming direction competes with light source offshore, if leaving the beach in the vicinity of the Materials Offloading Facility/loading jetty. If hatchlings swim towards the lights they may remain in the lit area increasing their risk of predation Actual shore crossing site is approximately 60 m inland of the high water mark. Turtles generally nest within the first 50 metres from high water
27	Marine fauna	Artificial light	Change in movement/behaviour of seabirds (potential attraction of shore birds (e.g. shearwaters) to flare)	Maintenance activities at the Gas Treatment Plant; additional flaring during commissioning and during non-routine operation	MEDIUM	Additional lighting sources adding to the light glow load experienced. Additional non-routine flaring required; additional light due to reflection off additional infrastructure	5	2	MEDIUM	5	2	MEDIUM	Tugs and pilots have had their lighting design in a specific way. No ability to regulate open-market vessels
28	Marine fauna	Artificial light	Disorientation of marine turtle hatchlings and associated increased mortality and predation	Installation activities in shallow water as it approaches Barrow Island North Whites Beach - artificial lighting from installation vessels	MEDIUM	Additional construction activities on the west of Barrow Island at the horizontal directional drilling site requiring artificial light sources and navigational/security/work lighting on marine vessels involved in preparation and laying of the Feed Gas Pipeline System. New geographical area potentially affected	5	2	MEDIUM	5	2	MEDIUM	_
29	Marine fauna	Artificial light	Hatchlings attracted to artificial lights and move towards these rather than the ocean leading to reduced survival rates	Gas treatment plant operation; Maintenance activities at the Gas Treatment Plant; additional flaring during commissioning and during non-routine operation	MEDIUM	Additional lighting sources adding to the light glow load experienced. Additional flaring required; additional light due to reflection off additional infrastructure	5	3	LOW	5	2	MEDIUM	_

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30	Marine fauna	Artificial light	Increased predation of marine fauna attracted to light spill (except marine turtles which are assessed separately given sensitivity)	Additional artificial lighting at the Gas Treatment Plant	LOW	Additional lighting sources adding to the light glow load experienced. Additional flaring required; additional light due to reflection off additional infrastructure	5	3	LOW	5	3	LOW	_
31	Marine fauna	Artificial light	Interruption to marine turtle nesting, breeding and mating, and interruption to juvenile foraging	Installation activities in shallow water as it approaches Barrow Island North Whites Beach - artificial lighting from installation vessels	LOW	Additional construction activities on the west of Barrow Island at the horizontal directional drilling site requiring artificial light sources and navigational/security/work lighting on marine vessels involved in preparation and laying of the Feed Gas Pipeline System. New geographical area potentially affected	6	2	LOW	6	2	LOW	Fourth Train Proposal not expected to add to the risks already assessed and approved for Foundation Project. Impact has been reduced to ALARP Fourth Train Proposal Feed Gas Pipeline System will likely follow a similar route alongside the Foundation Project's Feed Gas Pipeline Systems in State Waters
32	Marine fauna	Artificial light	Juvenile wedge-tailed shearwaters attracted to the lights of the gas treatment plant may be injured through collision with infrastructure	Gas treatment plant operation; Maintenance activities at the Gas Treatment Plant; additional flaring during commissioning and during non-routine operation	LOW	Additional lighting sources adding to the light glow load experienced. Additional flaring required; additional light due to reflection off additional infrastructure	6	3	LOW	6	2	LOW	_
33	Marine fauna	Artificial light	Out-competition of native shore birds/change in community structure in area affected by light spill - due to the attraction of non-native seabirds (e.g. silver gull) - attracted by insects etc around additional plant lighting	Gas treatment plant operation; Maintenance activities at the Gas Treatment Plant; additional flaring during commissioning and during non-routine operation	MEDIUM	Additional lighting sources adding to the light glow load experienced. Additional flaring required; additional light due to reflection off additional infrastructure	6	4	LOW	6	2	LOW	Light spill modelling to determine the extent to which the Fourth Train Proposal's operational lighting affects Foundation Project light spill
34	Marine fauna	Artificial light	Reduced turtle nesting by deterring female turtles from emerging onto the beach. Longer-term shift of flatback turtle nesting effort to adjacent beaches	Construction of fourth train at the Gas Treatment Plant	MEDIUM	Additional light sources during construction of fourth train adding to light glow experienced	4	3	MEDIUM	4	2	MEDIUM	Direct light spill onto the beach is not anticipated
35	Marine fauna	Artificial light	Reduced turtle nesting, by deterring females from emerging onto beach Longer-term shift of flatback turtle nesting effort to adjacent beaches	Operation of the Materials Offloading Facility/WAPET Landing during construction and operation of the Fourth Train Proposal Artificial lighting on marine vessels (and their tugs/pilot vessels) coming to and from the Materials Offloading Facility/WAPET Landing	MEDIUM	Additional artificial task lighting used for safe operation of MOF/WAPET and LNG Jetty; increased frequency of artificial light experienced from logistic related marine vessels coming to and from the Port Authority Area	5	3	LOW	5	3	LOW	Foundation Project risk took into account construction works and dredging activities off East Coast. for Fourth Train Proposal, additional lighting restricted to additional vessels and Materials Offloading Facility/WAPET Landing Notes in Public Environmental Review (2008): Turtles observed approaching beaches to nest both north and south of Town Point on the same night
36	Marine fauna	Artificial light	Reduced turtle nesting, by deterring females from emerging onto beach Longer-term shift of Flatback turtle nesting effort to less suitable beaches adjacent	Operation of Fourth Train at Gas Treatment Plant	MEDIUM	Additional lighting from operation of gas treatment plant; maintenance lighting activities; additional flaring; reflection from additional infrastructure	5	3	LOW	5	2	MEDIUM	_

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							C	L	R	C	L	R	
37	Marine fauna	Artificial light	Reduction in local population viability of native seabirds (e.g. terns) due to attraction of more adaptable species (e.g. silver gulls) to insects, fish, turtle hatchlings etc to areas of light spill	Additional duration and frequency of lighting on Jetty for safe docking and loading of LNG and condensate produced by Fourth train Lighting on additional LNG and condensate vessels and their tugs/pilot vessels	MEDIUM	Additional lighting	5	2	MEDIUM	5	2	MEDIUM	Potential to reduce local population viability of seabirds (terns etc.). Nesting success goes through natural boom and bust cycles. Residual risk for Foundation Project assumes a monitoring program of the silver gull population The Foundation Project risk took into account construction works and dredging activities off East Coast
38	Marine fauna	Artificial light	Reduction in local population viability of native seabirds (e.g. terns) due to attraction of more adaptable species (e.g. silver gulls) to insects, fish, turtle hatchlings etc to areas of light spill	Artificial task lighting used for safe operation of the Materials Offloading Facility/WAPET Landing during construction and operation of the Fourth Train Proposal Artificial lighting on vessels coming to and from the Materials Offloading Facility/WAPET Landing	MEDIUM	Additional lighting	5	2	MEDIUM	5	2	MEDIUM	Potential to reduce local population viability of seabirds (terns etc.). Nesting success goes through natural boom and bust cycles. Residual risk for Foundation Project assumes a monitoring program of the silver gull population The Foundation Project risk took into account construction works and dredging activities off East Coast
39	Marine fauna	Atmospheric emissions (except dust)	Impacts to species abundance or changes to community composition of marine fauna including dolphins, turtles, birds etc from: # Acid deposition or bioaccumulation of dioxins and metals resulting from atmospheric emissions	Commissioning and start-up emissions (flaring etc) Additional operational process and ship loading emissions Emissions associated with small additional workforce and their transport	LOW	Additional emissions (but will be only approximately a third of that predicted for the Foundation Project)	6	6	TRIVIAL	–	–	–	Most species are transient and only spending a small amount of time near the Gas Treatment Plant
40	Marine fauna	Atmospheric emissions (except dust)	Inhalation of atmospheric emissions by marine fauna including dolphins, turtles, birds etc, resulting in a decline in species abundance or change to community composition	Commissioning and start-up emissions (flaring etc) Additional operational process and ship loading emissions Emissions associated with small additional workforce and their transport	LOW	Additional emissions (but will be only approximately a third of that predicted for the Foundation Project)	6	6	TRIVIAL	–	–	–	–
41	Marine fauna	Creation of heat and/or cold	Behavioural changes to Marine fauna in area affected by discharges leading to potential mortality	Discharge of cooling water from pipe-lay and support vessels	LOW	New geographical areas affected. Increase in the overall volume of discharged cooling water	6	6	TRIVIAL	–	–	–	Relatively small quantity of cooling water discharged to highly dispersive marine environment. Impacts not anticipated
42	Marine fauna	Discharges to sea	Increase in turbidity of water column resulting in adverse impacts to marine life (disorientation of turtles and blockage of fish gills leading to asphyxia and death)	Planned loss of drilling fluids and cuttings to the marine environment at the exit point of the shore crossing site	MEDIUM	Small increase in volume of discharges released	6	4	LOW	6	4	LOW	There is limited BPPH in the shore crossing area Assume that vessel activities could be occurring over a full annual cycle (not restricted to a non-marine fauna sensitive time period)

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							C	L	R	C	L	R	
43	Marine fauna	Discharges to sea	Metabolic impacts on marine fauna, with consequent impacts on species abundance and/or community structure as a result of the introduction of additional nutrients, chemicals or pathogens	Discharge of deck drainage, deck wash, ballast water (from module carriers), treated sewage and putrescibles wastes to the marine environment from vessels approaching or at berth at Materials Offloading Facility/WAPET Landing	LOW	Additional frequency of discharge and additional loads of nutrients and chemicals to the marine environment. Additional areas potentially exposed to discharges	6	4	LOW	6	3	LOW	_
44	Marine fauna	Discharges to sea	Metabolic impacts on marine fauna, with consequent impacts on species abundance and/or community structure as a result of the introduction of additional nutrients, chemicals or pathogens	Discharge of cooling water, stormwater, deck drainage, ballast water, brine from desalination and grey-water from additional LNG and condensate vessels	LOW	Additional frequency of discharge and additional loads of nutrients and chemicals to the marine environment. Additional areas potentially exposed to discharges	6	3	LOW	6	3	LOW	_
45	Marine fauna	Discharges to sea	Reduction in water quality with consequent health effects on marine organisms and their communities	Discharge of small volumes of hydrotest fluids from umbilical casing near Barrow Island	_	Additional frequency of discharge and additional loads of nutrients and chemicals to the marine environment. Additional areas potentially exposed to discharges	6	3	LOW	6	3	LOW	Impact will be localised with concentration returning to no-effect concentration within a few hours
46	Marine fauna	Discharges to sea	Reduction in water quality with consequent health effects on marine organisms and their communities	Discharge of treated sewage, greywater and putrescibles wastes	LOW	Additional frequency of discharge and additional loads of nutrients and chemicals to the marine environment. Additional areas potentially exposed to discharges	5	5	LOW	5	5	LOW	Consequence assumes pollution of water column is localised
47	Marine fauna	Discharges to sea	Reduction in water quality with consequent health effects on marine organisms and their communities	Discharge of deck drainage and from equipment and machinery	LOW	Additional frequency of discharge and additional loads of nutrients and chemicals to the marine environment. Additional areas potentially exposed to discharges	5	5	LOW	5	5	LOW	_
48	Marine fauna	Discharges to sea	Reduction in water quality with consequent health effects on marine organisms and their communities	Planned discharge of potentially contaminated water to the marine environment from: # deck washing, # cooling water disposal # treated sewage or putrescibles wastes	MEDIUM	Additional frequency of discharge and additional loads of nutrients and chemicals to the marine environment. Additional areas potentially exposed to discharges	6	3	LOW	6	3	LOW	_
49	Marine fauna	Noise and vibration	Change in behaviour of mating and foraging adult and juvenile marine turtles	Marine vessel activities pertaining to Feed Gas Pipeline System installation	MEDIUM	Additional construction activities off the west coast of Barrow Island	5	3	LOW	5	3	LOW	Evidence from the Foundation Project (approximately 2 years of monitoring data) has not shown impacts to turtles and
50	Marine fauna	Noise and vibration	Disturbance and change in behaviour/disorientation of fauna, including listed species such as dolphins, dugong, turtles (including hatchlings) and whales, due to underwater noise and vibration	Noise and vibration generated by additional condensate and LNG vessels	LOW	Increased frequency of noise and vibration generated by condensate and LNG vessels	5	3	LOW	5	3	LOW	_
51	Marine fauna	Noise and vibration	Disturbance to marine fauna including localised avoidance of area	Marine Vessel movements; helicopter transfers	LOW	Additional construction activities off the west coast of Barrow Island	5	3	LOW	5	3	LOW	_
52	Marine fauna	Noise and vibration	Disturbance to nesting turtles and/or turtle egg development reducing overall breeding success	Operation of the fourth train at the Gas Treatment Plant	_	Additional noise generated from Gas Treatment Plant	5	3	LOW	5	3	LOW	_
53	Marine fauna	Noise and vibration	Disturbance to nesting turtles and/or turtle egg development reducing overall breeding success.	Earthworks, vehicle movements and operation of machinery and equipment Cutting and grinding	_	Additional construction activities on the east coast of Barrow Island with construction of fourth train	6	3	LOW	6	3	LOW	vibration monitoring data suggests that sand is a poor conductor and vibration is unlikely to increase in the foreshore areas were nesting occurs

