Wheatstone Project

Trunkline Installation Environmental Monitoring and Management Plan

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ACRONYMS, ABBREVIATIONS AND TERMINOLOGY

ANSIA	Ashburton North Strategic Industrial Area
ADCP	Acoustic Doppler Current Profiler
AHT	Anchor Handling Tug
ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agricultural and Resource Management Council of Australia and New Zealand
AS/NZS	Australian/New Zealand Standard
AWTI	Above Water Tie In
BACI	Before/After/Control/Impact
Backfill	Trunkline stabilisation will involve covering the trunkline with sand and/or rock to prevent movement in storm or cyclonic conditions.
BHD	Backhoe Dredge
BPP	Benthic Primary Producers; 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.
BPPH	Benthic Primary Producer Habitat; 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. BPPH also include areas of seabed that can support these communities.
CAR	Compliance Assessment Report
CEO	Chief Executive Officer of the Office of the Environmental Protection Authority
Chevron	Chevron Australia Pty Ltd
CPCe	Coral Point Count with Excel extensions
CSD	Cutter suction dredge
CSFM	Conservation Significant Marine Fauna; specifically marine mammals, marine turtles, whale sharks and sawfish
CSMFIMP	Conservation Significant Marine Fauna Interaction Management Plan
Cth	Commonwealth
Coral EPO Assessment	An assessment of achievement of the coral EPOs described in Condition 8-7 (iii) and (vi) undertaken at the mid-term and post development works and in the event of a Level 3 management trigger exceedence.
CWR	Centre for Whale Research
DDF	Direct Disturbance Footprint; the area which will be directly removed during trunkline installation activities
DDSPEMMP	Dredging and Spoil Disposal Placement Environmental Monitoring and Management Plan
DEC	Department of Environment and Conservation (WA) – now the Department of Parks and Wildlife
DEH	Department of Environment and Heritage (Cth)
DEWHA	Department for the Environment, Water, Heritage and the Arts (Cth) – formerly DEH

DGPS	Differential Global Positioning System
Domgas	Domestic gas
DotE	Department of the Environment
DP	Dynamic Positioning
DPA	Dampier Port Authority – now Pilbara Port Authority
DPaW	Department of Parks and Wildlife
Draft EIS/ERMP	The Environmental Impact Statement/Environmental Review and Management Programme
DSPS	Dredge Spoil Placement Site
Dredging	Refer to *Trenching*.
DTAP	Dredging Technical Advice Panel
EAG	Environmental Assessment Guideline
EIS	Environmental Impact Statement
EIS/ERMP	Environmental Impact Statement / Environmental Review and Management Programme
EP Act (WA)	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority (WA)
EPBC Act (Cth)	*Environmental Protection and Biodiversity Conservation Act 1999*
EPBC 2008/4469	The Commonwealth Primary Environmental Approval and conditional requirements for the Wheatstone Project. Commonwealth Government of Australia, Minister for Sustainability, Environment, Water, Populations and Communities, Hon. Tony Burke, 22 September 2011, as amended from time to time.
EPO	Environmental Protection Outcomes (as defined in MS 873)
EQO	Environmental Quality Objective
EQC	Environmental Quality Criteria
Final EIS/RTS	Final Environmental Impact Statement/Response to Submissions on the Environmental Review and Management Programme
FPV	Fall Pipe Vessel
GPS	Global Positioning System
ha	hectare(s)
Irreversible Loss	Loss refers to direct removal or destruction of benthic primary producer habitat. Irreversible loss is when the direct modification of benthic primary producer habitat has a significant impact such that the benthic primary producer habitat would not be expected to recover to the pre-impact state. As defined in EAG #3
km	Kilometre(s)
KP	Kilometre Point
LAT	Lowest Astronomical Tide
LAU	Local Assessment Units
LNG	Liquefied Natural Gas
m	Metre(s)

Management triggers	Management trigger indicators used to implement appropriate management actions in an adaptive management process. These are not used as a compliance matter.
Marine mammals	Whales, dugongs and coastal dolphins
Marine fauna	Whales, dolphins, dugongs and marine turtles
MFO	Marine Fauna Observer; A suitably trained and dedicated person engaged to be on duty on vessels actively engaged in dredging during all daylight hours when dredging is conducted
Mm^3	Million cubic metres
MO	Management Objective (as defined in MS 873)
Monitored Reef formations	Reef formations within the Project adjacent to which water quality data will be collected for the Responsive Monitoring Programme, and upon which BPPH data will be collected for the Verification Monitoring Programme, as illustrated in Figure 6.5
MODIS	Moderate Resolution Imaging Spectroradiometer
MOF	Materials Offloading Facility
MS 873	Ministerial Statement No. 873: The State (WA) Primary Environmental Approval, and conditional requirements for the Wheatstone Project. Government of Western Australia, Minister for the Environment; Water, Hon. Bill Marmion MLA, 30 August 2011 as amended by MS 903 and amended from time to time.
MS 903	Ministerial Statement No. 873: The State (WA) Statement to amend conditions applied to the Wheatstone Project. Government of Western Australia, Minister for the Environment; Water, Hon. Bill Marmion MLA, 6 July 2012.
MTPA	Million tonnes per annum
NADG	National Assessment Guidelines for Dredging
Nearshore	Marine habitat from the 20 m contour to the shoreline
Nearshore facilities	Includes the shipping channel, product loading facility, materials offloading facility, Dredge Spoil Disposal Site A and discharge lines.
NES	National Environmental Significance (see Table 3.2)
NTU	Nephelometric Turbidity Units
OEPA	Office of Environmental Protection Authority (WA)
Offshore	Marine habitat beyond the 20 m contour to the shoreline
Offshore facilities	Includes the shipping channel, dredge spoil disposal sites B, C, D and E and produced water outfall.
PAR	Photosynthetically active radiation
PIO	Pilbara Offshore bioregion
(The) Plan	Trunkline Installation Environmental Monitoring and Management Plan
PLF	Product Loading Facility
PPA	Pilbara Port Authority – formerly Dampier Port Authority
Practicable	Means reasonably practicable having regard to, among other things, local conditions and circumstances (including costs) and to the current state of technical knowledge (taken from the EP Act)
Project	The Wheatstone Project as assessed and approved under MS 873 and EPBC 2008/4469.

Proponent	Chevron Australia Pty Ltd
PSD	Particle Size Distribution
QA/QC	Quality Assurance and Quality Control
Responsive Management	Management undertaken for adaptive management and includes corrective actions as detailed in Section 6.3.2
Responsive Monitoring	Monitoring undertaken to inform adaptive environmental management as detailed in Section 6.4.1
ROV	Remote Operated Vehicle
Serious Damage	‘Serious damage’ is intended to apply to damage to benthic primary producer habitat that is effectively irreversible or where recovery, if that can be reasonably predicted at all, would not occur for at least 5 years. As defined in EAG #3
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Cth) – now the Department of the Environment
SDP	Sea Dumping Permit
SMFG	Size Management Fish Grounds
SoW	Scope of Works
SSC	Suspended Sediment Concentration
SSDV	Side Stone Dumping Vessel
Suitably trained and dedicated person	The person has demonstrated knowledge (detailed in MS 873 Condition 10-1) in marine fauna observation, distance estimation and reporting and must not have any other duties while engaging in visual observations of marine fauna
TBM	Tunnel Boring Machine
TSHD	Trailing suction hopper dredge
TSS	Total Suspended Solids
Trenching	Includes all activities associated with the capital dredging and disposal of material including: the excavation or dredging of the material, the loading and carriage of dredge spoil for the purpose of dumping and the dumping of the material at the prescribed spoil grounds for the trunkline activities.
TRIP	Trunkline Route and Infrastructure Plan
Trunkline installation activities	Means the key activities undertaken in the marine environment required for the installation of the trunkline in State waters.
Turbidity–generating activities associated with trunkline installation	Is a subset of trunkline installation activities (see per definition above) and means dredging and trenching for trunkline installation, dredge spoil disposal and rock/sediment dumping for pipeline stabilisation
UKC	Under Keel Clearance
WA	Western Australia
ZoHI	Zone of High Impact. As defined in the Approved Trunkline Route and Installation Plan (Figure 5.13)

ZoI	Zone of Influence. As defined in the Approved Trunkline Route and Installation Plan (Figure 5.13)
ZoMI	Zone of Moderate Impact. For the purposes of this Plan the Zone of Moderate Impact is as defined in the Approved Trunkline Route and Installation Plan (Figure 5.13). The Zone of Moderate Impact as defined in EPBC 2008/4469 applies to the seagrass sampling under the Dugong Research Plan and is not relevant to this Plan.

1.0 INTRODUCTION

1.1 Wheatstone Project

Chevron Australia Pty Ltd (Chevron Australia) will construct and operate a multi-train Liquefied Natural Gas (LNG) facility and domestic gas (Domgas) plant near Onslow on the Pilbara Coast, Western Australia. The Wheatstone Project (the Project) will process gas from various fields located offshore in the West Carnarvon Basin. Ashburton North Strategic Industrial Area (ANSIA) is the approved site for the LNG and Domgas plants.

The Project requires installation of gas gathering, export and processing facilities in Commonwealth and State waters and on land. The initial Project will produce gas from Production Licences WA-46-L, WA-47-L and WA-48-L, 145 km offshore from the mainland, approximately 100 km north of Barrow Island and 225 km north of Onslow, and will also process gas from Production Licence WA-49-L operated by Apache Corporation. Figure 1.1 shows the location of the Project.

The ANSIA site is located approximately 12 km south-west of Onslow along the Pilbara coast within the Shire of Ashburton. The initial Project will consist of two LNG processing trains, each with a capacity of approximately 4.45 million tonnes per annum (MTPA). Environmental approval was granted for a 25 MTPA plant to allow for the expected further expansions. The Domgas plant will be a separate but co-located facility and will form part of the Project. The Domgas plant will tie-in to the existing Dampier-to-Bunbury Natural Gas Pipeline infrastructure via third party DBP Development Group Pty Ltd Domgas pipeline. Figure 1.2 shows the onshore and nearshore project footprint.

1.2 Proponent

Chevron Australia is the proponent and the company taking the action for the Project on behalf of its joint venture participants Apache Corporation, PE Wheatstone Pty Ltd a company part-owned by Tokyo Electric Power Company, Kuwait Foreign Petroleum Exploration Company and Kyushu Electric Power Company.

1.3 Objectives

The objectives of the Trunkline Installation Environmental Monitoring and Management Plan (the Plan) are to:

- Manage the impacts to matters of national environment significance (Table 3.2), associated with dredging required for the Project

  and

- Ensure that turbidity–generating activities associated with trunkline installation:
  - i. Achieve the environmental protection outcomes (EPOs) set in WA Ministerial Statement No. 873 (MS 873), Condition 8-7 or any approved revised EPOs (Table 1.1)
  - ii. Are managed with the aim of achieving the management objectives (MOs) set out in Condition 8-8 (Table 1.1).