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							C	L	R	C	L	R	
54	Marine fauna	Noise and vibration	Localised disturbance and change in behaviour/disorientation of listed fauna (dolphins, dugong, turtles - including hatchlings and whales) due to underwater noise and vibration	Noise and vibration generated by vessel movements (engines and positioning systems) to/from Materials Offloading Facility/WAPET Landing and from engines and equipment activities on the Materials Offloading Facility/WAPET Landing	LOW	_	5	3	LOW	5	3	LOW	_
55	Marine fauna	Noise and vibration	Masking of biologically important sounds Disturbance to normal behaviour resulting in possible displacement from affected area Temporary or permanent reductions in hearing sensitivity	Vessel engines, especially if using dynamic positioning Helicopter transfers	LOW	Additional construction activities off the west coast of Barrow Island	6	3	LOW	6	3	LOW	_
56	Marine fauna	Physical interaction	Fauna injury or fatality from boat strike, entrapment or entrainment; behavioural changes in fauna such as area avoidance	Feed Gas Pipeline System preparation activities; pipe-lay activates and stabilisation activities, marine vessels movement and positioning	MEDIUM	Additional construction activities on the east and west coast of Barrow Island and marine vessels operating in the area	6	2	MEDIUM	6	2	LOW	Fourth Train Proposal Incremental Residual Risk is based on the worst case scenario, being a barge with support vessels (as barges requires more support vessels) Fourth Train Proposal Residual Risk Assessment assumes low numbers of vessels and slow-moving vessels Likelihood risk ranking based on a higher density of turtles
57	Marine fauna	Physical interaction	Injury to or mortality of marine fauna resulting from anchoring	Anchoring of pipelay and support vessels in anchor spread	LOW	Additional construction activities on the west coast of Barrow Island and marine vessels operating in the area	6	6	TRIVIAL	_	_	–	_
58	Marine fauna	Physical interaction	Injury to or mortality of marine fauna resulting from entrainment	Feed Gas Pipeline System preparation activities; pipe-lay activates and stabilisation activities - marine vessel movement and positioning	MEDIUM	Additional construction activities on the west coast of Barrow Island and marine vessels operating in the area	6	4	MEDIUM	6	4	LOW	Fourth Train Proposal Residual Risk Assessment assumes low numbers of vessels and slow-moving vessels
59	Marine fauna	Physical interaction	Reduced turtle nesting, by deterring females from emerging onto beach Trampling of marine turtle nests Recreational and malicious interference causing fauna injury or fatality	Recreational activities of construction and operational workforce Uncontrolled personnel interaction with fauna	LOW	Additional construction workers present on Barrow Island	6	4	LOW	6	4	LOW	Access to beach areas is restricted. Ranking is based on greater workforce numbers during construction
60	Marine fauna	Physical interaction	Vessel collision with marine fauna, including listed species, resulting in injury or death	Movement of additional LNG and condensate vessels and associated pilot and tug boats during operations	MEDIUM	Additional condensate and LNG vessels frequenting the east coast of Barrow Island	5	2	MEDIUM	5	2	MEDIUM	_
61	Marine fauna	Physical interaction	Vessel collision with marine fauna, including listed species, resulting in injury or death	Movement of vessels to and from Materials Offloading Facility/WAPET Landing during operations	MEDIUM	Additional logistics vessel movements	5	2	MEDIUM	5	2	MEDIUM	_

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							C	L	R	C	L	R	
62	Marine fauna	Physical interaction	Disturbance of sea bird nests or foraging birds; nesting marine turtles	Workforce walking on beach	–	Additional personnel present on Barrow Island	6	5	TRIVIAL	–	–	TRIVIAL	Access to intertidal and foreshore areas will be strictly controlled Nuisance disturbance to avifauna is not anticipated
63	Marine fauna	Physical presence	Displacement or attraction of marine fauna	Long-term presence of the Feed Gas Pipeline System on the seabed creating a new habitat for fauna	LOW	Additional infrastructure present on the west coast of Barrow Island (Feed Gas Pipeline System)	6	3	LOW	6	3	LOW	–
64	Marine fauna	Seabed disturbance	Increase in turbidity of water column resulting in adverse impacts to marine life (disorientation of marina fauna and/or blockage of fish gills)	Trenching for Feed Gas Pipeline System installation	LOW	Additional construction activities on the west coast of Barrow Island and marine vessels operating in the area	5	4	LOW	5	4	LOW	–
65	Marine fauna	Seabed disturbance	Increase in turbidity of water column resulting in adverse impacts to marine life (disorientation of marina fauna and/or blockage of fish gills)	Thruster wash (use of dynamic positioning on vessels during Feed Gas Pipeline System installation)	LOW	Additional construction activities on the west coast of Barrow Island and marine vessels operating in the area	6	5	TRIVIAL	–	–	–	–
66	Marine fauna	Seabed disturbance	Permanent physical loss of seabed habitat over which rocks are installed leading to marine fauna fatalities and/or a change in population densities or distribution Increase in turbidity of water column resulting in adverse impacts to marine life	Rock Installation for Feed Gas Pipeline System stabilisation	LOW	–	5	4	LOW	5	4	LOW	–
67	Marine fauna	Spills and leaks	Acute/chronic toxic effects on marine fauna and oiling of birds	Rupture or leak of condensate from live Feed Gas Pipeline System e.g. from anchoring during shore crossing activities, or once the Feed Gas Pipeline System for the Fourth Train Proposal is operational	MEDIUM	Additional source of a spill or leak from a rupture occurring when crossing over a live Foundation Project pipeline during construction or operation of the Fourth Train Proposal	2	5	MEDIUM	2	5	MEDIUM	–
68	Marine fauna	Spills and leaks	Acute/chronic toxic effects on marine fauna and oiling of birds	Release of MEG	LOW	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	5	5	TRIVIAL	–	–	–	MEG is classified under the CEFAS OCNS system as a PLONOR chemical (i.e. it Poses Little Or No Risk to the Marine Environment). The release of MEG in mall quantities is not expected to result in any discernible adverse impact within the marine environment
69	Marine fauna	Spills and leaks	Change in species abundance and/or in population age structure of mobile fauna (e.g. turtle hatchlings and adults) and/or foraging shore-birds resulting from contact with a hydrocarbon or chemical spill. Acute/chronic toxic effects on marine fauna and oiling of birds	Marine vessel collision or grounding during mobilisation of equipment, materials and supplies to Barrow Island during construction. Condensate or LNG vessel grounding at the LNG Jetty; condensate; re-fuelling incident (oil types: diesel; crude oil or condensate)	LOW	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	4	4	LOW	4	4	LOW	–

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							C	L	R	C	L	R	
70	Marine fauna	Spills and leaks	Change in species abundance and/or in population age structure of mobile fauna (e.g. turtle hatchlings and adults) and/or foraging shore-birds resulting from contact with a hydrocarbon or chemical spill	Marine vessel collision or grounding during mobilisation of equipment, materials and supplies to Barrow Island during construction. Condensate or LNG vessel grounding at the LNG Jetty; condensate; re-fuelling incident (oil types: diesel; crude oil or condensate)	MEDIUM	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	2	4	MEDIUM	2	4	MEDIUM	_
71	Marine Fauna	Spills and leaks	Creation of small 'mud pools' which could destroy turtle nests	Frac-out (unplanned discharge) of drill cuttings or fluids from drilling activities	LOW	Additional source of a spill or leak affecting a new geographical area	6	2	LOW	6	2	LOW	_
72	Marine Fauna	Spills and leaks	Degradation or loss of benthic species due to acute or chronic toxicity	Leak from Materials Offloading Facility during transportation (no storage)	_	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	4	4	LOW	4	4	LOW	_
73	Marine fauna	Spills and leaks	Physical (smothering/coating) or chemical (lethal or sublethal) effects to marine fauna resulting in reduced health or mortality	Unplanned spill of hydrocarbons or chemicals to the marine environment from the failure of storage, refuelling or handling equipment	LOW	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	6	3	LOW	6	3	LOW	_
74	Marine fauna	Spills and leaks	Physical (smothering/coating) or chemical (lethal or sublethal) effects to marine fauna resulting in reduced health or mortality	Frac-out (unplanned discharge) of drill cuttings or fluids from drilling activities	LOW	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	6	4	LOW	6	4	LOW	_
75	Marine fauna	Spills and leaks	Injury to or mortality of marine fauna from ingestion or entanglement	Accidental disposal of wastes and hazardous materials to sea	LOW	Small increase in volume of discharges released	6	4	LOW	6	4	LOW	_
76	Marine fauna	Spills and leaks	Metabolic impacts on intertidal and shallow tidal fauna habitats	Marine vessel collision or grounding during mobilisation of equipment, materials and supplies to Barrow Island during construction. Condensate or LNG vessel grounding at the LNG Jetty; condensate; re-fuelling incident (oil types: diesel; crude oil or condensate)	MEDIUM	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	3	4	MEDIUM	3	4	MEDIUM	_
77	Marine fauna	Spills and leaks	Reduction in oxygen within the water column and/or mortality of fauna in contact with spilled biocide	Unplanned spill of hydrotest water, containing oxygen scavenger and biocide into marine environment	LOW	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	5	5	LOW	5	5	LOW	Consequence of reduction in oxygen within the water column is assumed to be highly localised with re-equilibrium rapid
78	Marine fauna	Spills and leaks	Physical (smothering/coating) or chemical (lethal or sublethal) effects to marine fauna resulting in reduced health or mortality	Unplanned spill of hydrocarbons or chemicals to the marine environment from a vessel grounding	LOW	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	5	4	LOW	5	4	LOW	_
79	Marine fauna	Spills and leaks	Physical (smothering/coating) or chemical (lethal or sublethal) effects to marine fauna resulting in reduced health or mortality	Rupture or leak of condensate from live Feed Gas Pipeline System e.g. from anchoring during shore crossing activities, or once the Feed Gas Pipeline System for the Fourth Train Proposal is operational	_	Additional source of a spill or leak from a rupture occurring when crossing over a live Foundation Project pipeline during construction or operation of the Fourth Train Proposal	3	5	LOW	3	5	LOW	_
80	Marine fauna	Vegetation clearing and earthworks	Disturbance or displacement of shorebirds feeding, roosting and nesting sites on the beach and rocky reef platform	Laying the contingency water winning line and guidewires, span correction etc	LOW	New geographical areas affected (the shore crossing site for the Fourth Train Proposal is closer to whites beach than for the Foundation Project)	5	4	LOW	5	4	LOW	Consequence of disturbance to seabirds is assumed to be localised

Consolidated Risk Assessment Results: Impacts to the Coastal and Nearshore Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact: Incremental C	Incremental L	Incremental R	Additional C	Additional L	Additional R	Comments
	Marine Water Quality												
81	Marine water quality	Atmospheric emissions (except dust)	Accumulation of dioxins and metals in marine waters Acidification of marine waters from the deposition of SO_2, NO_2, O_3	Commissioning and start-up emissions (flaring etc) Additional operational process and ship loading emissions Emissions associated with small additional workforce and their transport	LOW	Additional emissions - dioxins and metals and SO_2; NO_2; O_3 (but will be only approximately a third of that predicted for the Foundation Project)	6	5	TRIVIAL	–	–	–	Emission concentrations are not anticipated to impact water chemistry equilibriums. Emissions are order of magnitude less than ANZECC guidelines for 99% marine species protection
82	Marine water quality	Creation of heat and/or cold	Reduction in water quality from a change in water temperature	Discharge of cooling water from vessels	–	New and additional geographical areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	5	TRIVIAL	–	–	–	Relatively small quantity of cooling water discharged to highly dispersive marine environment. Potential impacts highly localised and transient. No impact on stratified water column anticipated
83	Marine water quality	Discharges to sea	Reduction in water quality due to the introduction of nutrients and contaminants; and change in water temperature and salinity levels	Discharge of cooling water, stormwater and deck drainage, ballast water brine from desalination and grey-water from marine vessels during construction and LNG and condensate vessels during the operations phase	LOW	Additional frequency of discharge and additional loads of nutrients and chemicals to the marine environment. Additional areas potentially exposed to discharges	6	4	LOW	6	4	LOW	Small quantities discharged to a highly dispersive marine environment. Potential impacts are likely to be highly localised. Impact to wider water quality parameters not expected. Sewage must be treated if discharged within 3 nm and release of putrescibles is prohibited within 12 nm
84	Marine water quality	Discharges to sea	Reduction in water quality parameters with the introduction of chemical contaminants	Testing of the Feed Gas Pipeline System and infrastructure at gas treatment plant releasing hydrotest water	–	Additional hydrotest water from testing of the Gas Feed Pipeline System; and LNG Tank	6	2	LOW	6	2	LOW	Risk assessed based on ocean outfall (i.e. worst case) Hydrotest water may be saline but no chemicals added If, discharged to sea, may result in some discolouration of water, a possible small increase in water temperature due to warming of water while in the tank (not expected to be > 3 °C) and small particulates being discharged Only expected to occur once - will be volume of the LNG tank

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Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
85	Marine water quality	Discharges to sea	Reduction in water quality parameters with the introduction of suspended sediment	Planned loss of drilling fluids and cuttings to the marine environment at the exit point of the shore crossing site	–	Additional drill cuttings and fluids released off the west coast of Barrow Island affecting a new geographical area of BPPH	5	1	MEDIUM	5	1	MEDIUM	Based on GFP HDD dispersal modelling, 90% of material discharged at the exist point is coarse sand which was modelled to readily settle and remain close to the seabed, having a very localised and short-term impact (<24 hours) on water quality parameters. The volume discharged is also half of that discharged during the GFP campaign so will further reduce the anticipated geographical extent of impact when compared to the modelled GFP HDD discharge
86	Marine water quality	Discharges to sea	Changes to water quality parameters, in particular pH, temperature and chemical toxicity	Discharge of brine from the temporary reverse osmosis facility (or similar) on the east coast of Barrow Island during Fourth Train Proposal construction and the operations phase	MEDIUM	Extended duration of operation of the temporary reverse osmosis (or similar) facility for construction of the Fourth Train Proposal	5	2	MEDIUM	5	2	MEDIUM	40 fold dilution factor is predicted to still be achieved within the Zone of High Impact (with 75 m either side of the Materials Offloading Facility). Modelling has predicted that salinity concentrations will remain within natural range
87	Marine water quality	Dust	Reduction in water quality	Generation of dust during concrete coating blown into water	–	–	6	5	TRIVIAL	–	–	–	The likelihood of this impact resulting in a discernible impact on marine water quality is considered remote, given the high-energy nature of the ocean off the west coast of Barrow Island
88	Marine water quality	Seabed disturbance	Reduction in water quality due to increased suspended sediment load in water column	Pre- and post- pipe lay activities (i.e. trenching, jetting, ploughing, rock stabilisation etc); horizontal directional drilling exit point breakout on the west coast; seabed preparation activities required for the laydown of barge accommodation and barge laydown on the east coast of Barrow Island	LOW	Additional construction activities and subsequently seabed disturbance on the west coast from Feed Gas Pipeline System preparation and installation New source of seabed disturbance off east coast due to seabed preparation for the barge accommodation and laydown	6	4	LOW	6	4	LOW	Impact could occur in Commonwealth Marine Area or closer to shore (e.g. for stabilisation of shore-end of the Feed Gas Pipeline System) Turbidity levels expected to return to normal soon after completion of work (impact is expected to be temporary and localised)
89	Marine water quality	Spills and leaks	Reduction in water quality and exceedance of ANZECC/ARMCANZ marine water quality guidelines	Product loading incident at the LNG Export Jetty (oil type: condensate)	–	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	5	3	LOW	5	3	LOW	–
90	Marine water quality	Spills and leaks	Reduction in water quality and exceedance of ANZECC/ARMCANZ marine water quality guidelines	Leak from Materials Offloading Facility during transportation (no storage)	–	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	5	3	LOW	5	3	LOW	–
91	Marine water quality	Spills and leaks	Reduction in water quality and exceedance of ANZECC/ARMCANZ marine water quality guidelines	Release of diesel or heavy fuel oil during vessel refuelling (small volume of spill) or from accidental damage to vessel	LOW	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	5	3	LOW	5	3	LOW	–

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Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
92	Marine water quality	Spills and leaks	Reduction in water quality and exceedance of ANZECC/ARMCANZ marine water quality guidelines	Release of MEG	LOW	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	5	5	TRIVIAL	_	_	_	MEG is classified under the CEFAS OCNS system as a PLONOR chemical (i.e. it Poses Little Or No Risk to the Marine Environment). The release of MEG in small quantities is not expected to result in any discernible adverse impact within the marine environment
93	Marine water quality	Spills and leaks	Reduction in water quality parameters with the introduction of dissolved aromatics; physical surface slicks or entrained oil components	Rupture or leak of condensate from live Feed Gas Pipeline System e.g. from anchoring during shore crossing activities, or once the Feed Gas Pipeline System for the Fourth Train Proposal is operational	_	Additional source of a spill or leak from a rupture occurring when crossing over a live Foundation Project Feed Gas Pipeline System during construction or operation of the Fourth Train Proposal	2	6	LOW	2	6	LOW	Risk assessment based on worst case scenario being a hydrocarbon spill (not a MEG spill) Fourth Train Proposal's Feed Gas Pipeline System will need to cross a number of live pipelines, including the Gorgon and Jansz Feed Gas Pipeline Systems
94	Marine water quality	Spills and leaks	Reduction in water quality and exceedance of ANZECC/ARMCANZ marine water quality guidelines	Unplanned spill of hydrocarbons or chemicals to the marine environment from the failure of storage, refuelling or handling equipment	LOW	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	6	3	LOW	6	3	LOW	_
95	Marine water quality	Spills and leaks	Reduction in water quality and exceedance of ANZECC/ARMCANZ marine water quality guidelines	Grounding of a marine vessel during mobilising equipment, materials and supplies to Barrow Island during construction and operation (oil type: diesel); Re-fuelling incident at the Materials Offloading Facility/WAPET Landing (oil type: diesel); Rupture of supply lines on Materials Offloading Facility/WAPET Landing (oil type: condensate)	LOW	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	6	4	LOW	6	4	LOW	_
96	Marine water quality	Spills and leaks	Reduction in water quality and exceedance of ANZECC/ARMCANZ marine water quality guidelines	Condensate or LNG vessel grounding at the LNG Jetty (oil type: bunker fuel oil)	_	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	3	6	LOW	3	6	LOW	Probability of an event occurring is very low (RPS 2012). Modelling assumed not reactive response. A response plan will be developed as part of the project
	Seabed												
97	Seabed	Discharges to sea	Change in seabed profile and changes to physio-chemical sediment characteristics	Loss of drilling fluids and cuttings to the marine environment at the exit point of the horizontal directional drilling	MEDIUM	Additional drill cuttings and fluids in addition to that already discharged to the marine environment by the Foundation Project. Volume is anticipated to be half of that discharged by the Foundation Project New area of seabed being affected south of the marine exit point for the Foundation Project's shore crossings. However no different site conditions anticipated	6	1	MEDIUM	6	1	MEDIUM	Nearly 90% of these cuttings are expected to range from coarse gravel to coarse sand, which will settle and accumulate on the seabed close to the discharged point
98	Seabed	Discharges to sea	Change in seabed profile and changes to physio-chemical sediment characteristics	Discharge of deck drainage, treated sewage and cooling water from LNG and condensate vessels during operations phase	_	Additional frequency of discharge and additional loads of nutrients and chemicals to the marine environment	6	5	TRIVIAL	_	_	_	highly dissipative environment; discharges considered unlikely to impact seabed

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Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
99	Seabed	Physical presence	Permanent loss and replacement of seabed with an artificial substrate (pipeline and stabilisation material) off west coast of Barrow Island. potential creation of barrier to sediment transportation process Change in seabed profile from preparation activities associated with Barge accommodation laydown	Permanent presence of the Feed Gas Pipeline System and stabilisation material Presence of barge accommodation and barge laydown	**LOW**	Additional permanent infrastructure present on the west coast of Barrow Island and temporary infrastructure on the east coast of Barrow Island	5	5	**LOW**	5	5	**LOW**	Risk assessment assumes the impact is limited to where the pipeline system is laid. Barge accommodation will be short-term: for construction only, with infrastructure removed. Low profile of the Gas Feed Pipeline System will not impede sediment transport
100	Seabed	Seabed disturbance	Abrasion of seabed and/or change in seabed profile (e.g. anchor scars; depressions)	Anchoring of vessels, laying and stabilising pipe (up to approximately 400m beyond the shore crossing exit points) directly on the seabed, accidental vessel grounding, use of dynamic positioning on vessels (thrusters), laying the initial water winning line and guidewires, span correction, seabed preparation for barge accommodation and barge laydown on east coast	**LOW TO MEDIUM**	Additional construction activities off west coast resulting in extension of seabed disturbance period. New area of seabed disturbed as part of the Feed Gas Pipeline System construction. Seabed reprofiling on the east coast of Barrow Island	6	2	**LOW**	6	2	**LOW**	Risk assessment is based on worst case (anchoring rather than dynamic positioning). Anchoring will be highly localised and within close proximity to the Feed Gas Pipeline system. Seabed reprofiling on the east coast is within an area already disturbed by Foundation Project activities and is unlikely to be in its natural state
101	Seabed	Spills and leaks	Physical and/or chemical contamination of seabed sediments	Grounding of a marine vessel during mobilising equipment, materials and supplies to Barrow Island during construction and operation (oil type: diesel); Re-fuelling incident at the Materials Offloading Facility/WAPET Landing (oil type: diesel); Rupture of supply lines on Materials Offloading Facility/WAPET Landing (oil type: condensate)	**LOW**	Increased likelihood of a spill or leak occurring due to increase in number of marine vessels operating in the vicinity of Barrow Island. An additional geographical area has the potential to be affected	6	3	**LOW**	6	3	**LOW**	Probability of a spill occurring is considered very low (RPS 2012). Modelling completed assumed 'no intervention', in practice reactive controls will be in place
102	Seabed	Spills and leaks	Physical and/or chemical contamination of seabed sediments	Release of tributyltin paint from LNG and condensate vessel hulls into water column and contamination of seabed sediments	**LOW**	Additional LNG and condensate vessels frequenting Barrow Island Port Area	5	5	**LOW**	5	5	**LOW**	tributyltin ban in place, any tributyltin present is likely to be historical
103	Seabed	Spills and leaks	Physical and/or chemical contamination of seabed sediments	Accidental damage to vessel or refuelling incident as part of the Feed Gas Pipeline System construction (oil type: diesel or heavy fuel)	**LOW**	Increased likelihood of a spill or leak occurring, affecting an additional geographical area	5	4	**LOW**	5	4	**LOW**	Probability of a spill occurring is considered very low (RPS 2012). Modelling completed assumed 'no intervention', in practice reactive controls will be in place
104	Seabed	Spills and leaks	Physical and/or chemical contamination of seabed sediments	Rupture or leak of condensate from live Feed Gas Pipeline System e.g. from anchoring during shore crossing activities, or once the Feed Gas Pipeline System for the Fourth Train Proposal is operational	**LOW**	Additional source of a spill or leak from a rupture occurring when crossing over a live Foundation Project pipeline during construction or operation of the Fourth Train Proposal	2	6	**LOW**	2	6	**LOW**	Area of potential impact localised (supported by modelling results) due to rapid degradation of condensate. Mitigation measures in place mean only a remote chance of incident occurring