Table 1.1: Environmental Protection Outcomes and Management Objectives as Required by WA Ministerial Statement No. 873

No.	Condition
8-7	The Proponent shall undertake turbidity-generating activities associated with trunkline installation in State waters consistent with the approved Trunkline Route and Infrastructure Plan and ensure that each of the following environmental protection outcomes are achieved:
i.	no irreversible loss of, or serious damage to, macroalgal habitats due to the installation of the trunkline
ii.	no irreversible loss of, or serious damage to, seagrass habitat outside of the Trunkline Direct Disturbance Footprint
iii.	no irreversible loss of, or serious damage to, coral habitats outside of the Zone of High Impact
iv.	no irreversible loss of, or serious damage to filter feeder habitats outside of the Zone of High Impact
v	no detectible net negative change from the baseline state of seagrass habitats determined by implementing Condition 7, outside of the Zone of High Impact
vi	no detectible net negative change from the baseline state of filter feeder and macroalgal habitats determined by implementing Condition 7, outside the Zone of High Impact and the Zones of Moderate Impact
vii.	no detectable reduction of net live coral cover within the Zones of Influence, including reef formations at Ashburton Island and Brewis Reef,
	unless and until, at a specified site(s), outside the Zones of Moderate Impact or reef formations at Ashburton Island or Brewis Reef or site(s) in the Zones of Moderate Impact, a revised environmental protection outcome has been approved to have effect for that specified site(s) or reef formation(s) by the Minister in accordance with Condition 8-16, in which case the approved revised environmental protection outcome for the specified site(s) or designated reef formation(s) shall be achieved due to turbidity generating activities associated with trunkline installation.
8-8	Notwithstanding the Environment Protection Outcomes specified in Condition 8-7 which the Proponent must achieve, the Proponent shall design and execute trunkline installation activities in State waters with the aim of achieving the following management objectives:
i.	irreversible loss of, and serious damage to, benthic habitats is restricted to the area within the Trunkline Direct Disturbance Footprint (excluding macroalgal habitats to which there shall be no irreversible loss or serious damage)
ii.	impacts to the marine environment within the Zones of Moderate Impact are minimised to the greatest extent practicable
iii.	cumulative impacts from turbidity-generating activities associated with trunkline installation undertaken simultaneously with turbidity-generating activities associated with the construction of the nearshore and offshore marine facilities are managed so as to achieve the environmental protection outcomes set in Condition 8-7 and Condition 6-1 (or any approved revised environmental protection outcomes).

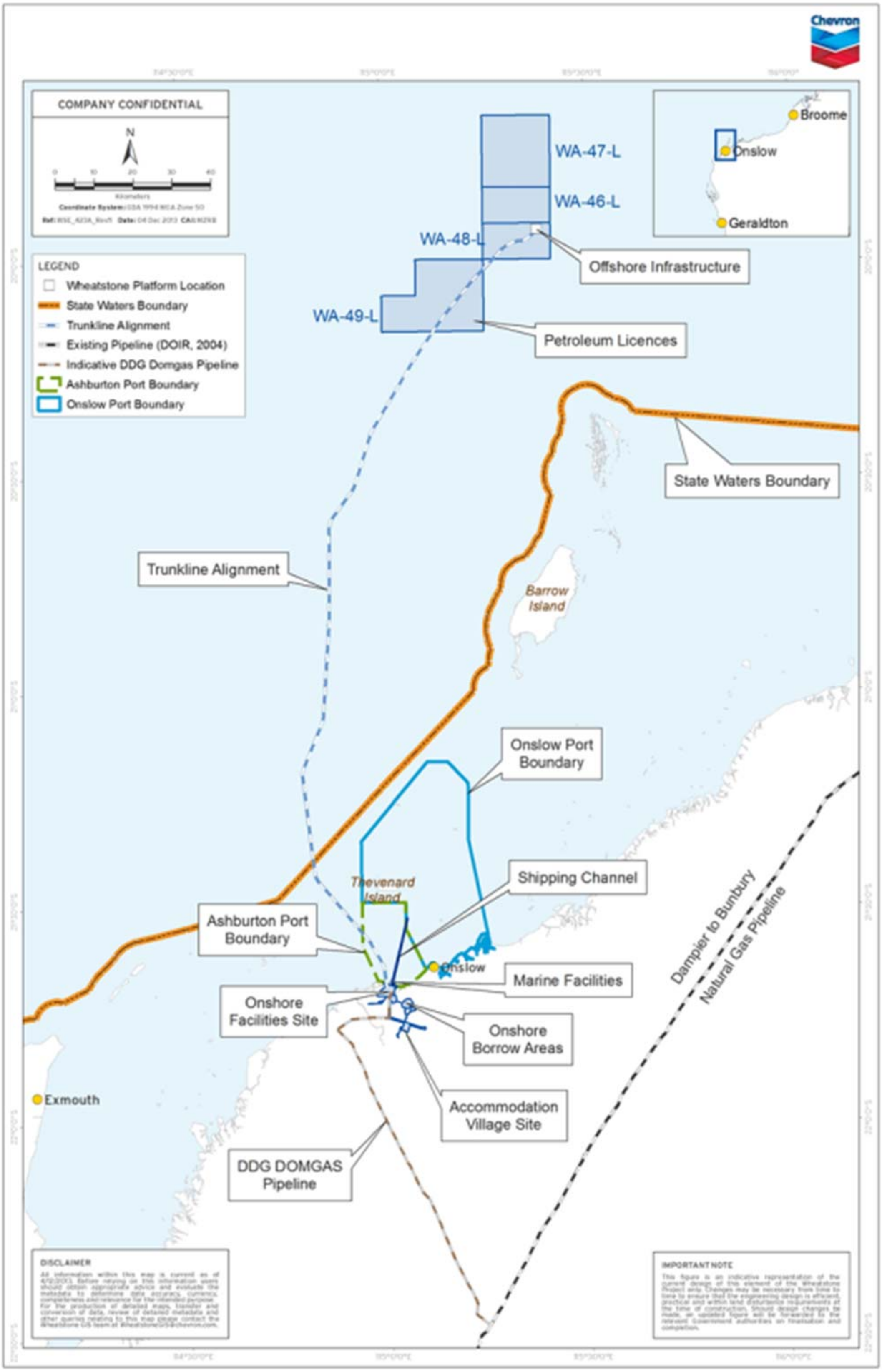

Figure 1.1: Location of Wheatstone Project Infrastructure

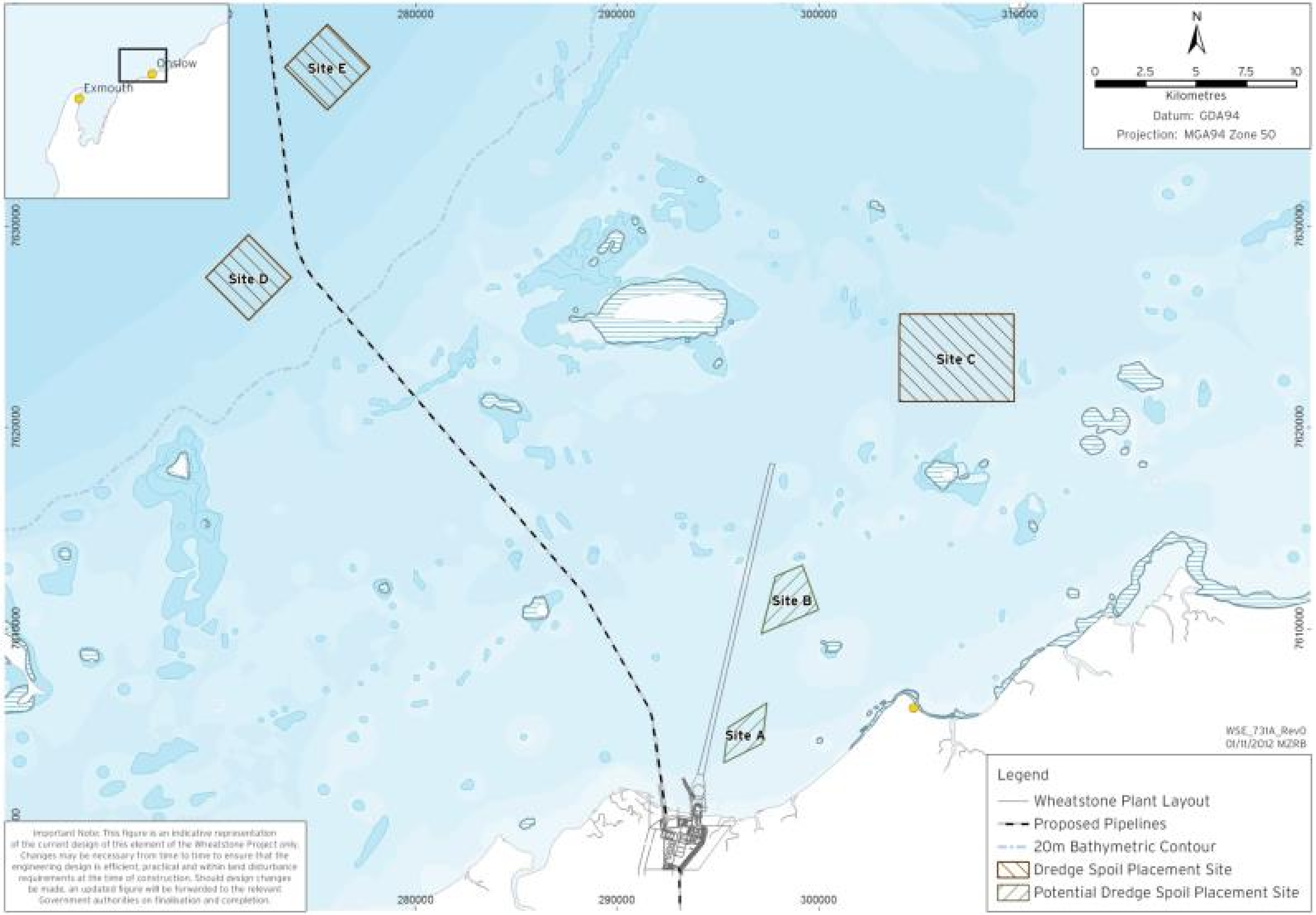

Figure 1.2: Nearshore Project Infrastructure

1.4 Scope

The Plan has been prepared to address the potential impacts from trunkline installation activities in accordance with Condition 8-9 of MS 873 and Condition 10 of EPBC 2008/4469 (Table 1.2; Table 1.3) of the Project.

Chevron Australia will meet Condition 10 and 11 of EPBC 2008/4469 through the submission of two environmental monitoring and management plans, to better align with requirements under MS 873:

1. This Plan, the Trunkline Installation Environmental Monitoring and Management Plan (TIEMMP), to manage trunkline installation activities.
2. Dredging and Dredge Spoil Placement Environmental Monitoring and Management Plan (DDSPEMMP), to manage turbidity-generating activities which are part of the construction of the nearshore and offshore marine facilities.

The separation of the dredging activities into two separate environmental monitoring and management plans does not affect the objectives of the Plans or the EPOs as they are directly related to distinct dredging activities, being those turbidity generating activities which are part of the construction of nearshore and offshore marine facilities and, separately, those that are part of the trunkline installation. Cumulative impacts from the dredging for the nearshore marine facilities, offshore marine facilities and the trunkline installation are dealt with within this Plan in order to achieve the MO as specified in Condition 8-8 of MS 873 (Section 11.0). The Minister has allowed the submission of the DDSPEMMP and TIEMMP to meet Condition 10 and 11 of EPBC 2008/4469 as per the letter dated 19 October 2012.

The following installation activities which are relevant to this plan are the trenching (dredging) and stabilisation (including sourcing sand from an offshore area and the sand and rock backfill), microtunnel exit pit construction, tunnel boring machine (TBM) retrieval, pipe lay and spoil placement activities at dredge spoil placement sites (DSPSs) – C, D and E. The following activities are excluded from this Plan:

- Dredging for the shipping channel, Product Loading Facility (PLF); Materials Offloading Facility (MOF); and associated spoil placement activities at DSPS (A to E) which are dealt with in the DDSPEMMP (Chevron 2012d).

Condition 23 of MS 873 allows this plan to be submitted and approved for stages of a facility or activity. This plan covers all trunkline installation activities with the exception of the activities required to source sand backfill material and manage the laybarge anchoring. An update to this plan, or a supplementary plan, which addresses the conditions relevant to these activities will be submitted for approval prior to commencing those activities. The timing, nature and potential locations of these activities means they will not have impacts, including cumulative impacts, which are relevant for consideration under this plan.

This plan covers both Commonwealth and State waters however the only management measure required in Commonwealth waters are marine fauna management measures associated with dredge spoil placement at dredge spoil placement site (DSPS) E which is covered in Section 9.0. This is because the only dredging activity in Commonwealth waters is placement of dredge spoil at DSPS E. No management measures to reduce turbidity and afford protection to coral reefs and seagrass are required when placing dredge spoil at DSPS E due to the lack of coral reefs and seagrass at those depths and therefore there are no predicted impacts to those benthic communities.