Consolidated Risk Assessment Results: Impacts to the Coastal and Nearshore Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
105	Seabed	Spills and leaks	Physical and/or chemical contamination of seabed sediments	Condensate or LNG vessel grounding at the LNG Jetty (oil type: bunker fuel oil)	–	Increased likelihood of a spill or leak occurring, however, consequence is not expected to be greater for the Fourth Train Proposal than for the Foundation Project	5	2	MEDIUM	5	2	MEDIUM	Probability of a spill occurring is considered very low (RPS 2012) although the consequence to the seabed is considered severe. Modelling completed assumed 'no intervention', in practice reactive controls will be in place
106	Seabed	Spills and leaks	Physical and/or chemical contamination of seabed sediments	Condensate or LNG vessel grounding at the LNG Jetty (oil type: crude oil or condensate)	–	Additional source of a spill or leak. Increase in the likelihood of a spill or leak affecting the foreshore	5	5	LOW	5	5	LOW	Probability of a spill occurring is considered very low (RPS 2012). Modelling completed assumed 'no intervention', in practice reactive controls will be in place

Consolidated Risk Assessment Results: Potential Impacts to the Commonwealth Marine Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
Air Quality													
1	Air quality	Atmospheric emissions (except dust)	Depletion of stratospheric ozone	Use of ozone depleting substances (ODSs) on board marine vessels and drill rig	LOW	Possible small increase in emissions associated with marine vessels (including those used during construction, operations and decommissioning)	6	6	TRIVIAL	_	_	_	Not specifically generated by the Fourth Train Proposal, however ODSs may be integrated into older marine vessels contracted by the Fourth Train Proposal
2	Air quality	Atmospheric emissions (except dust)	Reduction in air quality over the Commonwealth Marine Area	Flaring of hydrocarbons during production well testing and/or clean-up	LOW	Additional emissions Additional presence of stressor during construction	6	4	LOW	6	4	LOW	Impacts expected to be temporary and localised. The receiving environment is considered to be highly dispersive and will serve to dissipate emissions quickly
3	Air quality	Atmospheric emissions (except dust)	Reduction in air quality over the Commonwealth Marine Area	Routine emissions of CO_2, CO, NO_x, SO_2, CH_4 and VOCs from marine vessel engines, power generation and incinerator emissions associated with offshore drilling, pipe-laying, operational maintenance activities and additional operational shipping	LOW	Additional emissions Additional presence of stressor associated with marine vessels (including those used during construction, operations and decommissioning)	6	4	LOW	6	4	LOW	Impacts will be temporary and localised The highly dispersive receiving environment will serve to dissipate emissions quickly Emissions estimate to be included within the PER/Draft EIS: Not significant in the context of national emissions
Cultural Heritage													
4	Cultural Heritage	Physical interaction	Damage to listed or historic shipwrecks or relics	Anchoring of pipe-lay vessels and drill rig Laying of the Feed Gas Pipeline System	LOW	New / additional geographic areas affected	6	6	TRIVIAL	_	_	_	Interrogation of available information has identified no historic shipwrecks in the vicinity of Fourth Train Proposal drill sites or Feed Gas Pipeline System route options. Pre-development seabed surveys will help to verify findings to date
Land and sea use													
5	Land and sea use	Introduction and/or spread of Marine Pests	Indirect impact on fish stocks and the viability of established fisheries	Biofouling (from wetsides or from discharge of ballast water) from drill rigs, marine construction and operational maintenance vessels and additional LNG and condensate vessels	LOW	New / additional geographic areas potentially affected Increased likelihood of introduction due to increased vessel activities Risk of introducing Marine Pests from different regions when compared to the Foundation Project (depending on the origins of the vessels used for both projects)	4	5	LOW	4	5	LOW	Relevant to marine vessels and rigs moving from other international or regional ports. No 'high risk ballast water' allowed to be discharged within Australian Territorial Seas
6	Land and sea use	Physical presence	Displacement/ disruption of other users in marine environment (i.e. commercial fishing and/or shipping)	Presence of drill rig at well sites, pipe-lay and associated marine construction vessels and establishment of exclusion zones. Additional LNG and condensate vessels	LOW	Additional vessel activity and petroleum safety zones in the Fourth Train Proposal Area. New / additional geographic areas affected	5	4	LOW	4	5	LOW	_

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Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
7	Land and sea use	Spills and Leaks	Disruption to other sea users (i.e. commercial and recreational fishing, tourism and/or shipping) Loss of commercial fish stocks	Release of diesel or heavy fuel oil during refuelling (minor spill volume of ~2,500L)	–	Different geographic areas potentially affected Increased likelihood given additional activities	6	4	LOW	6	4	LOW	No known areas of aggregation or spawning within Commonwealth Marine Area associated with the Fourth Train Proposal Area (i.e. near vicinity of spill sites with greater potential for impact). Due to nature of diesel (i.e. rapid weathering), potential impacts are expected to be short-term and localised
8	Land and sea use	Spills and Leaks	Disruption to other sea users (i.e. commercial and recreational fishing, tourism and/or shipping) Loss of commercial fish stocks	Release of diesel or heavy fuel oil from accidental damage to vessel (spill volume 80,000 L)	–	Different geographic areas potentially affected Increased likelihood given additional activities	5	4	LOW	5	4	LOW	No known areas of aggregation or spawning within Commonwealth Marine Area associated with the Fourth Train Proposal Area (i.e. near vicinity of spill sites with greater potential for impact). Due to nature of diesel (rapid weathering), potential impacts are expected to be short-term and localised
9	Land and sea use	Spills and Leaks	Disruption to other sea users (i.e. commercial and recreational fishing, tourism and/or shipping) Loss of commercial fish stocks	Rupture of live pipeline (during construction or once operational) or uncontrolled release from the well due to a strike from a construction or third party marine vessel	–	Different geographic areas potentially affected Increased likelihood given additional activities and pipelines	2	6	LOW	2	6	LOW	No known areas of aggregation or spawning within Commonwealth Marine Area associated with the Fourth Train Proposal Area (i.e. near vicinity of spill sites with greater potential for impact)
10	Land and sea use	Spills and Leaks	Disruption to other sea users (i.e. commercial and recreational fishing, tourism and/or shipping) Loss of commercial fish stocks	Subsea well blow out	–	Different geographic areas potentially affected Increase in likelihood given additional wells will be drilled	2	6	LOW	2	6	LOW	No known areas of aggregation or spawning within Commonwealth Marine Area. Water quality predicted to be within ANZEC/ARMCANZ marine water quality guidelines for benzene which is deemed suitable to protect 99% of marine life. Due to nature of condensate (i.e. evaporative), potential impacts would be expected to be short-term
	Marine benthic fauna and communities												
11	Marine benthic fauna and communities	Discharges to sea	Smothering and loss of benthic communities	Cementing discharges during drilling/completions	LOW	New / additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	3	LOW	6	3	LOW	Rapid dispersion of cement materials due to the high-energy environment. Small / temporally discrete discharge volume No sensitive / unique benthic habitats expected to be within the vicinity of the discharge Impact expected to be highly localised

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Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
12	Marine benthic fauna and habitats	Discharges to sea	Smothering and loss of benthic fauna and habitats Acute or chronic toxic effects to benthic faunal communities	Discharge of cuttings with adhered drilling fluid during offshore drilling	LOW	New / additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	2	LOW	6	2	LOW	In deeper water, the effect of wave action, wind driven currents, deeper local and ocean currents is expected to aid dispersion of drill cuttings, and reduce the potential for the accumulation of drill cuttings in piles. Lack of significant benthic habitat in vicinity of discharge
13	Marine benthic fauna and habitats	Introduction and/or spread of Marine Pests	Increased competition with existing (native) species resulting in a reduction in native community health, diversity and ecosystem productivity	Biofouling (from wetsides or from discharge of ballast water) from drill rigs, marine construction and operational maintenance vessels and additional LNG and condensate vessels	LOW	New / additional geographic areas potentially affected. Increased likelihood of introduction due to increased vessel activities. Risk of introducing Marine Pests from different regions when compared to the Foundation Project (depending on the origins of the vessels used for both projects)	4	4	LOW	4	4	LOW	Relevant to marine vessels and rigs moving from other international or regional ports. No 'high risk ballast water' allowed to be discharged within Australian Territorial Seas
14	Marine benthic fauna and habitats	Physical interaction	Direct physical injury or mortality of benthic communities (including Benthic Primary Producers) in contact area	Anchoring of construction and operational maintenance vessels	LOW	New / additional geographic areas and communities potentially impacted	6	6	TRIVIAL	6	6	_	Two rocky reef structures have been identified in pipeline surveys for northern Feed Gas Pipeline System route: at the 50-60 m water depth and the 40-45 m water depth. Fourth Train Proposal currently anticipating using Dynamic Positioning when crossing these reef structures
15	Marine benthic fauna and habitats	Physical interaction	Direct physical injury to or crushing of benthic flora and fauna causing loss of species abundance and habitat and an increase in turbidity	Accidental interaction of remotely operated vehicle with seafloor Maintenance to Feed Gas Pipeline System during operation, in shallower areas (i.e. seabed within photic zone) of the Commonwealth Marine Area	_	New / additional geographic areas and communities potentially impacted	6	6	TRIVIAL	6	6	_	Seabed communities expected to be well represented across the wider North-west Shelf Region. No unique features or communities affected. Scarp crossing hosts scattered corals. Also note two rocky reef structures have been identified in pipeline surveys for northern Feed Gas Pipeline System route: at the 50-60 m water depth and the 40-45 m water depth Based on survey information impacts to benthic primary producer habitat would only be relevant in shallow areas of the Commonwealth Marine Area, within approximately 5km of the State water boundary (RPS, 2010): these areas support only sparse cover and no unique communities expected

Consolidated Risk Assessment Results: Potential Impacts to the Commonwealth Marine Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
16	Marine benthic fauna and habitats	Seabed disturbance	Alteration of sediment characteristics resulting in a change in habitat for benthic communities	Displacement of drill cuttings direct to seabed around well-bore during riser-less drilling of top-hole sections of each well	LOW	New / additional geographic areas affected	6	2	LOW	6	2	LOW	Well sites are not expected to support any unique or sensitive benthic communities; communities that are present are expected to be well represented within the wider North-west Shelf Region Potential impact expected to be highly localised
17	Marine benthic fauna and habitats	Seabed disturbance	Direct loss of benthic communities in the contact area leading to a change in the benthic community and wider ecosystem implications	Positioning and anchoring of drill rig and other marine construction vessels (if anchored)	LOW	New / additional geographic areas affected	5	4	LOW	5	4	LOW	Consequence of loss of, or disturbance to, benthic communities is expected to be localised No unique or sensitive benthic communities expected to be present
18	Marine benthic fauna and habitats	Seabed disturbance	Direct loss of benthic communities in the contact area leading to a change in the benthic community and wider ecosystem implications	Trenching/jetting /ploughing of Feed Gas Pipeline System route and installation of pipeline stabilisation materials	LOW	New / additional geographic areas affected	5	4	LOW	5	4	LOW	Seabed communities expected to be well represented across the wider North-west Shelf Region. No unique features or communities affected. Scarp crossing hosts scattered corals. Also note two rocky reef structures have been identified in pipeline surveys for northern Feed Gas Pipeline System route: at the 50-60 m water depth and the 40-45 m water depth Based on survey information impacts to benthic primary producer habitat would only be relevant in shallow areas of the Commonwealth Marine Area, within approximately 5km of the State water boundary (RPS, 2010); these areas support only sparse cover and no unique communities expected
19	Marine benthic fauna and habitats	Seabed disturbance	Mortality of sessile benthic communities in the immediate area surrounding each well bore due to smothering	Displacement of drill cuttings direct to seabed around well-bore during riser-less drilling of top-hole sections of each well	LOW	New / additional geographic areas affected	5	4	LOW	5	4	LOW	Well sites are not expected to support any unique or sensitive benthic communities; communities that are present are expected to be well represented within the wider North-west Shelf Region Potential impact expected to be highly localised

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Consolidated Risk Assessment Results: Potential Impacts to the Commonwealth Marine Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
20	Marine benthic fauna and habitats	Seabed disturbance	Reduction in water quality (turbidity) leading to smothering of sensitive or ecologically important benthic communities	Trenching/jetting /ploughing of Feed Gas Pipeline System route and installation of pipeline stabilisation materials	LOW	New / additional geographic areas affected	5	4	LOW	5	4	LOW	Potential impact expected to be localised and benthos to recover quickly Limited sensitive benthic communities are expected to be present based on nearby survey information
21	Marine benthic fauna and habitats	Spills and Leaks	Acute and/or chronic toxic effects of hydrocarbons on benthic communities	Release of diesel or heavy fuel oil during refuelling (minor spill volume of ~ 2,500 L)	LOW	Different geographic areas potentially affected Increased likelihood given additional activities	6	4	LOW	6	4	LOW	Potential impacts (if any, given surface release and depth of water over most of Commonwealth Marine Area within the Fourth Train Proposal Area) is likely to be localised
22	Marine benthic fauna and habitats	Spills and Leaks	Acute and/or chronic toxic effects of hydrocarbons on benthic communities	Release of diesel or heavy fuel oil from accidental damage to vessel (spill volume 80,000 L)	–	Different geographic areas potentially affected Increased likelihood given additional activities	5	4	LOW	5	4	LOW	Potential impact likely to be localised and temporary given rapid degradation and dispersion of spilt hydrocarbons in warm open ocean. Potential impacts expected to be associated with the upper water column rather than at depth/ at the seabed interface
23	Marine benthic fauna and habitats	Spills and Leaks	Acute and/or chronic toxic effects of hydrocarbons on benthic communities	Rupture of live pipeline (during construction or once operational) or uncontrolled release from the well due to a strike from a construction or third party marine vessel	LOW	Different geographic areas potentially affected Increased likelihood given additional activities and pipelines	3	5	LOW	3	5	LOW	Area of potential impact localised (supported by modelling results) due to rapid degradation of condensate Released hydrocarbons expected to evaporate, or become entrained into the water column, and are not expected to partition into the sediment phase Commonwealth Marine Area associated with the Fourth Train Proposal Area not known to host any unique or sensitive benthic communities or habitats. Communities and habitats are expected to be well represented within the wider North-west Shelf Region

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24	Marine benthic fauna and habitats	Spills and Leaks	Loss of benthic communities through physical impact of the blowout Acute and/or chronic toxic effects of hydrocarbons on benthic communities affected by entrained hydrocarbons	Subsea well blow out	**LOW**	Different geographic areas potentially affected Increase in likelihood given additional wells will be drilled	5	4	**LOW**	5	4	**LOW**	No unique or sensitive benthic communities expected to be present in the near vicinity of the well sites Released hydrocarbons expected to evaporate, or become entrained into the water column, and are not expected to partition into the sediment phase Potential impacts to marine benthic fauna and habitats would likely be localised to the immediate area surrounding the blowout and of short-term duration
	Marine fauna												
25	Marine fauna	Artificial light	Altered foraging and breeding activity in seabirds, fish, marine mammals and marine reptiles within the Commonwealth Marine Environment Disorientation of marine fauna such as birds Increased incidents of marine fauna interactions with vessels and equipment Increased mortality of food source where predators may adapt to take advantage of the light source	Artificial light generated by drill rig, pipe-lay and other marine construction vessels, marine vessels involved in operational maintenance activities and additional LNG and condensate vessels during operation Flaring of hydrocarbons during well testing / well clean-up	**LOW**	New / additional geographic areas affected Some geographic areas will be subject to additional light spill (e.g. at Jansz PTS; along Feed Gas Pipeline System route) Additional condensate and LNG vessels will increase frequency of light spill by approximately 1/3 in relation to the Foundation Project	6	4	**LOW**	6	4	**LOW**	Currently no monitoring data for light in relation to seabirds, fish or dolphins in the Commonwealth Marine Environment associated with the Fourth Train Proposal Area Static sources of new light (drill rig and associated marine vessels) short-term and isolated from other light sources Unlikely to be spatial or temporal overlap between areas affected by Foundation Project and Fourth Train Proposal during construction. Any overlap would be short term With exception of crossing the Humpback Whale migration route, no faunal aggregation areas for seabirds, fish or affected
26	Marine fauna	Creation of heat and/or cold	Behavioural changes to marine fauna in areas affected by discharges leading to potential mortality	Discharge of cooling water from pipe-lay and marine support vessels	**LOW**	New / additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	6	**TRIVIAL**	–	–	–	Relatively small quantity of cooling water discharged to highly dispersive marine environment. Potential impacts highly localised

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27	Marine fauna	Creation of heat and/or cold	Behavioural changes to marine fauna in area affected by discharges leading to potential mortality	Discharge of heated freshwater (approximately 60°C - 70°C as enters sea) with no chemical additives during well testing	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	5	TRIVIAL	6	5	_	Minor stress may occur but unlikely to cause mortality. May cause short range / short term displacement of some mobile species Temporary activity associated with well-testing. Discharge is freshwater (from steam exchanger) with no chemical additives Given offshore environment meteorological conditions, potential impacts highly localised and temporary - heat is expected to dissipate rapidly
28	Marine fauna	Discharges to sea	Physiological and genetic damage to marine fauna resulting in long-term impacts on species populations	Loss of radioactive sources during drilling and during Feed Gas Pipeline System maintenance and decommissioning	VERY LOW	New geographic areas potentially affected	5	6	TRIVIAL	5	6	_	Very low quantities of radioactive materials used, and only very small area likely to be affected in the instance of loss of radioactive material to sea
29	Marine fauna	Discharges to sea	Reduction in water quality causing adverse impacts to marine fauna	Discharge of whole drilling fluid during offshore drilling	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	4	LOW	6	4	LOW	Only water based (i.e. low toxicity) drilling fluids are permitted to be discharged. No discharge of whole synthetic based fluids Potential impacts likely to be localised and temporary given rapid dispersion in offshore environment
30	Marine fauna	Discharges to sea	Reduction in water quality causing adverse impacts to marine fauna	Disposal of domestic waste water (sewage, grey water and putrescible/galley wastes) from drill rig, Feed Gas Pipeline System construction vessels marine support and supply vessels, operational maintenance vessels and additional LNG and condensate vessels, and decommissioning vessels	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	4	LOW	6	4	LOW	Potential impacts are expected to be temporary and localised due to water depth and the dispersive nature of the offshore environment Vessels will be mobile and their discharges transient. Discharges unlikely to persist or accumulate in a particular area
31	Marine fauna	Discharges to sea	Reduction in water quality causing adverse impacts to marine fauna, particularly marine plankton	Discharge of deck drainage, equipment / machinery space and bilge water from Feed Gas Pipeline System marine construction vessels, drill rigs, marine support vessels, vessels involved in operational maintenance and additional LNG and condensate vessels	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	3	LOW	6	3	LOW	Potential impacts expected to be temporary and localised due to the highly dispersive offshore environment Vessels will be mobile and their discharges transient. Discharges unlikely to persist or accumulate in a particular area

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32	Marine fauna	Discharges to sea	Reduction in water quality causing adverse impacts to marine fauna, particularly marine plankton	Discharge of soapy synthetic-based mud tank wash during drilling	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	2	LOW	6	2	LOW	Potential impacts will be temporary and localised due to the highly dispersive offshore environment No spatial / temporal overlap of discharges anticipated with the Foundation project or other Fourth Train Proposal wells
33	Marine fauna	Discharges to sea	Reduction in water quality resulting in acute or chronic toxic effects on marine fauna, particularly marine plankton	Discharge of hydrotest fluids (for whole pipeline system)	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	3	LOW	6	3	LOW	Discharges are discrete / short-term. Modelling by Foundation Project indicates any impacts would be highly localised and temporary
34	Marine fauna	Introduction and/or spread of Marine Pests	Increased competition with and/or disease to existing (native) mobile fauna species resulting in a reduction in native community health, diversity and ecosystem productivity	Biofouling (from wetsides or from discharge of ballast water) from drill rigs, marine construction and operational maintenance vessels and additional LNG and condensate vessels	LOW	New / additional geographic areas potentially affected Increased likelihood of introduction due to increased marine vessel activities Risk of introducing Marine Pests from different regions when compared to the Foundation Project (depending on the origins of the vessels used for both projects)	4	4	LOW	4	4	LOW	Relevant to marine vessels and rigs moving from other international or regional ports. No 'high risk ballast water' allowed to be discharged within Australian Territorial Seas
35	Marine fauna	Noise and vibration	Change in behaviour (e.g. attraction to or deterrence from the noise source, alteration of feeding or migration patterns) to sensitive marine fauna, including EPBC Act-listed threatened and migratory species	Engine noise from drill rig, marine construction vessels and additional LNG and condensate vessels, particularly from dynamic positioning systems	LOW	New and additional geographic areas potentially affected Additional noise sources introduced into the Commonwealth Marine Area	6	4	LOW	6	4	LOW	With the exception of operational shipping, noise emissions from the Foundation Project and Fourth Train Proposal are not expected to overlap
36	Marine fauna	Noise and vibration	Change in behaviour (e.g. attraction to or deterrence from the noise source, alteration of feeding or migration patterns) to sensitive marine fauna, including EPBC Act-listed threatened and migratory species	Noise from drilling	LOW	New and additional geographic areas potentially affected Additional noise sources introduced into the Commonwealth Marine Area	6	2	LOW	6	2	LOW	Risk Assessment based worst case (Dynamic Positioning of drill rig) Short term and intermittent activity outside whale migration routes
37	Marine fauna	Noise and vibration	Change in behaviour (e.g. attraction to or deterrence from the noise source, alteration of feeding or migration patterns) to sensitive marine fauna, including EPBC Act-listed threatened and migratory species	Noise from helicopter transfers	LOW	Increased frequency of helicopter trips and therefore increase in potential for exposure of fauna to noise New and additional geographic areas potentially affected	6	3	LOW	6	3	LOW	Noise generated will be intermittent / transient Periods of increased frequency of helicopter use within the Commonwealth Marine Environment likely to be related to construction or decommissioning activities, which are temporary

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38	Marine fauna	Noise and vibration	Change in behaviour (e.g. attraction to or deterrence from the noise source, alteration of feeding or migration patterns) to sensitive marine fauna, including EPBC Act-listed threatened and migratory species	Noise from operation of subsea equipment including well heads and manifold choke valves	LOW	New / additional geographic areas affected. Additional noise source.	6	4	LOW	6	4	LOW	Relatively low intensity noise expected (e.g. when compared to VSP) from long-term operations Location of the noise source fixed hence unlikely to result in startled / alarmed response from marine fauna
39	Marine fauna	Noise and vibration	Physiological damage to marine fauna or disruption of behaviour patterns, including migration, of sensitive marine fauna	Noise from Vertical Seismic Profiling (VSP) (undertaken during drilling)	LOW	New and additional geographic areas potentially affected Additional noise sources introduced into the Commonwealth Marine Area	5	4	LOW	5	4	LOW	Temporary activity and occurring at a small number of widely dispersed locations; also expected to be temporally discrete (reducing the total marine area exposed to VSP noise at any one time).
40	Marine fauna	Physical interaction	Injury to or mortality of marine fauna due to entanglement in anchor chains	Anchoring of construction and operational maintenance vessels	LOW	New / additional geographic areas potentially impacted	6	6	TRIVIAL	6	6	_	Operations involving anchoring are expected to be geographically dispersed within the Commonwealth Marine Area (associated with the Fourth Train Proposal Area), and away from areas of aggregation for Threatened and / or Migratory Species
41	Marine fauna	Physical interaction	Physical injury to marine fauna including protected species (cetaceans, turtles, fish) resulting from collision or vessel strikes	Movement of drill rig and its marine support and supply vessels Movement of marine construction vessels, operational maintenance vessels and additional LNG and condensate vessels	MEDIUM	New / additional geographic areas and communities potentially impacted Scope of Foundation Project assessment included State Waters around Barrow Island and risk associated with marine turtles. Scope of the current assessment is only the Commonwealth Marine Area	6	2	LOW	6	2	LOW	Assessment based on worst case scenario of impacts to turtles (as turtles are more likely to physically interact with vessels than cetaceans or fish) Foundation Project impact rating was for interactions with marine turtles occurring in State waters around Barrow Island Consequence of collision likely to be on individuals only Main risk of collisions in Commonwealth Marine Area is from marine vessels moving between drill rig and Dampier
42	Marine fauna	Physical presence	Creation of artificial habitats causing a change in population densities and distribution	Long-term presence of the in-field flow lines, Feed Gas Pipeline System and associated stabilisation materials on the seabed	LOW	New / additional geographic areas affected	6	3	LOW	6	3	LOW	Creation of habitat in the long term may be considered beneficial whereby it could increase the biological productivity and/ or species diversity in the area
43	Marine fauna	Physical presence	Creation of artificial habitats causing a change in population densities and distribution	Presence of drill rig at well site	LOW	New / additional geographic areas affected	6	6	TRIVIAL	6	6	_	Short-term activity with no long-term consequences