1.5 Environmental Approvals

The Project was assessed through an Environmental Impact Statement / Environmental Review and Management Programme (EIS/ERMP) assessment process under the WA *Environmental Protection Act 1986* (EP Act) and the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Project was approved by the WA Minister for Environment; Water on 30 August 2011 by way of Ministerial Statement No.873 (MS 873) and as amended by Ministerial Statement No. 903 (MS 903), Ministerial Statement No.922 (MS 922), Ministerial Statement No.931 (MS 931) and Attachments 1 to 4. Revised Environmental Protection Outcomes under Condition 8-7 to allow for trunkline installation were approved by the Minister by way of letter dated 30 January 2013. The Commonwealth Minister for Sustainability, Environment, Water, Population and Communities approved the Project on 22 September 2011 (EPBC 2008/4469) with variations to EPBC 2008/4469 Conditions 44, 45, 55, 56 and 66 made pursuant to section 143 of the EPBC Act. Other amendments may be made from time to time and where relevant will be reflected in the next revision of this Plan.

The Project, including the installation of the trunkline component, also involves the placement of dredge spoil at sea within both Commonwealth and State waters and therefore requires a Sea Dumping Permit (SDP) under the *Environmental Protection (Sea Dumping) Act 1981*. The identified environmental impacts related to the SDP for the management of dredge spoil management were assessed as part of the EIS/ERMP under the EPBC Act, as agreed with the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC, now the Department of the Environment [DotE]). Approval to undertake sea dumping was granted through SDP 2011/2102.

This Plan has been prepared to meet the following requirements for both MS 873 and EPBC 2008/4469, as per the Note[1] in EPBC 2008/4469:

- Prior to the commencement of trunkline installation activities and consistent with the Trunkline Route and Infrastructure Plan (TRIP) required by Condition 8-1, unless otherwise approved by the Chief Executive Officer (CEO) of the Office of Environmental Protection Authority (OEPA), the Proponent shall submit a Trunkline Installation Environmental Monitoring and Management Plan that meets the objectives set out in Condition 8-10 to be approved by the CEO (Condition 8-9 of MS 873).
- The person taking the action must submit a DDSPEMMP to the Minister (Condition 10 of EPBC 2008/4469)[2].

The sections in this Plan which are noted (Table 1.3) to meet the conditions of EPBC 2008/4469 shall be read and interpreted as only requiring implementation of EPBC 2008/4469 for managing the impacts of the dredging on, or protecting, the EPBC Act matters listed in Table 3.2. The implementation of matters required only to meet the

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[1] If a condition of another approval held by the proponent requires submission of a plan that meets the requirements of condition 10, the proponent may simultaneously meet the relevant requirements of both conditions by submitting a single plan.

[2] This Plan along with the Dredging and Dredge Spoil Placement Environmental Monitoring and Management Plan prepared to manage turbidity-generating activities which are part of the construction of nearshore and offshore marine facilities, together meet condition 10 of EPBC 2008/4469.

requirements of MS 873 are not the subject of EPBC 2008/4469. Similarly, the implementation of matters required only to meet the requirements of EPBC 2008/4469 are not the subject of MS 873.

This Plan has been developed to meet the relevant environmental conditions within the State Ministerial Statement (MS 873) (Table 1.2) and Commonwealth conditions (EPBC 2008/4469) (Table 1.3).

Table 1.2: WA Ministerial Statement No. 873 Requirements for this Plan

No.	Condition	Section
8-10	The objectives of the Trunkline Installation Environmental Monitoring and Management Plan are to ensure that turbidity-generating activities associated with trunkline installation, in State waters: i. Achieve the environmental protection outcomes set in condition 8-7(or any approved revised environmental protection outcome); and ii. Are managed with the aim of achieving the management objectives set out in condition 8-8.	
8-11	The The Trunkline Installation Environmental Monitoring and Management Plan shall include:	
i.	information describing the actual trunkline route to be used consistent with the approved Trunkline Route and Infrastructure Plan;	Section 2.1
ii.	descriptions of key trunkline installation activities, including information about where and when each activity will occur consistent with the approved Trunkline Route and Infrastructure Plan;	Section 2.2
iii.	descriptions of monitoring sites, including key physical attributes, geographic locations and measures of the baseline condition of benthic communities to be monitored	Figure 6.5 Table 6.5 Table 6.5
iv.	the monitoring methodologies to be applied, unless otherwise approved by the CEO to:	
a.	measure relevant physical indicators (e.g. water currents, water quality conditions including turbidity, photosynthetic radiation and light attenuation coefficient, and sediment production and deposition rates) at a frequency to allow near-real time dredge management and the validation and calibration of numerical models that may be used to assist in the management of dredging activities; and	Section 6.4.1 and 7.3.1
b.	measure relevant biological indicators for environmental management (e.g. live coral cover, coral mortality) at a frequency of approximately not less than each 14 days (depending on weather conditions and the biological indicators);	Section 6.3.2
v.	the measures, procedures and monitoring strategy to be applied for monitoring achievement of the environmental protection outcomes set in accordance with Conditions 8-7(iii) and (vi) (or any approved revised environmental protection outcome that may apply);	Section 6.4.1.2
vi.	evidence demonstrating that the design of the monitoring strategy applied to determine achievement of environmental protection outcomes set in accordance with Conditions 8-7(iii) and (vi) (or any approved revised environmental protection outcome that may apply) is based on tests using appropriate effect size(s) and has statistical power value of at least 0.8 or an alternative value as determined by the CEO;	Section 6.4.1.2
vii.	the trigger indicators, values and circumstances that shall be applied to determine whether the management objectives detailed in condition 8-8 are being achieved;	Section 6.3.1 and 7.2.1 and 11.0
viii.	a risk-based tiered approach to management of the environmental impacts of trunkline installation activities	Section 6.3.2 and 7.2.1

No.	Condition	Section
ix.	management actions that will be implemented in the event that tiered management trigger levels for the various indicators being monitored are not being achieved;	Section 6.3.2
x.	methods and procedures that will be implemented to regularly characterise, spatially-define and report the realised Zone of Influence caused by turbidity-generating activities associated with trunkline installation;	Section 6.4.1.2
xi.	procedures to be implemented to minimise the environmental impact of trunkline installation vessel operations, including vessel anchoring;	Section 5.0; Section 6.0 to 11.0 Table 9.1
xii.	coral reproductive status monitoring to assist with predicting the timing and duration of coral spawning events; and	Section 8.3
xiii.	reporting requirements.	Section 12.0
8-12A	The Proponent shall provide relevant stakeholders with a draft copy of the Trunkline Installation Environmental Monitoring and Management Plan required under Condition 8-9 and provide those stakeholders a reasonable opportunity to comment on the plan before it is submitted to the CEO for approval under Condition 8-9.	Section 1.7
10-12 i	a description of the environmental stressors relating to the construction….of nearshore and offshore marine facilities…which are likely to impact on marine fauna (environmental stressors may include, but are not limited to….dredge entrainment…)	Section 9.0
10-12 ii	a description of design features and management actions which the Proponent will implement to avoid, or where this is not practicable, mitigate impacts of the environmental stressors relating to the construction and operation of nearshore and offshore marine facilities, trunkline and Onshore Facility on conservation significant marine fauna (for example, darkness strategies that avoid, or where this is not practicable, the impact of lights or light glow from the construction and operations of the Proposal, vessels and offshore accommodation vessel, interfering with female turtles and hatchlings);	Section 9.0
10-12 iii	environmental performance standards to determine whether the design features and management actions are achieving the plan objectives referred to in Condition 10-11; and	Section 9.0
10-12 iv	a process (including a monitoring programme) to determine that the environmental performance standards are being achieved.	Section 9.0

Table 1.3: Commonwealth Ministerial Conditions EPBC 2008/4469 Requirement for this Plan

No.	Condition	Section
11	The DDSPEMMP [and TIEMMP] must include the following:	
a.	Consideration and analysis of different dredging mitigation measures, which have the potential to reduce the impact on coral reefs, mapped seagrass beds or other dugong (*Dugong dugon*) habitat	Section 2.3; 5.1.2[3]
b.	Consideration of any data collected through the Dugong Research Plan, referred to at Condition 37, and implementation of adaptive management measures, if applicable	Section 9.0
c.	A monitoring program, management triggers and corrective actions to manage impacts to coral reefs, seagrass and dugongs, taking into consideration the revised modelling referred to at Condition 9, any data collected through the Dugong Research Plan referred to at Condition 37 and any seagrass surveys that are undertaken. *Note: For the purposes of clarification, Condition 11 (c) does not require that seagrass presence or health is used as a specific management trigger.*	Section 6.0; 7.2.1; 7.3.1
d.	A commitment to cease dredging activities at least 3 days prior to the predicted commencement of mass coral-spawning, or as soon as mass coral spawning is detected, if prior to the predicted time, and to only recommence dredging activities after at least 7 days have passed since the commencement of mass coral spawning unless 11 e. applies.	Section 8.2
e.	The Minister may approve in writing, a reduction in the period over which dredging must cease (refer Condition 11 d), if the person taking the action provides peer-reviewed scientific evidence that demonstrates that if dredging activities were to continue during mass coral spawning events, any effect, if it were to occur, would not significantly impact the functional ecology of local and regional reefs.	Section 8.2
f.	Adaptive management processes.	Section 6.0
g.	Operating procedures to minimise injury to, or mortality of, EPBC Act listed threatened or migratory species from dredging or nearshore facilities construction.	Section 9.0
h.	Reporting within one business day to the Minister when injury to, or mortality of, an EPBC Act listed threatened or migratory species occurs from dredging activities.	Section 12.0

Note: The modelling has been re-run and the relevant results have been incorporated into this plan to meet Condition 9 (EPBC 2008/4469)

1.6 Relationship between Ministerial Requirements

This Plan details the methods to assess achievement of EPOs 8-7 (iii) and (vi). The results from these assessments will be used to reactively manage the turbidity–generating activities associated with the trunkline installation. The data collected under this plan will be used to assess achievement of the EPOs 8-7 (iii) and (vi) for Ministerial Condition 8-13.

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[3]. The modelling undertaken for the trunkline dredging (trenching) has indicated limited impacts on coral reefs, mapped seagrass beds or other dugong habitats.

To the extent of any differences or inconsistencies between this Plan and the State of the Marine Environment Scope of Works (SoW), with respect to the assessment of achievement of Conditions 8-7 (iii) and (vi) this Plan will take precedence.

The survey data collected under the State of the Marine Environment SoW (Chevron 2012a) will be used to assess the achievement of the EPOs in Condition 8-7 (i), (iiia), (iv) and (v), at the mid-term, post development and potentially 2nd post development survey. In the event of any differences or inconsistencies, with respect to the assessment of achievement of Conditions 8-7 (i). (ii), (iiia), (iv) and (v), between this Plan and the State of the Marine Environment SoW, the State of the Marine Environment SoW will take precedence. The survey data collected under the TIEMMP may be used to assist in the interpretation of achievement of the EPOs assessed through the State of the Marine Environment SoW (Table 1.4).