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44	Marine fauna	Physical presence	Entanglement of marine fauna with subsea infrastructure	Long-term presence of subsea infrastructure, (in-field flow lines, manifolds, well head equipment and Feed Gas Pipeline System)	LOW	New / additional geographic areas affected	6	6	TRIVIAL	6	6	_	The potential for this impact to have any consequence beyond the level of individual fauna is considered remote. The subsea nature of the development precludes the potential for any significant impact to seabirds or pelagic marine fauna
45	Marine fauna	Seabed disturbance	Reduction in water quality (turbidity) causing adverse impacts to marine fauna	Trenching/jetting /ploughing of Feed Gas Pipeline System route and installation of pipeline stabilisation materials	LOW	New / additional geographic areas affected	5	4	LOW	5	4	LOW	Turbidity levels expected to return to normal soon after completion of work (i.e. potential impact is expected to be temporary and localised)
46	Marine fauna	Spills and Leaks	Acute or chronic toxic effects on marine fauna, including EPBC-listed species	Accidental release of MEG	LOW	New / additional geographic areas potentially affected Increase in likelihood given additional MEG line will be installed	6	6	TRIVIAL	6	6	_	MEG is classified under the CEFAS OCNS system as a PLONOR chemical (i.e. it Poses Little Or No Risk to the Marine Environment). The release of MEG in small quantities is not expected to result in any chronic / long term adverse impacts within the marine environment
47	Marine fauna	Spills and Leaks	Acute or chronic toxic effects on marine fauna, including EPBC-listed species	Spill of chemicals (e.g. drilling fluids or treatment chemicals for pipe-lay pre-commissioning and maintenance activities) to sea during bunkering	LOW	New / additional geographic areas potentially affected Increased likelihood given additional activities	5	5	LOW	5	5	LOW	Potential impacts expected to be localised given rapid dispersion in offshore environment. Volumes spilt likely to be small and of low toxicity / low bioaccumulation potential given mitigation in place
48	Marine fauna	Spills and Leaks	Acute or chronic toxic effects on marine fauna, including EPBC-listed species Oiling of birds	Release of diesel or heavy fuel oil during refuelling (minor spill volume of ~ 2,500 L)	LOW	Different geographic areas potentially affected Increased likelihood given additional activities	6	4	LOW	6	4	LOW	Potential impacts anticipated to be localised given likely rapid degradation and dispersion in warm open ocean environment. Modelling indicates that dissolved aromatics >5ppb will not extend beyond immediate spill site
49	Marine fauna	Spills and Leaks	Acute or chronic toxic effects on marine fauna, including EPBC-listed species Oiling of birds	Release of diesel or heavy fuel oil from accidental damage to vessel (spill volume 80,000 L)	LOW	Different geographic areas potentially affected Increased likelihood given additional activities	5	4	LOW	5	4	LOW	Released diesel is likely to weather rapidly, disperse and dissipate under the high energy offshore meteorological conditions. Only a relatively small proportion of the Commonwealth Marine Area would be expected to be impacted
50	Marine fauna	Spills and Leaks	Acute or chronic toxic effects on marine fauna, including EPBC-listed species Oiling of birds	Rupture of live pipeline (during construction or once operational) or uncontrolled release from the well due to a strike from a construction or third party marine vessel	MEDIUM	Different geographic areas potentially affected Increased likelihood given additional activities and pipelines	2	5	MEDIUM	2	5	MEDIUM	Assessment based on a worst-case scenario of the rupture occurring in whale migration season close to whale migration route. Likelihood of this occurring is however remote

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51	Marine fauna	Spills and Leaks	Acute or chronic toxic effects on marine fauna, including EPBC-listed species Oiling of birds	Subsea well blow out	MEDIUM	Different geographic areas potentially affected Increase in likelihood given additional wells will be drilled	3	4	MEDIUM	3	4	MEDIUM	Potential impacts at population level unlikely due to low aromatic content and rapid weathering of Fourth Train Proposal condensate. Oiling of seabird communities unlikely given the type of hydrocarbons released and the degradation of those hydrocarbons in the time taken to reach known seabird roosting, nesting and or foraging areas. Potential impacts therefore likely to be limited to individuals coming into contact with fresh release (i.e. localised around blow-out site) and short-term Modelling predicts only a remote chance of hydrocarbons reaching Humpback Whale migration route during migration season Likelihood of this occurring is however remote
	Marine Protected Areas												
52	Marine Protected Areas	Physical presence	Reduction in the conservation values of the proposed Montebello Commonwealth Marine Reserve	Long-term presence of the Feed Gas Pipeline System through the proposed Montebello Commonwealth Marine Park	–	Montebello Commonwealth Marine Reserve is newly proposed since approval of the Foundation Project	6	4	LOW	6	4	LOW	Reserve is zoned for multiple use; IUCN Category VI which permits the sustainable use of natural resources. Zone of potential impact very small in comparison with the area of the reserve. Seabed feature means no impact on pelagic species
53	Marine Protected Areas	Seabed disturbance	Reduction in the conservation values of the proposed Montebello Commonwealth Marine Reserve	Laying of the Feed Gas Pipeline System through the proposed reserve	–	Montebello Commonwealth Marine Reserve is newly proposed since approval of the Foundation Project	6	4	LOW	6	4	LOW	Reserve is zoned for multiple use; IUCN Category VI which permits the sustainable use of natural resources Zone of potential disturbance very small in comparison with the area of the reserve. Potential impacts will be localised
54	Marine Protected Areas	Spills and Leaks	Impact on the ecological values for which the proposed Montebello Commonwealth Marine Reserve has been protected	Rupture of live pipeline (during construction or once operational) or uncontrolled release from the well due to a strike from a construction or third party marine vessel	–	Montebello Commonwealth Marine Reserve is newly proposed since approval of the Foundation Project	2	5	MEDIUM	2	5	MEDIUM	Assessment based on a worst-case scenario of the rupture occurring in whale migration season close to whale migration route. Likelihood of this occurring is however remote
55	Marine Protected Areas	Spills and Leaks	Reduction in the conservation values for which the proposed Montebello Commonwealth Marine Reserve has been protected	Release of diesel or heavy fuel oil during refuelling (minor spill volume of ~ 2,500 L)	–	Montebello Commonwealth Marine Reserve is newly proposed since approval of the Foundation Project	6	4	LOW	6	4	LOW	In unlikely event that spill occurred in or close to the reserve during Feed Gas Pipeline System installation / maintenance, potential impacts predicted to be localised to vicinity of spill

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56	Marine Protected Areas	Spills and Leaks	Reduction in the conservation values for which the proposed Montebello Commonwealth Marine Reserve has been protected	Release of diesel or heavy fuel oil from accidental damage to vessel (spill volume 80,000 L)	_	Montebello Commonwealth Marine Reserve is newly proposed since approval of the Foundation Project	5	4	LOW	5	4	LOW	Released diesel is likely to weather rapidly, disperse and dissipate under the high energy offshore meteorological conditions
57	Marine Protected Areas	Spills and Leaks	Reduction in the conservation values for which the proposed Montebello Commonwealth Marine Reserve has been protected	Subsea well blow out	_	Montebello Commonwealth Marine Reserve is newly proposed since approval of the Foundation Project	4	4	LOW	4	4	LOW	Modelling suggests low probability of condensate, at ecologically significant levels, reaching the proposed reserve. Water quality predicted to be within ANZECC/ARMCANZ guidelines (for benzene). Could affect individuals of migratory seabirds, whale sharks, marine turtles or whales but no population-wide impacts anticipated given transient nature of these species through the area. Oiling of birds unlikely due to nature of condensate. No sedimentation of hydrocarbons anticipated
	Marine Water Quality												
58	Marine water quality	Creation of heat and/or cold	Reduction in water quality from a change in water temperature	Discharge of heated freshwater (approximately 60°C - 70°C as enters sea) with no chemical additives during well testing Discharge of cooling water from vessels	_	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	5	TRIVIAL	6	5	_	Relatively small quantity of cooling water discharged to highly dispersive marine environment. Potential impacts highly localised
59	Marine water quality	Discharges to sea	Reduction in water quality	Discharge of blowout preventer (BOP) hydraulic control fluid during weekly testing of BOP	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	4	LOW	6	4	LOW	Hydraulic fluid expected to be biodegradable, water soluble and low toxicity. Only small volume released into a highly dispersive environment. Potential impacts will be temporary and localised due to the highly dispersive offshore environment
60	Marine water quality	Discharges to sea	Reduction in water quality	Discharge of completion brine during production well completion activities	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	2	LOW	6	2	LOW	Completion brines typically have no acute or chronic aquatic toxicity and no potential for bioaccumulation (IMO, 2008) Highly dispersive offshore environment - potential impacts, if any, will be temporary and localised Water quality could on occasions be affected but it is unlikely to have an indirect impact on marine fauna

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61	Marine water quality	Discharges to sea	Reduction in water quality	Discharge of deck drainage, equipment / machinery space and bilge water from Feed Gas Pipeline System marine construction vessels, drill rigs, marine support vessels, vessels involved in operational maintenance and additional LNG and condensate vessels	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	3	LOW	6	3	LOW	Potential impacts expected to be temporary and localised due to the highly dispersive offshore environment
62	Marine water quality	Discharges to sea	Reduction in water quality	Discharge of hydraulic fluids from umbilical (i.e. for actuation of emergency shutdown valves)	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	4	LOW	6	4	LOW	Potential impacts expected to be temporary and localised due to the highly dispersive offshore environment
63	Marine water quality	Discharges to sea	Reduction in water quality	Discharge of hydrotest fluids (for whole pipeline system)	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	2	LOW	6	2	LOW	Modelling by Foundation Project indicates any impacts would be highly localised and temporary
64	Marine water quality	Discharges to sea	Reduction in water quality	Planned release of small volumes of hydraulic fluid from valves in subsea infrastructure	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	6	TRIVIAL	_	_	_	Only very small volume of hydraulic fluid is likely to be involved. May result in highly localised, temporary change in water quality which is unlikely to result in harm to marine fauna
65	Marine water quality	Discharges to sea	Reduction in water quality (Increase in particulate load within the water column in the near vicinity of the cuttings discharge, also traces of hydrocarbons and / or chemicals (e.g. drilling muds) may be entrained)	Discharge of drilling related materials including cuttings with adhered muds, whole muds, and cement	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	4	LOW	6	4	LOW	Potential impacts expected to be temporary and localised due to the highly dispersive offshore environment
66	Marine water quality	Discharges to sea	Reduction in water quality (increased nutrient availability and biological oxygen demand)	Disposal of domestic waste water (sewage, grey water and putrescible/galley wastes) from drill rig, Feed Gas Pipeline System construction vessels marine support and supply vessels, operational maintenance vessels and additional LNG and condensate vessels	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected during construction	6	3	LOW	6	3	LOW	Potential impacts will be temporary and localised due to the highly dispersive offshore environment
67	Marine water quality	Seabed disturbance	Reduction in water quality (turbidity)	Trenching/jetting /ploughing of Feed Gas Pipeline System route and installation of pipeline stabilisation materials	LOW	New / additional geographic areas affected	6	4	LOW	6	4	LOW	Turbidity levels expected to return to normal soon after completion of work (i.e. potential impact is expected to be temporary and localised)
68	Marine water quality	Spills and Leaks	Reduction in water quality	Spill of chemicals (e.g. drilling fluids or treatment chemicals for pipe-lay pre-commissioning and maintenance activities) to sea during bunkering	LOW	New / additional geographic areas potentially affected Increased likelihood given additional activities	5	3	LOW	6	3	LOW	Potential impacts expected to be localised given rapid dispersion in offshore environment. Volumes spilt likely to be small and of low toxicity given mitigation in place