Table 1.4: Relationship between Variables and the Assessment of the Achievement of EPOs in Conditions 8-7

Variable	Condition	Timing of Assessment
Coral		
	8-7 iii. no irreversible loss of, or serious damage to, coral habitats outside of the Zone of High Impact;	1. During Dredging (Interim assessment; Condition 8-9 TIEMMP)* 2. Mid term (interim assessment)/Post Development and potentially 2nd Post Development (Condition 7 under the State of the Marine Environment - SoW)*
	8-7 vi. no detectable reduction of net live coral cover within the Zones of Influence, including reef formations at Ashburton Island and Brewis Reef,	1. During trunkline installation activities (Condition 8-9 TIEMMP) 2. Mid term/Post Development and potentially 2nd Post Development (Condition 7 under the State of the Marine Environment - SoW)
Seagrass, macroalgae and filter feeders		
	8-7 i. no irreversible loss of, or serious damage to macroalgal habitats due to the installation of the trunkline;	1. Mid term (interim assessment)/Post Development and potentially 2nd Post Development (Condition 7 under the State of the Marine Environment - SoW)*
	8-7 ii. no irreversible loss of, or serious damage to, seagrass habitat outside of the Trunkline Direct Disturbance Footprint;	1.Mid term (interim assessment)/Post Development and potentially 2nd Post Development (Condition 7 under the State of the Marine Environment - SoW)*
	8-7 iii(a). no irreversible loss of, or serious damage to filter feeder habitats outside of the Zone of High Impact;	1. Mid term (interim assessment)/Post Development and potentially 2nd Post Development (Condition 7 under the State of the Marine Environment - SoW)*
	8-7 iv. no detectible net negative change from the baseline state of seagrass habitats determined by implementing Condition 7, outside of the Zone of High Impact;	1. Mid term/Post Development and potentially 2nd Post Development (Condition 7 under the State of the Marine Environment - SoW)
	8-7 v. no detectible net negative change from the baseline state of filter feeder and macroalgal habitats determined by implementing Condition 7, outside the Zone of High Impact and the Zones of Moderate Impact; and	1. Mid term/Post Development and potentially 2nd Post Development (Condition 7 under the State of the Marine Environment - SoW)

** NOTE: Interim assessments can only provide an indication of achievement a due to the definition of 'irreversible loss of, or serious damage' as achievement cannot be determined until recovery is understood.*

In the event of any amendments to, or inconsistencies between this Plan and the TRIP, the TRIP will take precedence in the following matters:

- The trunkline route (Section 2.1)
- Key Activity Descriptions (Section 2.2)
- Locations of the approved impact zones (Section 5.6).

The TIEMMP will take precedence over the TRIP in the following matters:

- Changes to EPOs
- Further modelling verification (Sections 5.1).

Management actions for Conservation Significant Marine Fauna (CSMF) from potential impacts from the physical presence of the DSPSs, due to dredge spoil placement activities associated with the trunkline installation activities, are dealt with in this Plan. Management actions for potential impacts to CSMF from dredging activities, including entrainment and disturbance are also dealt with in this plan. Other potential impacts from the construction and operations of the Project are dealt with within the Conservation Significant Marine Fauna Interaction Management Plan (CSMFIMP) (Chevron 2012c). To the extent of any differences or inconsistencies between this Plan and the CSMFIMP, with respect to management measures associated with dredging and dredge spoil placement activities this Plan will take precedence.

1.7 Stakeholder Consultation and Public Availability

In accordance with Condition 8-12A of MS 873 (Table 1.2) Chevron Australia has provided a reasonable opportunity for the following relevant stakeholders, as agreed with the OEPA, to comment on a draft of this Plan before submission to the CEO for approval:

- OEPA
- Department of Environment and Conservation (DEC) – now Department of Parks and Wildlife (DPaW)
- The Wilderness Society
- Cape Conservation Group
- Dampier Port Authority (DPA).

The comments received from these stakeholders have been taken into consideration in the preparation of this Plan.

In accordance with the Commonwealth Ministerial Condition 12 (EPBC 2008/4469) the Plan has been reviewed and endorsed by the Dredging Technical Advice Panel (DTAP) prior to submission to the Minister for approval.

The final Plan will be made publicly available in a manner approved by the CEO (MS 873 Condition 8-12) and will be published on Chevron Australia's website after approval in accordance with EPBC 2008/4469 Condition 8.

In accordance with Condition 20 of MS 873, Chevron Australia is required to make publicly available, in a manner approved by the CEO, validated environmental data relevant to the implementation of the MS 873.

1.8 Plan Structure

This Plan adopts an adaptive approach for the environmental management of trunkline installation activities which reflects the EPOs and MOs detailed in MS 873 Condition 8-7 and 8-8 or any approved revised EPOs.

The Plan is structured as follows:

- Section 2.0 of this plan provides an overview of the applicable activities
- Section 3.0 provides a high-level overview of the existing environment and the key studies that have been completed.
- Section 4.0 of this plan details the methods and results of the Environmental Risk Assessment (ERA) that has been undertaken.
- Section 5.0 details the results of the sediment plume modelling and the development of the relevant impact zones.
- Sections 6.0 to 11.0 present the specific management strategies that will be adopted for each parameter and the monitoring programme that informs any necessary management. The management strategies provide the outcomes and management triggers against which environmental performance will be measured.
- Section 12.0 details the reporting requirements for this Plan.

2.0 WORKS OVERVIEW

The Project elements description which follows describes the actual trunkline route and trunkline installation activities. These may be amended from time to time, for example under section 45C of the EP Act. The project elements which are detailed in this Plan should therefore be read as subject to any project amendments which are made from time to time.

2.1 Trunkline Route

Condition 8-11 (i) requires this Plan to include: *information describing the actual trunkline route to be used consistent with the approved Trunkline Route and Infrastructure Plan*. In order to avoid differences and inconsistencies between this Plan and the TRIP this is a direct duplication of the TRIP and may be amended from time to time if the TRIP is amended. If the TRIP is amended the same amendments will be taken to be made as part of the TIEMMP and an updated copy will be prepared and provided to OEPA and DotE as soon as practicable. If the TRIP amendments also require a review of the TIEMMP the review will be in accordance with Section 12.0. In the event of any inconsistencies or differences between the two plans, within Section 2.0, the TRIP takes precedence to the extent of any difference or inconsistency.

A single cement coated, welded carbon steel, 44 inch diameter trunkline will transport co-mingled dry gas and condensate from the WP to the onshore plant. The alignment of the secondary stabilised portion of the trunkline rises from 50 m water depth transiting sand and sedimentary rock to a series of low ridges in 10–12 m water depth. The trunkline then traverses a seabed of relative uniform water depth consisting of sedimentary rock, sand and clays. The seabed gently rises from 12 m water depth to the shore line where the trunkline will pass through the shore crossing microtunnel in around 2 m of water. The microtunnel exit point is located approximately 200 m from the shore line. The trunkline route centreline positions and corresponding kilometre points (KP) within State waters are listed in Table 2.1. The key activities associated with trunkline installation are further described in Section 2.2 of this plan.

Table 2.1: Trunkline Route Centreline Coordinates and Corresponding KPs within State Waters

KP	Easting	Northing
0.184 (Microtunnel Exit)	292290	7601695
1	292178	7602503
2	292040	7603494
3	291903	7604484
4	291763	7605474
5	291393	7606397
6	290898	7607266
7	290403	7608135
8	289907	7609003
9	289412	7609872
10	288917	7610741
11	288422	7611610
12	287810	7612398
13	287158	7613157
14	286506	7613915
15	285854	7614673
16	285202	7615431
17	284550	7616190
18	283898	7616948
19	283246	7617706
20	282594	7618464
21	281942	7619223
22	281290	7619981
23	280639	7620739
24	279987	7621497
25	279335	7622256
26	278683	7623014
27	278031	7623772
28	277379	7624531
29	276727	7625289
30	276075	7626047
31	275423	7626805
32	274791	7627579
33	274303	7628451

KP	Easting	Northing
34	273999	7629402
35	273856	7630391
36	273731	7631383
37	273606	7632375

** Note – The trunkline will be laid within an allowable tolerance which is nominally +/- 2.5 m from the trunkline centreline. Also see section 2.2.4 for a description of the tolerance required for the Above Water Tie In.*

Figure 2.1 shows that the trunkline route is wholly contained within the coordinates specified in Table 3 and Figure 7 of Schedule 1 of MS 873. Section 2.3 of this Plan describes the key benefits of the final trunkline route selection.

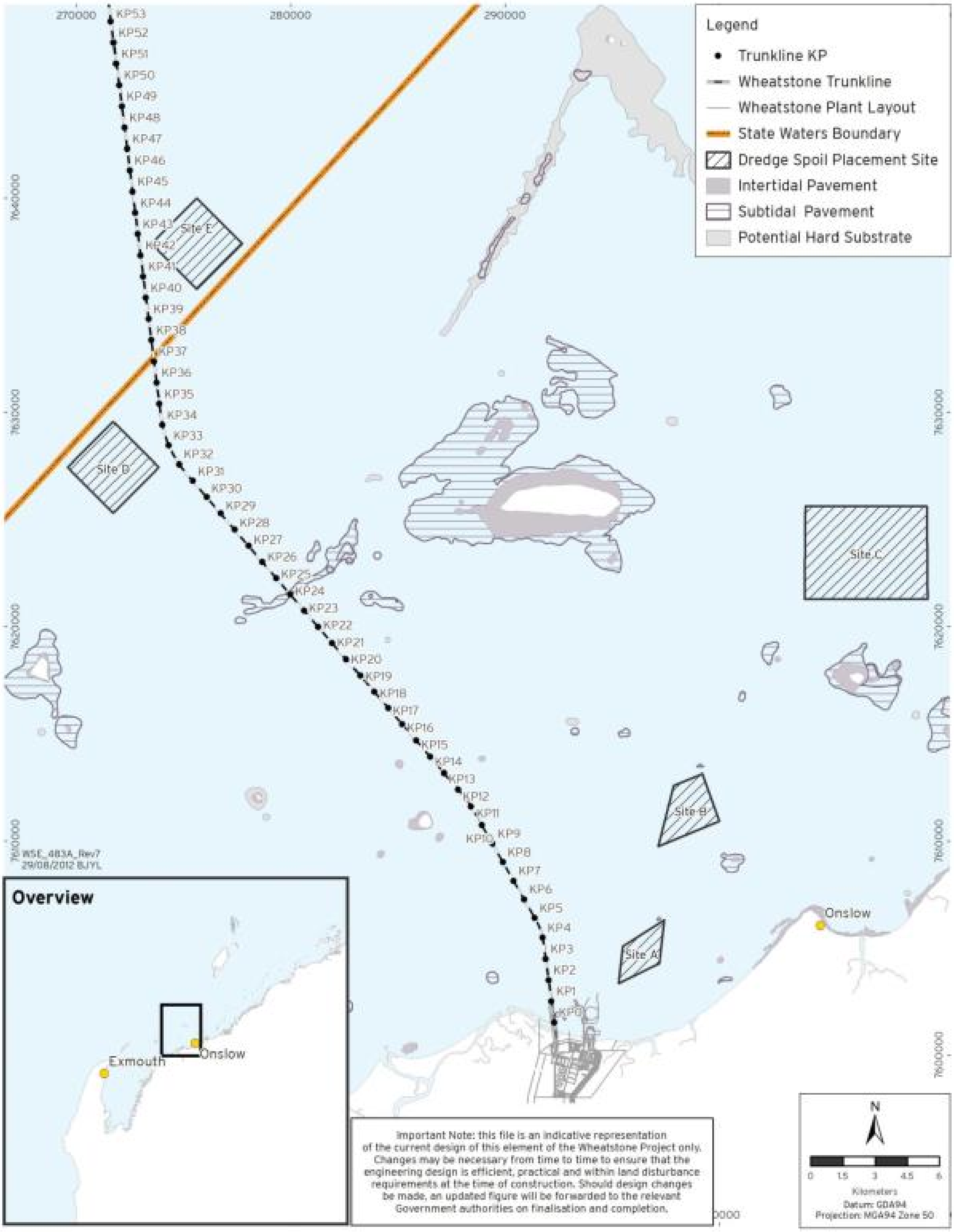


Figure 2.1: Trunkline Route Relative to the MS 873 Approvals Envelope and Dredge Spoil Placement Sites

Note: Sites A and B will only be considered in the event of an emergency situation and will require the approval of the Dampier Port Authority prior to use

2.2 Key Trunkline Installation Activities

Condition 8-11 (ii) requires this Plan to include: *descriptions of key trunkline installation activities, including information about where and when each activity will occur consistent with the approved Trunkline Route and Infrastructure Plan*; In order to avoid differences and inconsistencies between this Plan and the TRIP, this section is a direct duplication and may be amended from time to time if the TRIP is amended. If the TRIP is amended the same amendments will be taken to be made as part of the TIEMMP and an updated copy will be prepared and provided to OEPA and DotE as soon as practicable. If the TRIP amendments also require a review of the TIEMMP the review will be in accordance with Section 12.0. In the event of any inconsistencies or differences between the two plans, the TRIP takes precedence to the extent of any difference or inconsistency.