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69	Marine water quality	Spills and Leaks	Reduction in water quality	Accidental release of MEG	LOW	New / additional geographic areas potentially affected Increase in likelihood given additional MEG line will be installed	6	6	TRIVIAL	–	–	–	MEG is classified under the CEFAS OCNS system as a PLONOR chemical (i.e. it Poses Little Or No Risk to the Marine Environment). The release of MEG in small quantities is not expected to result in any discernable adverse impact within the marine environment
70	Marine water quality	Spills and Leaks	Reduction in water quality and exceedance of ANZECC/ARMCANZ marine water quality guidelines	Release of diesel or heavy fuel oil during refuelling (minor spill volume of ~ 2,500 L)	LOW	Different geographic areas potentially affected Increased likelihood given additional activities	6	4	LOW	6	4	LOW	Potential impacts anticipated to be localised given likely rapid degradation and dispersion in warm open ocean environment
71	Marine water quality	Spills and Leaks	Reduction in water quality and exceedance of ANZECC/ARMCANZ marine water quality guidelines	Release of diesel or heavy fuel oil from accidental damage to vessel (spill volume 80,000 L)	LOW	Different geographic areas potentially affected Increased likelihood given additional activities	5	4	LOW	5	4	LOW	Released diesel is likely to weather rapidly, disperse and dissipate within the high energy offshore environment
72	Marine water quality	Spills and Leaks	Reduction in water quality and exceedance of ANZECC/ARMCANZ marine water quality guidelines	Rupture of live pipeline (during construction or once operational) or uncontrolled release from the well due to a strike from a construction or third party marine vessel	LOW	Different geographic areas potentially affected Increased likelihood given additional activities and pipelines	5	5	LOW	5	5	LOW	Potential impacts to water quality could be widespread but temporary given nature of condensate of Fourth Train Proposal gas fields
73	Marine water quality	Spills and Leaks	Reduction in water quality and exceedance of ANZECC/ARMCANZ marine water quality guidelines	Subsea well blow out	–	Different geographic areas potentially affected Increase in likelihood given additional wells will be drilled	5	5	LOW	5	5	LOW	Potential impacts to water quality could be widespread but temporary given nature of condensate of Fourth Train Proposal gas fields Modelling predicts levels of benzene to be an order of magnitude less than ANZECC/ARMCANZ marine water quality guidelines (for benzene) at 1.5 km distance from the blow-out
	Public Safety												
74	Public Safety	Physical Interaction	Collision between Fourth Train Proposal vessels and vessels of other sea users	Movement of drill rig and its marine support and supply vessels Movement of marine construction vessels, operational maintenance vessels and additional LNG and condensate vessels Laying of the Feed Gas Pipeline System	–	New / additional geographic areas affected Increase in vessel movements, especially during construction and decommissioning	3	6	LOW	3	6	LOW	Small area impacted compared with the available space within and outside of the fourth Train Proposal area for other marine users. Notices to other mariners with details of offshore activities being undertaken
75	Public Safety	Physical presence	Loss or damage to third party equipment (e.g. fishing nets) from entanglement or contact with subsea infrastructure	Long-term presence of subsea infrastructure, (in-field flow lines, manifolds, well head equipment and Feed Gas Pipeline System)	–	New / additional geographic areas affected	5	5	LOW	5	5	LOW	A number of methods will be used during subsea construction to reduce risks of interaction with other marine users (e.g. rock cover and trenching)

Consolidated Risk Assessment Results: Potential Impacts to the Commonwealth Marine Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
	Seabed												
76	Seabed	Discharges to sea	Alteration of seabed physiochemical composition due to settlement of drilling related discharges including cuttings and cement	Drilling, cementing and completions discharges (including drilling of top-hole sections of each well during riser-less drilling)	LOW	New and additional geographic areas affected; however no overlap between Foundation Project and Fourth Train Proposal impacts expected	6	3	LOW	6	3	LOW	Zone of potential impact expected to be localised
77	Seabed	Physical presence	Permanent physical loss of seabed habitat and creation of barrier to sediment transportation processes on the seabed with potential impacts to seabed profile	Laying and long-term presence of the Feed Gas Pipeline System	LOW	New / additional geographic areas affected	5	5	LOW	5	5	LOW	Risk assessment assumes the impact is limited to where the pipeline system is laid Habitat types are widespread and well represented in the region
78	Seabed	Seabed disturbance	Alteration of seabed sediment characteristics and change in the seabed profile (e.g. creation of anchor scars)	Anchoring of drill rig and other marine construction vessels (if anchored). Use of other temporary installation aids (e.g. acoustic transponders, grout bags, temporary spool lay-down)	LOW	New / additional geographic areas affected.	5	4	LOW	5	5	LOW	Potential impact expected to be localised / contained within the near vicinity of the placement area / retrieval area
79	Seabed	Spills and Leaks	Creation of a crater in the seabed	Subsea well blow out	–	Different geographic areas potentially affected Increase in likelihood given additional wells will be drilled	5	4	LOW	5	4	LOW	If occurred, impact would be expected to be localised but depending on the size of the blow-out, could result in a long-term change in the seabed profile
80	Seabed	Spills and Leaks	Contamination of seabed sediment	Release of diesel or heavy fuel oil during refuelling (minor spill volume of ~ 2,500 L)	LOW	Different geographic areas potentially affected Increased likelihood given additional activities	6	4	LOW	6	4	LOW	Potential impacts (if any, given surface release and depth of water over most of Commonwealth Marine Area within the Fourth Train Proposal Area) is likely to be localised
81	Seabed	Spills and Leaks	Contamination of seabed sediment	Release of diesel or heavy fuel oil from accidental damage to vessel (spill volume 80,000 L)	LOW	New / additional geographic areas potentially affected Increased likelihood given additional activities	5	4	LOW	5	4	LOW	Potential impact likely to be localised and temporary given rapid degradation and dispersion of spilt hydrocarbons in warm open ocean. Modelling indicates diesel would predominantly evaporate and disperse throughout the water column, with limited quantities partitioning to the sediment phase within the Commonwealth Marine Environment

Consolidated Risk Assessment Results: Potential Impacts to the Commonwealth Marine Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
82	Seabed	Spills and Leaks	Contamination of seabed sediment	Rupture of live pipeline (during construction or once operational) or uncontrolled release from the well due to a strike from a construction or third party marine vessel	**LOW**	Different geographic areas potentially affected Increased likelihood given additional activities and pipelines	3	5	**LOW**	3	5	**LOW**	Area of potential impact localised (supported by modelling results) due to rapid degradation of condensate. Mitigation measures in place mean only a remote chance of incident occurring. Modelling indicates pipeline fluids would predominantly evaporate and disperse throughout the water column, with limited quantities partitioning to the sediment phase within the Commonwealth Marine Environment
83	Seabed	Spills and Leaks	Contamination of seabed sediment	Subsea well blow out	**LOW**	Different geographic areas potentially affected Increase in likelihood given additional wells will be drilled	5	5	**LOW**	5	5	**LOW**	Given nature of hydrocarbons in Fourth Train Proposal gas fields (gas and condensate; highly soluble etc), no sedimentation of released hydrocarbons is expected

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Consolidated Risk Assessment Results: Impacts to the Human Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
Workforce and Public Health and Safety													
1	Workforce and public health and safety	Atmospheric emissions (except dust)	Alteration of ambient air quality and creating a hazard to human health and wellbeing	Additional operational emissions	_	Extended duration of construction phase emissions from vehicles and equipment - however emissions comparatively smaller than for Foundation Project	6	5	TRIVIAL	_	_	_	Considered in the PER/Draft EIS due to potential regulator and public interest
2	Workforce and public health and safety	Fire	Pressure on public medical services in the event of a major emergency	Accident caused by simultaneous operations	_	No new ignition sources will be introduced by the Fourth Train Proposal	3	5	LOW	3	5	LOW	_
3	Workforce and public health and safety	Physical interaction	Risk of traffic accidents on the mainland between local road users and traffic associated with the Fourth Train Proposal	Transport of materials to mainland ports, resulting in increased usage of local roads	_	Extended duration of road usage	3	6	LOW	3	6	LOW	_
4	Workforce and public health and safety	Physical interaction	Risk of marine vessel incidents	Laying of the Feed Gas Pipeline System onto the seabed	_	Extended duration of heightened vessel activity in the Fourth Train Proposal Area	4	6	LOW	4	6	LOW	_
Cultural heritage													
5	Cultural heritage	Physical interaction	Damage to listed or historic shipwrecks or relics, disturbing the site context and resulting in the loss of archaeological data	Anchoring of vessels and drill rigs Installation of the Feed Gas Pipeline System and associated infrastructure	LOW	The Foundation Project had no known listed or historic ship wrecks or relics within the vicinity of drill sites. A different area is affected by the Fourth Train Proposal, however, the Fourth Train Proposal will have a limited seabed disturbance area and therefore risk for the Fourth Train Proposal is considered low	6	6	TRIVIAL	_	_	_	With the application of mitigation and management measures, the likelihood of such an impact occurring is rare Included in PER/Draft EIS due to possible regulator and public interest
6	Cultural heritage	Spills and leaks	Impacts to the cultural heritage site at the claypan environment (horizontal directional drilling site)	Release of hydrotest water containing biocides and corrosion inhibitors	_	Extended duration of construction activities during which impacts could occur No change in the type of hazardous substances required/generated for the Fourth Train Proposal	5	5	LOW	5	5	LOW	_
7	Cultural heritage	Vegetation clearing and earthworks	Destruction of, or disturbance to, cultural heritage sites at the horizontal directional drilling site	Excavation and vegetation clearing for horizontal directional drilling stringing area	LOW	Additional 10 ha of vegetation clearance and earthworks	5	4	LOW	5	4	LOW	_
Conservation areas													
8	Conservation areas	Discharges to sea	Reduction in the intrinsic value (through reduced visual amenity) of conservation areas	Discharge of liquid wastes (e.g. sewage, greywater and putrescibles wastes) from pipelay vessels	LOW	Ningaloo Reef is now listed as a World Heritage site. However, there is no change in impact from the Fourth Train Proposal	6	5	TRIVIAL	_	_	_	Impacts to conservation areas from this activity are considered to be localised with short term effects, therefore consequences
9	Conservation areas	Physical presence	Reduction in the intrinsic value (through reduced visual amenity and aesthetic value) of Barrow Island	Construction of the Feed Gas Pipeline System and Fourth Train Proposal infrastructure at the Gas Treatment Plant	LOW	The Fourth Train Proposal will extend the duration that construction activities are visible on Barrow Island. However, this is considered to be short term and there are no different impacts expected as a result of the Fourth Train Proposal	5	5	LOW	5	5	LOW	_
10	Conservation areas	Spills and leaks	Impacts to the social values of conservation areas including commercial fishing, tourism and pearling	Migration of hydrocarbons to the coast of Barrow Island or other conservation areas in the event of a leak or spill (various spill scenarios)	_	The Fourth Train Proposal will extend the period and geographical area of construction, during which there is an increased risk of accidental spills and leaks occurring	5	5	LOW	4	5	LOW	Modelling included a worst case scenario of impacts to the environment as a result of a blow-out and assumed no intervention (i.e. management of the spill)

Consolidated Risk Assessment Results: Impacts to the Human Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
	Land and sea use												
11	Land and sea use	Introduction and/or spread of Non-indigenous Terrestrial Species and/or Marine Pests	Indirect impact on fish stocks and the viability of established fisheries	Biofouling (from wetsides or from discharge of ballast water) from drill rigs, marine construction and operational maintenance vessels and additional LNG and condensate vessels	LOW	New / additional geographical areas potentially affected Increased likelihood of introduction due to increased marine vessel activities Risk of introducing Marine Pests from different regions when compared to the Foundation Project (depending on the origins of the vessels used for both projects)	4	5	LOW	4	5	LOW	Relevant to marine vessels and rigs moving from other international or regional ports. No 'high risk ballast water' allowed to be discharged within Australian Territorial Seas
12	Land and sea use	Physical interaction	Nuisance to local communities / longer journey times / damage to road infrastructure	Transport of materials to equipment and supply bases, resulting in increased usage of local roads	–	Extended duration of road use, however, the intensity of road use is expected to be the same or less than for the Foundation Project	5	4	LOW	5	4	LOW	–
13	Land and sea use	Physical presence	Adverse impacts to other oil and gas facilities	Temporary presence of construction and installation vessels in the vicinity of other oil and gas facilities	LOW	Extended duration of marine vessel activity in the Fourth Train Proposal Area	6	6	TRIVIAL	–	–	–	Activity will be temporary and consequence is incidental
14	Land and sea use	Physical presence	Displacement of, or disruption to, other users in the marine environment (i.e. commercial fishing, tourism and/or shipping)	Presence of drill rig at well sites, pipe-lay and associated marine construction vessels and establishment of petroleum exclusion zones. Additional LNG and condensate vessels	LOW	Extended duration of vessel activity and petroleum safety zones in the Fourth Train Proposal Area. New geographical areas affected	5	4	LOW	4	4	LOW	–
15	Land and sea use	Physical presence	Fishing and navigation hazard (net snagging)	Laying and long-term presence of the Feed Gas Pipeline System onto the seabed	–	New geographical areas affected	4	5	LOW	4	5	LOW	–
16	Land and Sea Use	Physical presence	Navigation or snagging hazards	Presence of the survey permanent monument frames on the seafloor	LOW	–	6	6	TRIVIAL	–	–	–	Approximately 6 frames will be used, which will be permanent during construction (approximately 4-5 years). There are no petroleum exclusion zones around the frames
17	Land and sea use	Physical presence	Obstacle and restricting access for other vessels to the area	Temporary presence of construction and installation vessels	LOW	Extended duration of vessel activity in the Fourth Train Proposal Area	6	3	LOW	6	3	LOW	–
18	Land and sea use	Physical presence	Obstruction and hindrance to other users of the sea (i.e. shipping, fishing and recreational users) resulting in them having to use alternative routes or change behaviour	Movement of additional LNG and condensate tankers to and from Barrow Island	LOW	Minor increase in number of vessel movements from 220-250 (Foundation Project) to 310-330 (Fourth Train Proposal)	6	3	LOW	6	3	LOW	–
19	Land and sea use	Physical presence	Obstruction and hindrance to other users of the sea (i.e. shipping, fishing and recreational users) resulting in them having to use alternative routes or change behaviour	Movement of vessels from supply bases and equipment yards to Barrow Island (Materials Offloading Facility/WAPET Landing)	LOW	Approximately 50 marine vessels may be used to support the construction phase of the Fourth Train Proposal	6	3	LOW	6	3	LOW	–
20	Land and sea use	Spills and leaks	Displacement of other land users (i.e. WA Oil) following a spill (short-term or long-term, depending on the magnitude of the spill)	Storage, handing and use of fuels and chemicals	–	No change in the type of hazardous substances required/generated for the Fourth Train Proposal	6	5	TRIVIAL	–	–	–	Onshore spills and leaks will be remediated when detected and experience gained through construction of the Foundation Project indicates there will be incidental impacts on other users of Barrow Island

Public

Consolidated Risk Assessment Results: Impacts to the Human Environment

Line Item	Affected Environmental Factor	Stressor	Potential Impact	Activity	Foundation Project Impact	Change Introduced by the Fourth Train Proposal	Residual Impact						Comments
							Incremental			Additional			
							C	L	R	C	L	R	
21	Land and sea use	Spills and leaks	Disruption to other sea users (i.e. commercial and recreational fishing, tourism and/or shipping) Loss of commercial fish stocks	Release of diesel or heavy fuel oil during refuelling (minor spill volume of ~ 2,500 L)	**LOW**	Extended duration of vessel activity in the Fourth Train Proposal Area Increased likelihood given additional activities	4	6	**LOW**	4	6	**LOW**	_
22	Land and sea use	Spills and leaks	Disruption to other sea users (i.e. commercial and recreational fishing, tourism and/or shipping) Loss of commercial fish stocks	Release of diesel or heavy fuel oil from accidental damage to vessel (spill volume 80,000 L)	**LOW**	Extended duration of vessel activity in the Fourth Train Proposal Area Increased likelihood given additional activities	5	4	**LOW**	5	4	**LOW**	_
23	Land and sea use	Spills and leaks	Disruption to other sea users (i.e. commercial and recreational fishing, tourism and/or shipping) Loss of commercial fish stocks	Rupture of live pipeline (during construction or once operational) or uncontrolled release from the well due to a strike from a construction or third party marine vessel	_	New geographical areas affected Increased likelihood given additional activities and pipelines	2	6	**LOW**	2	6	**LOW**	_
24	Land and sea use	Spills and leaks	Disruption to other sea users (i.e. commercial and recreational fishing, tourism and/or shipping) Loss of commercial fish stocks	Subsea well blow out	_	New / additional geographical areas potentially affected Increase in likelihood given additional wells will be drilled	2	6	**LOW**	2	6	**LOW**	_
	Livelihoods												
25	Livelihoods	Physical presence	Creation of labour opportunities	Demand for additional operational labour	_	Additional personnel will be required during the construction and operational phases of the Fourth Train Proposal	_	_	**POSITIVE**	_	_	**POSITIVE**	_
26	Livelihoods	Physical presence	Creation of demand for labour, contractors and suppliers	Engagement of contractors and labour for construction of the Fourth Train Proposal infrastructure	_	Extended duration of construction activities	_	_	**POSITIVE**	_	_	**POSITIVE**	_
	Local communities												
27	Local communities	Physical presence	Increased demand on services in regional centres	Additional personnel requiring transfers to and from Barrow Island	_	Additional personnel required during the construction and operation of the Fourth Train Proposal	5	4	**LOW**	5	4	**LOW**	_
28	Local communities	Physical presence	Increased traffic levels near mainland supply bases	Transport of materials to mainland ports, resulting in increased usage of local roads	_	Extended duration of road use	5	4	**LOW**	5	4	**LOW**	_
	Commonwealth, State and Regional Economy												
29	Commonwealth, State and Regional economy	Physical presence	Creation of additional expenditure and revenues that will contribute to the national, State and regional economy	Sale of additional LNG produced by the Fourth Train Proposal	_	Additional revenue created by the Fourth Train Proposal	_	_	**POSITIVE**	_	_	**POSITIVE**	_
30	Commonwealth, State and Regional	Physical presence	Creation of demand for labour, contractors and suppliers	Engagement of contractors and labour for construction of the Fourth Train Proposal infrastructure	_	Extended duration of construction activities resulting in longer period that construction workforce/contractors will be required	_	_	**POSITIVE**	_	_	**POSITIVE**	_

Appendix G: Foundation Project Incidents Relevant to the Assessment of the Fourth Train Proposal

Foundation Project Incidents Relevant to the Assessment of the Fourth Train Proposal

To inform the assessment of potential impacts to EPBC Act listed fauna as a result of the Fourth Train Proposal, incidents that have occurred on the approved Gorgon Foundation Project during activities that are relevant to the Fourth Train Proposal are collated in this Appendix (Table G-2). In line with the approved Foundation Project Environmental Management Plans, the following are classified as incidents:

- Material or Serious Environmental Harm outside the Terrestrial or Marine Disturbance Footprint attributable to the Gorgon Gas Development or Jansz Feed Gas Pipeline
- Significant Impact detected by the monitoring programs for matters of National Environmental Significance attributable to the Gorgon Gas Development and Jansz Feed Gas Pipeline
- harm or mortality to EPBC Act listed terrestrial or marine species attributable to the Gorgon Gas Development (irrespective of whether attributable or not at the horizontal directional drilling site)
- all Level 1, 2, or 3 quarantine incidents (Table G-1)
- spill to sea of >80 L of hydrocarbons or hazardous chemicals; unplanned gaseous release to atmosphere of 500 m^3 or more; any spillage of hydrocarbons or other material (e.g. drilling fluid, chemicals) that affects a ground surface area greater than 100 m^2; ignition of petroleum or other material associated with Horizontal Directional Drilling activities
- an uncontrolled gaseous release to atmosphere of 300 kg (~235 m^3 at standard atmospheric pressure) or more during the offshore gas feed pipeline installation
- all project-attributable fires.

Table G-1: Quarantine Incident Levels

Level 1 Quarantine Incidents
• The detection after final quarantine clearance of a confirmed Non-indigenous Terrestrial Species or Marine Pest on freight, people, vessels, or aircraft within and confined to the Quarantine Terrestrial Controlled Access Zone • Declaration of a quarantine incident is subject to the positive identification of a suspect specimen as a Non-indigenous Terrestrial Species or Marine Pest • The detection of species in the Limited Access Zone where the invasive risk of such species is assessed to be low • Records of new populations of existing weed species (i.e. proliferation of existing weeds) on Barrow Island due to Foundation Project activities
Level 2 Quarantine Incidents
• The detection of a confirmed Non-indigenous Terrestrial Species or Marine Pest in the Quarantine Terrestrial Limited Access Zone on Barrow Island, except where the species is assessed to be low risk (see Level 1) • The declaration of a quarantine incident is subject to the positive identification of a suspect specimen as a Non-indigenous Terrestrial Species or Marine Pest.
Level 3 Quarantine Incidents
• The detection of a confirmed Non-indigenous Terrestrial Species or Marine Pests in the Quarantine Terrestrial Restricted Access Zone on Barrow Island, except where the species is assessed to be low risk (see Level 1) • The declaration of a quarantine incident is subject to the positive identification of a suspect specimen as a

	Non-indigenous Terrestrial Species or Marine Pest
•	The detection of a Non-indigenous Terrestrial Species or Marine Pest in any Access Zone on Barrow Island where the invasive risk of such species is assessed to be high

Table G-2: Breakdown of Relevant Reportable Incidents by Environmental Performance Report Reporting Period

Note: The information in this table is condensed from the annual Gorgon Environmental Performance Reports (Chevron Australia 2009, 2010, 2011, 2012, 2013)

Incident Type	2008–2009	2009–2010	2010–2011	2011-2012	2012-2013
Spills and leaks incidents associated with the Horizontal Directional Drilling Management Plan	No incidents	No incidents	No incidents	Ten Level 1 spills. Six of the spills were within the marine disturbance footprint at the horizontal directional drilling site. Four spills occurred onshore at the horizontal directional drilling site.	No incidents
Fires	No incidents	No incidents	Four fires within the Foundation Project terrestrial disturbance footprint (TDF)	Six fires within the Foundation Project TDF	Eleven fires within the Foundation Project TDF. One of these fires extended outside the Foundation Project TDF.
Harm or mortality to EPBC Act listed species	No incidents	124 EPBC Act threatened or listed fauna recorded as deceased and one recorded as injured and cared for	317 EPBC Act threatened or listed fauna recorded as deceased and one recorded as injured and cared for	478 EPBC Act threatened or listed fauna recorded as deceased and six injured or cared for within common use areas where the responsible group (Gorgon or WA Oil) was unknown; 71 EPBC Act threatened or listed fauna recorded as deceased	383 EPBC Act threatened or listed fauna recorded (recorded as injured, cared for, and deceased) within the Gorgon Project Terrestrial Disturbance Footprint and 42 EPBC Act Threatened or Listed Fauna recorded where the responsible group (Gorgon or WA Oil) is unknown
Marine turtle harm or mortality	No incidents	Four marine turtles deceased	Two marine turtles deceased and one injured	Five marine turtles deceased and three injured	One marine turtle deceased.
Quarantine incidents	No incidents	One Level 2 incident	12 Level 1 and 17 Level 2 quarantine incidents	37 Level 1 quarantine incidents	42 Level 1 quarantine incidents and one Level 2 quarantine incident

References

Chevron Australia. 2009. *Statement No. 748 Environmental Performance Report September 2008 – September 2009*. Chevron Australia, Perth, Western Australia.

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