Sections of the trunkline in the nearshore area within the 50 m depth contour (up to KP 36.1) will require protection and secondary stabilisation to prevent excessive movement and afford additional protection. Stabilisation will require a combination of pre-lay trenching (by dredgers) and the placement of sand and/or rock over the trunkline once it is laid. The need for drilling and blasting pre-treatment is not anticipated, however there may be a requirement for this in areas where the seabed is too hard for direct excavation and there is a requirement to trench.

The decision on the methods to be employed, including the selection of the equipment types, has been based on a number of factors including:

- EPOs (MS 873)
- Environmental MOs (MS 873)
- Environmental benefits (See Section 2.3 for further details)
- Required productivity, efficiency and accuracy
- Vessel and equipment operability and capability (including vessel draught and cutting strength)
- Soil strength
- Transport distances
- Anticipated vessel and equipment availability.

The trunkline trench design volume is approximately 2.5 million m^3 and the sand backfill design volume is up to 2.5 million m^3. Approximately 0.5 million tonnes of rock will be required for berm construction and stitch dumping.

The indicative schedule, may be amended based on progress, downtime, cyclones and vessel ability, is provided in Table 2.2.

Table 2.2: Indicative Schedule for the Key Trunkline Installation Activities

Activity	Timeframe
Trenching (dredging)	February 2013 to January 2014
Microtunelling	May 2013 to July 2014
Offshore Trunkline Installation	March 2013 to June 2013
Nearshore Trunkline Installation	March 2014 to May 2014
Trunkline Stabilisation	June 2014 to September 2014

2.2.1 Microtunnelling

The shore crossing section of the trunkline will be installed using microtunnelling, which involves the creation of a tunnel beneath the dune system exiting in approximately 2 m water depth (Figure 2.2). The microtunnel will be used to pull the trunkline beneath the shoreline, avoiding significant environmental receptors such as the mangrove community located nearby and beach lagoon (Figure 2.3).

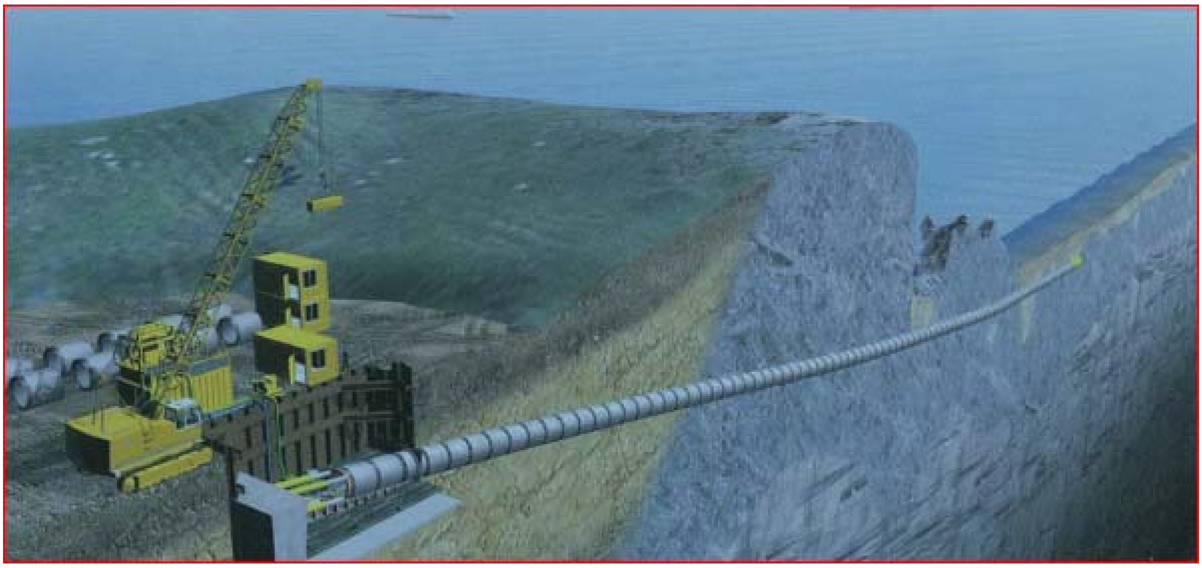


Figure 2.2: Schematic of the Microtunnel

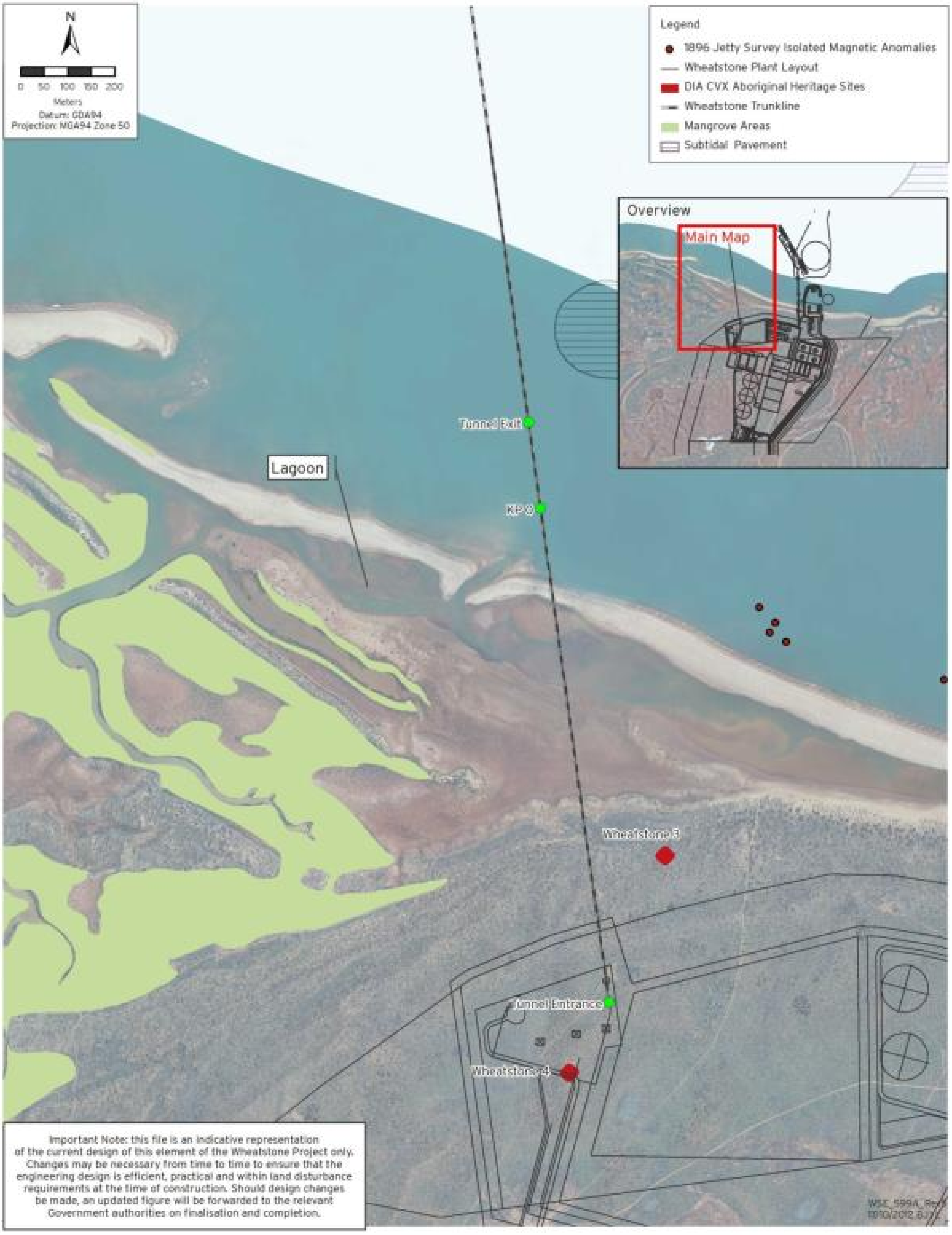


Figure 2.3: Microtunnel Entrance and Exit Point Relative to Mangrove Stands, Sand Dunes, Coastline and Lagoon

Microtunnelling will require creation of an onshore entrance shaft approximately 10 m deep by 20 m long and subsequent creation of a tunnel of approximately 2 m in diameter using a combined TBM/thrust system (See example in Figure 2.4). Disposal of the excavated material from the microtunnel (approximately 7000 m^3) will be managed onshore.

Figure 2.4: Example of a Tunnel Boring Machine

The exit point, approximately 1200 m from the entrance shaft at around KP 0.184, will require excavation with a Backhoe Dredge (BHD) to create a temporary reception pit from which the TBM can be retrieved, resulting in approximately 20 000 m^3 of dredged material from the temporary reception pit. The dredged material removed from the TBM reception pit will be transported to and disposed of at one of the approved DSPSs (Figure 2.1). For further details on dredging activities refer to Section 2.2.2. The reception pit will be approximately 50 m long, 6 m deep and the width will not extend beyond the Direct Disturbance Footprint (DDF) (i.e. 80 m about the trunkline), unless prior approval is received from the OEPA.

The reception pit may then be backfilled with a layer of selected sand fill to ensure the surface is adequately stabilised before the arrival of the TBM. If required, the addition of a layer of selected sand fill will be undertaken by placement of material from a suitable vessel (see Figure 2.5 for example methodology). Another option is to use a TSHD and the spreader technique, this involves filling of the exit pit by pumping the sand through a purpose-built nozzle connected to the bow connection installed about 2m above seawater. This sand fill may also be further stabilised with crushed rock or gravel and there may be a requirement for ground reinforcing which may consist of grout/cement injection or part of the reception pit to be backfilled with grout/cement.

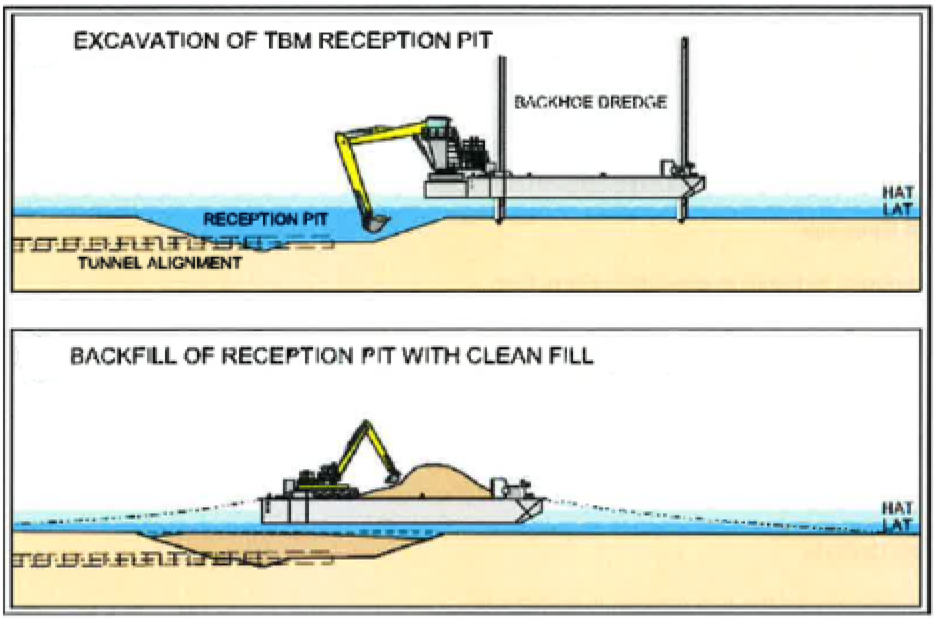


Figure 2.5: Example Excavation and Backfill of the TBM Reception Pit

The Contractor may also install layers of graded rubble as armour protection around the exposed pipe (microtunnel casing) to reduce the risk that the trunkline pulling operation may move these exposed pipes. This armour will also provide additional protection for the pipe exit point and gas trunkline. Once the TBM reaches the reception pit, a suitable vessel will be used to lift the TBM out and transport it to land for decommissioning. A low likelihood exists that a contingency second tunnel may be required in the event that technical issues are experienced during construction of the initial tunnel. If this is required, the tunnel and reception pit will be constructed as close to the original microtunnel route as practicable without compromising the integrity of the structure and within the approved footprints unless prior approval of the OEPA is received.

2.2.2 Trenching (Dredging) and Placement of Dredge Spoil

Table 2.3 details the key characteristics including the base case methodology and Figure 2.6 illustrates the typical profile of the trunkline trench. The width of the trenched portion of the trunkline alignment will not extend beyond the DDF unless the appropriate approval has been received from the OEPA.

The base case methodology is the primary trenching techniques and locations proposed for the trunkline (as described in Section 5.1.2).

Table 2.3: Trunkline Trench Characteristics and Methodology Base Case

From (KP)	To (KP)	Primary Soil Conditions	Primary Trenching Technique
0.184	2.0	Unconsolidated (Silty sand) and consolidated (Sandy Gravelly Clay) sediments	Backhoe Dredge
2.0	16.0	Unconsolidated (Silty sand) sediments, consolidated (Sandy Gravelly Clay) sediments and weak irregular cemented Calcarenite	Trailer Suction Hopper Dredge
16.0	27.1	Calcarenite	Cutter Suction Dredge
31.4	36.3	Unconsolidated (Silty sand) sediments, consolidated (Sandy Gravelly Clay) sediments, weak irregular cemented calcarenite	Trailer Suction Hopper Dredge

Note: No trenching is anticipated to be required within Commonwealth waters. Distances for each technique have been determined based on the water depth, metocean conditions and surveyed seabed properties. Conditions experienced in the field may require or invite variations to the trenching techniques proposed in the above table however all trenching activities will be undertaken in accordance with the relevant regulatory approvals envelope. Sections of the trench may also be dredged by multiple dredge types.

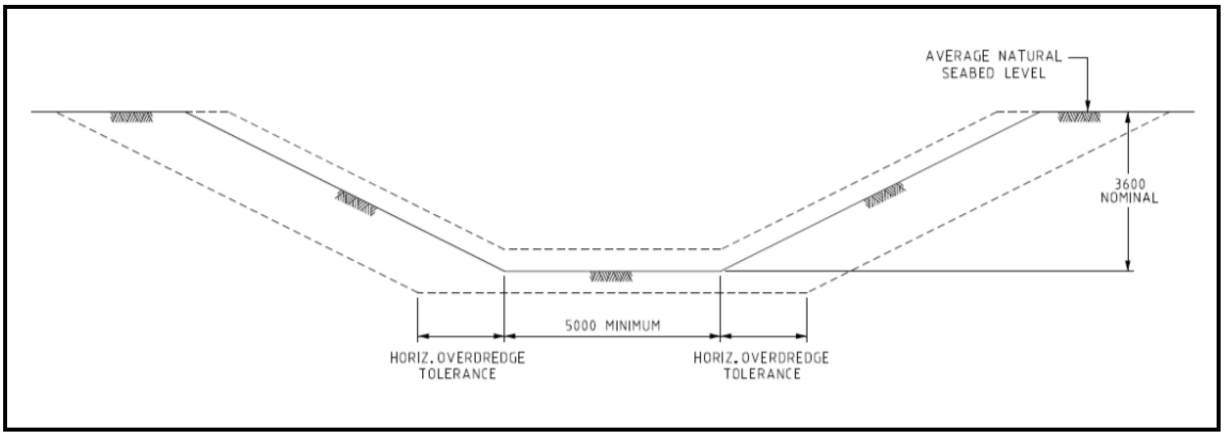


Figure 2.6: Typical Trunkline Trench Profile Cross Section

All dredges and specified attendant vessels in the field will be equipped with accurate and sophisticated navigation aids based primarily on Differential Global Positioning System (DGPS) and Real Time Kinematic (RTK) systems. For all dredge types, the technology includes high accuracy manual and automated control systems for the cutting edges of the excavation equipment including BHD buckets, cutter heads and dragheads. Water depths are measured in real-time by echo sounder and the tidal height by tide gauges. Accurate hydrographic surveys are undertaken prior to work commencing, which are used to create hydrographic charts of the seafloor and bathymetric data for electronic charts and dredging software.

2.2.2.1 Backhoe Dredge

The BHD is a floating excavator with a pontoon positioned and held securely on spuds (Figure 2.7). The spuds are designed to partially support the weight of the dredge, which prevents the usual wallowing motion of an anchored system. The dredger will be operational on either a 12 hour/7 days (12/7) or 24 hours/7 day (24/7) basis.

The excavation and vessel position is controlled by a dredging management system that provides a high level of three dimensional accuracy. The excavated material will be loaded into either a propelled or non-propelled hopper barges moored alongside. The dredged material will be taken to an approved DSPS and disposed of through bottom doors or by the hull sections opening (splitting).

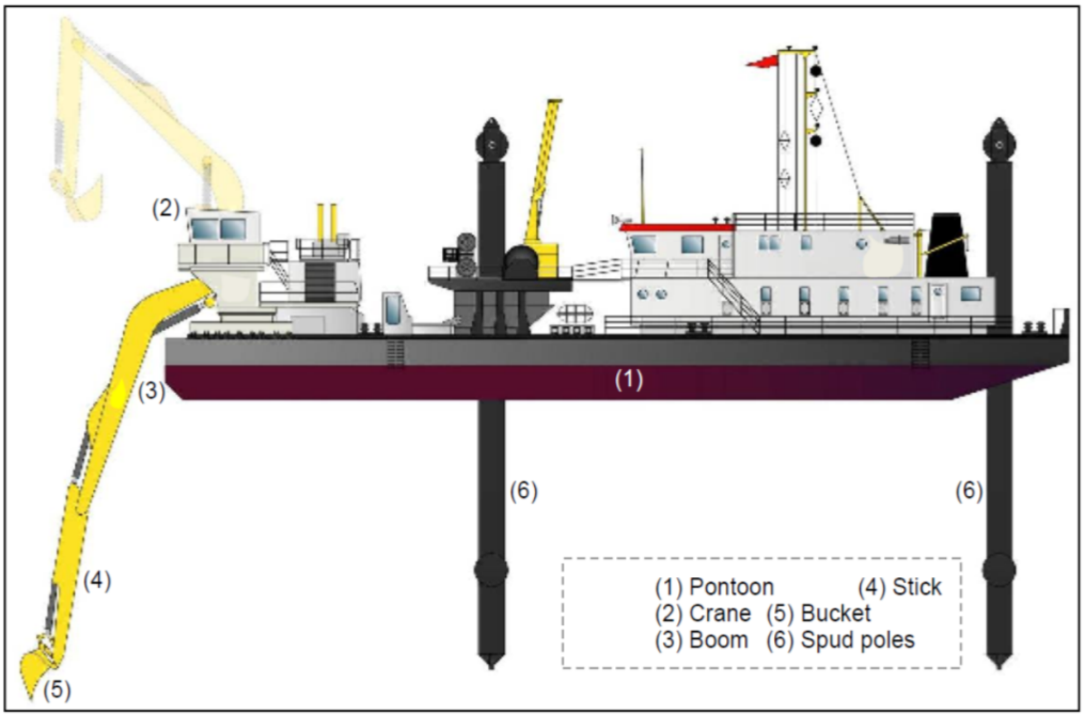


Figure 2.7: Typical Backhoe Dredge

For the backhoe dredge to operate with sufficient Under Keel Clearance (UKC) in the shallow water, a short temporary access channel leading up to the microtunnel entrance is included in the trench design. This will enable the BHD to continue to work without tidal restrictions which will reduce the length of time the dredge and support spread will be required onsite. The temporary access channel is anticipated to be approximately 1.5 m below seabed at its deepest point, nominally 1 km in length and the width will not extend beyond the DDF unless prior approval is received from the OEPA. The seabed will be re-instated following pipelay in accordance with Section 2.2.5.1 as part of the trench backfilling activity. There may also be a requirement to side-cast material with the BHD in some locations such as the temporary access channel to further optimise the programme.

2.2.2.2 Cutter Suction Dredge

Cutter Suction Dredges (CSDs) mechanically cut soil and rock, hydraulically transport the spoil, and can be self-propelled or non-propelled. When in dredging mode, the dredge acts as a spud and anchor pontoon and propulsion systems (if present) are not used. The dredging action involves cutting with a rotating cutter, while the dredge is winched sideways in a rotating arc around a main working spud. The dredging operation is controlled by a dredging management system that provides a high level of three-dimensional accuracy. The dredger will be operational on either a 12/7 or 24/7 basis.

Anchors are connected to the side wires and are deployed either side of the dredge by the use of multicat vessels, Anchor Handling Tugs (AHTs) or the vessel's own booms. Figure 2.8 demonstrates the typical dredging action of a CSD, the pink lines denote the side wires attached to anchors and blue lines show the cutter head track during the dredging sequence. The CSD may be equipped with several types of anchors to ensure all expected seabed conditions are accounted for. During routine operations the CSD anchor and spud system will only be deployed within the confines of the zone of high impact (ZoHI). The main and auxiliary spud-poles at the stern of the dredger are necessary to allow the dredger to move forward as the face of the excavation is advanced.

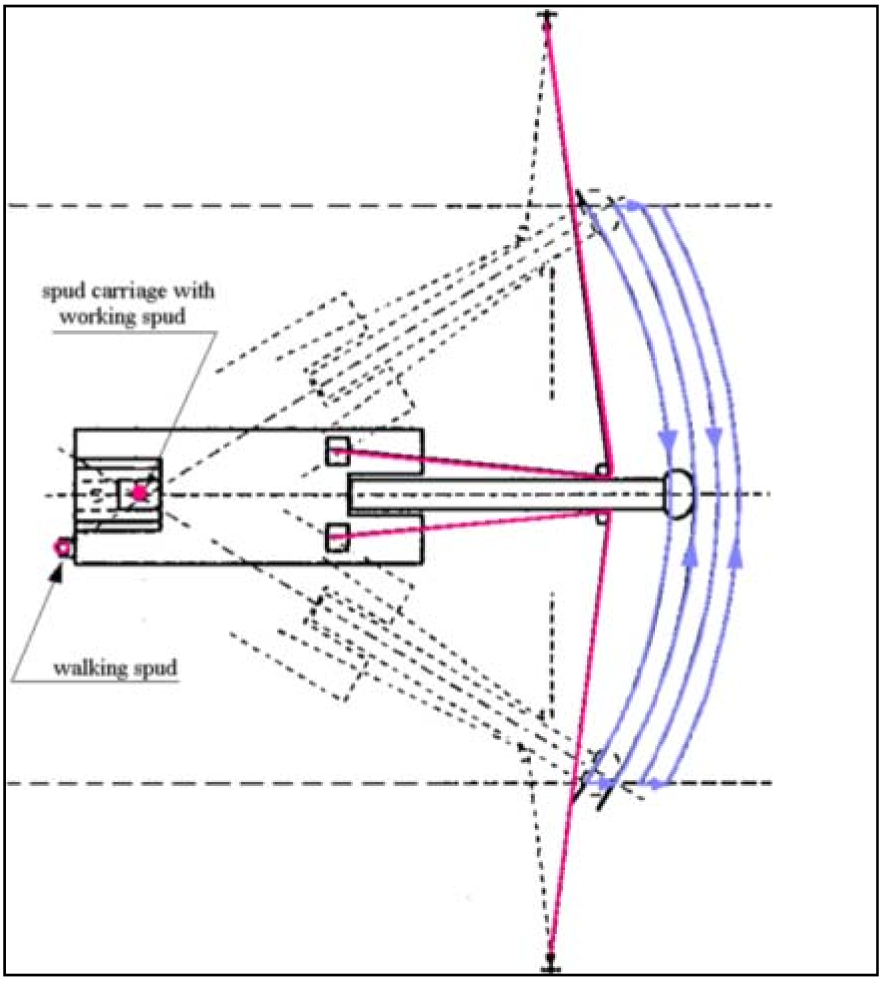


Figure 2.8: Typical Dredging Action of a CSD

The ladder which supports the underwater pump and cutter-head, situated at the front of the dredger (Figure 2.9), is connected to the pontoon by pivot and may be raised or lowered by means of a hoisting wire connected to the gantry above the ladder. The cutter-head, situated at the front of the ladder (Figure 2.9), excavates the material by a rotating action. Different types of cutter heads can be used for different soil types to optimise production. Teeth attached to the cutter head loosens or cuts the seabed depending on the nature of the material. The underwater pump located below the water line creates a vacuum in the suction tube and draws the soil/water mixture up through the pump. The mouth of the suction tube is situated inside the cutter head below the cutter shaft and is routed through a series of pumps which are all situated in the hull of the pontoon. These pumps are required to achieve the necessary horizontal thrust to transport the soil/water mixture.

Figure 2.9: Typical Cutter Suction Dredge

The soil/water slurry will then be pumped through a side discharge connection into a split hopper barge (operating in overflow mode), which will be alongside the CSD or at a distance bridged by a sufficient length of pipeline. The spoil will then be transported to an approved DSPS for placement. CSDs generally require attendant towing tugs, AHTs and workboats as do the non-propelled split hopper barges when they are used.

For this project the CSD may be used in either crushing mode only (no suction) or cutter and suction mode (as described above). Whilst operating in crushing only mode, dredged material may be left in-situ on the seabed for later recovery by a suitable dredger, e.g. a Trailing suction hopper dredge (TSHD) or BHD. This option will be exercised to optimise the environmental and efficiency performance of the dredge programme if required.

2.2.2.3 Trailer Suction Hopper Dredge – Dredging Mode

TSHDs are freely navigating ships and conduct their dredging operations while sailing. The vessel cannot dredge while stationary and consequently there are no stationary fixtures to the sea floor such as anchors, spuds or legs. Dredging occurs by mechanical scraping and hydraulic erosion of the seabed combined with hydraulic transport if spoil to an internal hopper. Spoil will be transported to an approved DSPS by the dredge itself and disposed through bottom doors.

The dredging operation is controlled by a dredging management system that provides a high level of three dimensional accuracy. TSHDs are manually driven except where operations can benefit from Dynamic Tracking (DT). DT is not mandatory for trenching operations but can enhance the efficiency and accuracy of the operation under certain conditions.

The initial collection of the spoil is achieved by trailing one or two pipes equipped with dragheads which can be aided by a water jet system to cut, fluidise and erode a soil layer (Figure 2.10). Dragheads vary in weight and scraping configuration depending on their speciality. Ripping dragheads can break up weak rock. The pipes in turn are part of the hydraulic transport system which is powered by dredge pumps that can be rigged in parallel or in series. The removed soil mixed with water is drawn up through the suction pipe by use of centrifugal pumps on board and pumped into the hopper of the vessel. Most of the solids will settle in the hopper and the water, together with the suspended fine solids, is discharged through the adjustable height overflow system. When the draught of the vessel reaches the dredging load mark or when the optimal loading point has been reached, dredging is stopped and the suction pipe is hoisted onto the deck. The vessel will then sail to one of the approved DSPSs where the load will be dumped by controlled opening of the bottom doors. TSHDs do not require attendant vessels in their normal dredging mode.

(1) drag head (2) suction pipe (3) hopper (4) hull

Figure 2.10: A Typical TSHD

2.2.2.4 Dredge Spoil Placement

Excavated material from the temporary access channel, microtunnel reception pit, sand borrow area (if load unsuitable for backfill) and the trunkline trench will be disposed within the approved DSPSs. In accordance with Schedule 1 of MS 873, the total volume shall not exceed 3 Mm^3 of dredge spoil for the trunkline activities.

Spoil placement will be managed by allotting dumping areas for each load. The TSHD and hopper barges (or their attendant vessels) will use their positioning systems to ensure that the spoil is placed in an approved area while the tracking systems will verify and record the action. Spoil placement may be undertaken with vessels moving or stationary.

Where further accuracy is required, the allotted dumping area can be gridded into “dump boxes” and spoil is placed within from a stationary or near stationary vessel. The helmsman can accurately position the TSHD or hopper barges at a specific location with the “dump box” area and discharge the dredged material.

The allotted “dump box” areas may also be shaped to receive spoil from a moving vessel. This method of dumping allows for the most efficient removal of spoil from the hopper, especially if the material is “sticky”. This method facilitates spreading the spoil more evenly over a wider area and will be utilised where there is a requirement for increased uniformity in elevation in areas within the DSPSs.

The allotted dumping areas are drawn to suit the progressive shaping of the spoil ground and will change as the DSPSs take shape. Records of relevant dredge spoil placement activities will be retained. Bathymetric surveys will also be undertaken to monitor the placement of dredged material within the DSPSs.

A summary of the DSPS characteristics and permitted volumes to be placed in each DSPS are provided in Table 2.4. The location of the approved DSPSs is illustrated in Figure 2.1.

Table 2.4: Summary of DSPS Characteristics

DSPS	Water Depth (m)	Capacity (BCM Mm^3)*
Site A[1]	<7	1.5
Site B[1]	10-12	3
Site C	12-15	40
Site D	38-48	40
Site E	63-71	40

**Includes dredge spoil from the capital dredging campaign*

1- DSPS A and B will only be used following prior approval from the Pilbara Port Authority (PPA)

2.2.3 Roller Skate Pipeline Crossing

The trunkline route will cross the Roller Skate Pipeline at nominally KP 8.807 between the Roller and Skate platforms. This SoW will either consist of (a) Option 1 – Base case, laying the trunkline and rock dump stabilisation over the existing Roller Skate crossing (Figure 2.11) or (b) Option 2 – Unlikely case, removal of a section of the decommissioned Roller Skate pipeline (20 inch oil and 6 inch piggy-back gas pipelines) in preparation for installation of the Wheatstone trunkline via trenching followed by backfill and possible rock dumping.

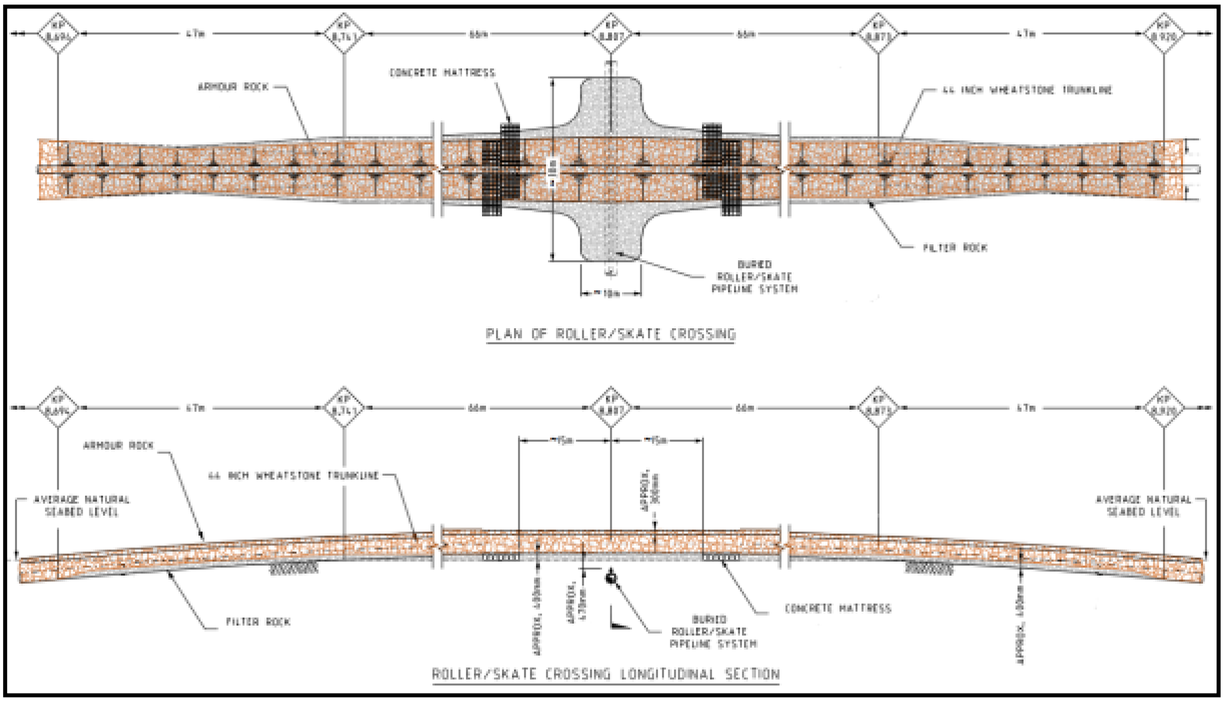


Figure 2.11: Roller Skate Pipeline System Crossing Option 1

For Option 1, a rock filter layer may initially be installed over the top of the Roller/Skate Pipeline to absorb the impact of rock armour during installation (Figure 2.11) or post trunkline installation. The required vertical separation distance for the two pipelines may be maintained by the placement of a concrete mattress either side of the buried Roller Skate Pipeline which will also support the spanning Wheatstone trunkline (Figure 2.11).

Option 2 consists of excavating (via TSHD or appropriate excavation tool), cutting, removing and placement of an approximate 120 m length of the Roller Skate Pipeline, i.e. approximately 60 m either side of the Wheatstone trunkline alignment (Figure 2.12 and Figure 2.13). This will include plugging the ends of the pipeline remaining on the seabed and may also include a trial excavation prior to the works being undertaken to establish the optimum operation of the equipment.

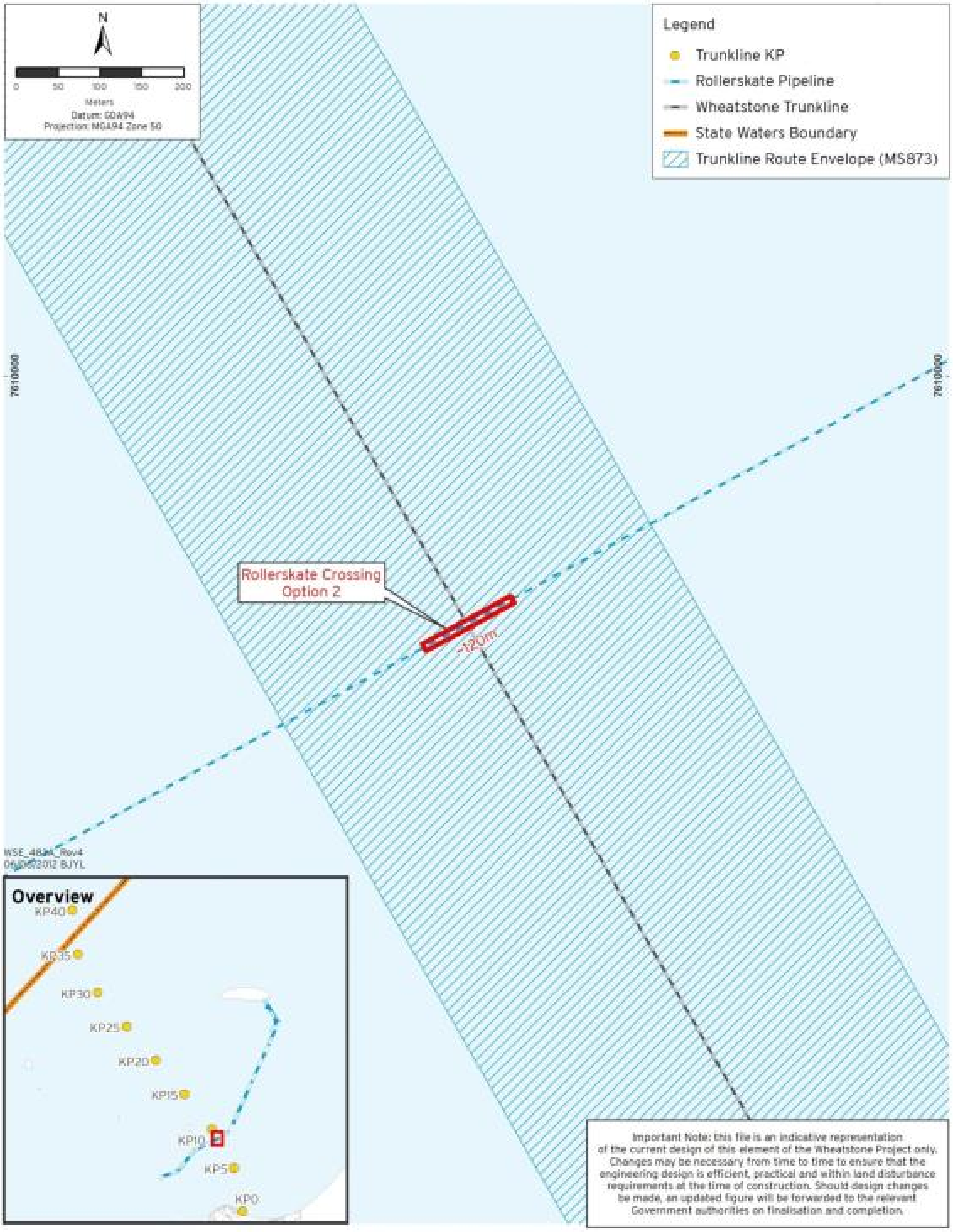


Figure 2.12: Location of Roller Skate Pipeline Crossing and Section to be removed to Exercise Option 2

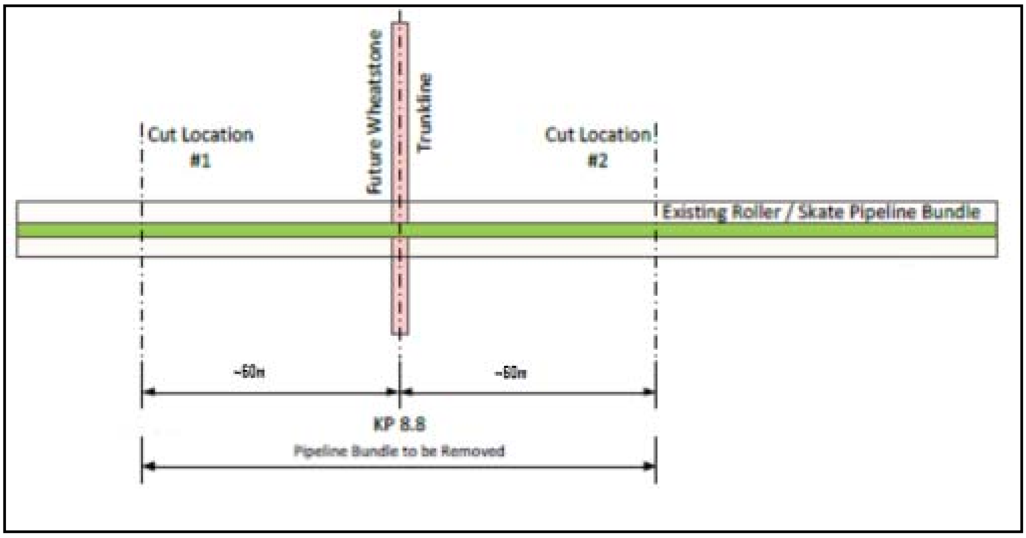


Figure 2.13: Option 2 – Roller/Skate Pipeline Cutting Locations for Removal and Placement

Decommissioning and flushing of the Roller Skate Pipeline prior to cutting and removal is out of scope for this plan as this activity will be managed by the relevant proponent under a separate management plan.

2.2.4 Pipelay

A pre-lay survey will be conducted to confirm the acceptability of the trench for pipelay. Prior to pipelay, the trench may require pre-lay intervention to reduce the likelihood of free-spans once the trunkline is laid, however currently the requirement for this is not anticipated. Pre-lay intervention may include removal of high spots, removal of debris or cleaning of any excess sediment by dredge or alternative techniques such as suction, jetting or mass-flow systems. A bedding layer of suitable granular material on the bottom of the trench may be laid in the pipe-pull location (approximately KP 0.2 to KP 1.8) to reduce the risk of freespans once the trunkline is laid.

For the offshore portion of the trunkline, i.e. approximately 20 m water depth (KP 28.2) to the WP, the dynamically positioned 4th generation pipelay vessel the "Solitaire" or similar, will be used to lay the trunkline (Figure 2.14). The Dynamic Positioning (DP) system will be adequate for all phases of installation including trunkline laying, station keeping, trunkline initiation, laydown, abandonment and recovery operations.

Figure 2.14: The 4th Generation Dynamically Positioned Pipelay Vessel "Solitaire"

In the nearshore area, from shore to approximately 20 m water depth, a flat bottom 2nd generation lay barge, the "TogMor" or similar, will be used (Refer to Figure 2.15). The vessel has a 10-12 point anchor mooring system that it uses to move along the trunkline route whilst laying pipe. These anchors will be placed and recovered by dedicated anchor handling vessels.

Figure 2.15: The 2nd Generation Moored Lay Barge "TogMor"

Nearshore trunkline operations may be commenced with the barge mooring approximately 1.5-2.0 km from shore to perform the shore pull operation. This will entail setting of all 10-12 anchors and welding pipe on the barge. As the pipe is welded, it is pulled to shore using a shore based winch system (Figure 2.16), along the prepared seabed trench and through the installed microtunnel shore crossing.

The barge will lay the trunkline out to the Above Water Tie In (AWTI) point on completion of the shorepull operations before abandoning and repositioning to deeper water to recover and tie into the offshore portion of the trunkline and lay in towards the nearshore AWTI point. The sequence of the nearshore trunkline operations could be reversed depending on operational and schedule drivers.

Figure 2.16: Typical Shore Pull Winch Configuration

The anticipated sequence of key pipelay activities is as follows:

- Initiation of 44-inch trunkline at approximately 20 m water depth (by the “Solitaire” DP vessel or similar)
- Pipe lay by DP vessel in offshore direction beyond the extent of State Waters towards KP 225. It is possible that trunkline installation may be performed from the WP towards shallow water depending on operational and schedule drivers
- Preparation of the Roller / Skate crossing
- Landfall preparations and pull-in winch installation
- Install pull in wire between onshore winch and laybarge position
- Trunkline initiation by shore pull-in through the microtunnel
- Lay trunkline towards AWTI point by laybarge at approximate KP 2.9 (12 m water depth)
- Temporarily abandon trunkline
- Relocate laybarge to trunkline tail installed by DP vessel at approximate KP 28.2 (20 m water depth)
- Partly dewater the offshore portion of the trunkline (nominally 1000 m) to recover and tie into the trunkline onboard the laybarge

- Lay trunkline towards AWTI point with laybarge and temporarily abandon trunkline
- Reposition laybarge for AWTI
- Complete AWTI (Figure 2.17)
- Flood, clean, gauge and hydrotest the completed trunkline. Note, description and management of these activities will be further addressed in the Hydrostatic Test Fluids Discharge Management Plan required via MS 873 Condition 13-16 and are not addressed further in this plan.

The trench will need to be widened at of the AWTI to allow the required space for the trunkline's as-built configuration once laid down on the seabed. The ultimate width of the trench will depend on the water depth at the AWTI location and the configuration of the recovered trunkline. The trench will be nominally 30 m width at the bottom of trench based on performing the AWTI at KP 2.9. The footprint of the widened trench will be maintained within the approved DDF unless an appropriate prior approval is received from the OEPA. Due to the additional length of pipeline required to perform the tie in at the surface, the pipeline may be laid up to 80 m about the original trunkline centreline in the vicinity of the AWTI.

Figure 2.17: Typical Above Water Tie In Operation

A post-lay survey will also be conducted and post-lay intervention may be required where the predicted span lengths exceed acceptable tolerances. Flooding, gauging and testing of the trunkline are not included in the scope of this plan.

2.2.4.1 Anchor Management of the Lay Barge

Due to the restricted water depth in the nearshore area and the required safe operating UKC, an anchored 2nd generation lay barge will be used to install the trunkline in the shallower water to approximately KP 28.2. As depicted by Figure 2.18, the lay barge anchors are deployed by AHT or multicat when the barge is in Position 1. The trunkline is then laid as the barge moves along the alignment via "pay-out and "haul-in" of anchor wires with the anchors remaining in the original deployed position. Once the barge has moved as far along its anchor wires as planned (as depicted by Position 2 in Figure 2.18), the anchors are recovered and redeployed and the process is repeated. Nominal anchor plot-plans are developed, which consider the identified benthic habitat, and used to manage anchor placement during the installation of the nearshore section. The respective anchor positions are determined and confirmed via AHT mounted, surface GPS. These nominal anchor plot-plans may be updated to allow for operation and metocean conditions.

By utilising a wider anchor configuration, longer lengths of trunkline can be laid for each anchor deployment, directly resulting in the reduction of total anchor deployments required for the full program, which will consequently reduce the total area of seabed disturbance. It is anticipated that the anchors will need to be re-deployed every time the barge has moved approximately 200 m along the trunkline alignment. Utilising a wider anchor configuration exerts zero uplift force on the anchors which should ensure that anchor positions on the seabed are maintained to the greatest extent possible once deployed. This will reduce the number of times the anchors will need to be retrieved and redeployed to ensure they are adequately set which in turn will reduce the total area of seabed disturbance. During operations the cable feeds and anchor wire tensions can be monitored to ensure the anchors have successfully set into the seabed which reduces the likelihood that the anchors will drag once operations have commenced.

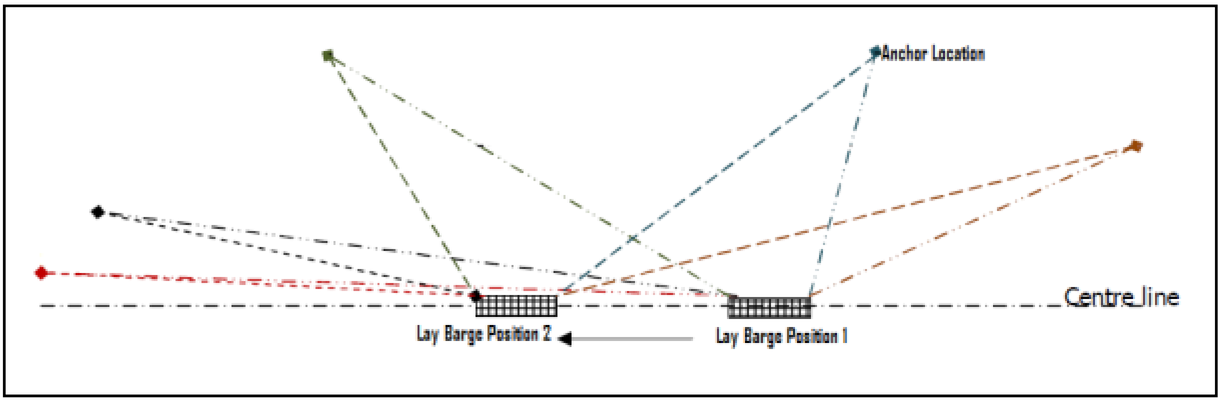


Figure 2.18: Typical Configuration for the Five Starboard Anchors during One Shift of the 2nd Generation Lay Barge

The lay barge shall be equipped with a mooring system adequate for all phases of installation including shore pull, pipe laying, station keeping, trunkline initiation, laydown and abandonment and recovery operations.

2.2.5 Secondary Stabilisation

Trunkline stabilisation will involve laying the trunkline in the excavated trench or directly on the seafloor and then covering with sand and/or rock on a continuous profile to prevent movement in storm or cyclonic conditions. Sand backfill will only be used where the trunkline is trenched, while rock backfill can be employed on both the trenched and un-trenched trunkline sections. It is anticipated that sand backfill may fill the trench with some overfill. Rock may be placed in berms on each side and over both the trenched and un-trenched trunkline. Where the trunkline is un-trenched, rock berms will generally occupy an envelope of approximately 20 m wide and can cover the trunkline by 1–2 m in height.

Trunkline backfill and rock dump locations along the trunkline (e.g. KPs) and execution methodologies are detailed in Table 2.5.

Table 2.5: Execution Methodology Summary for Backfill and Rock Dump Activities

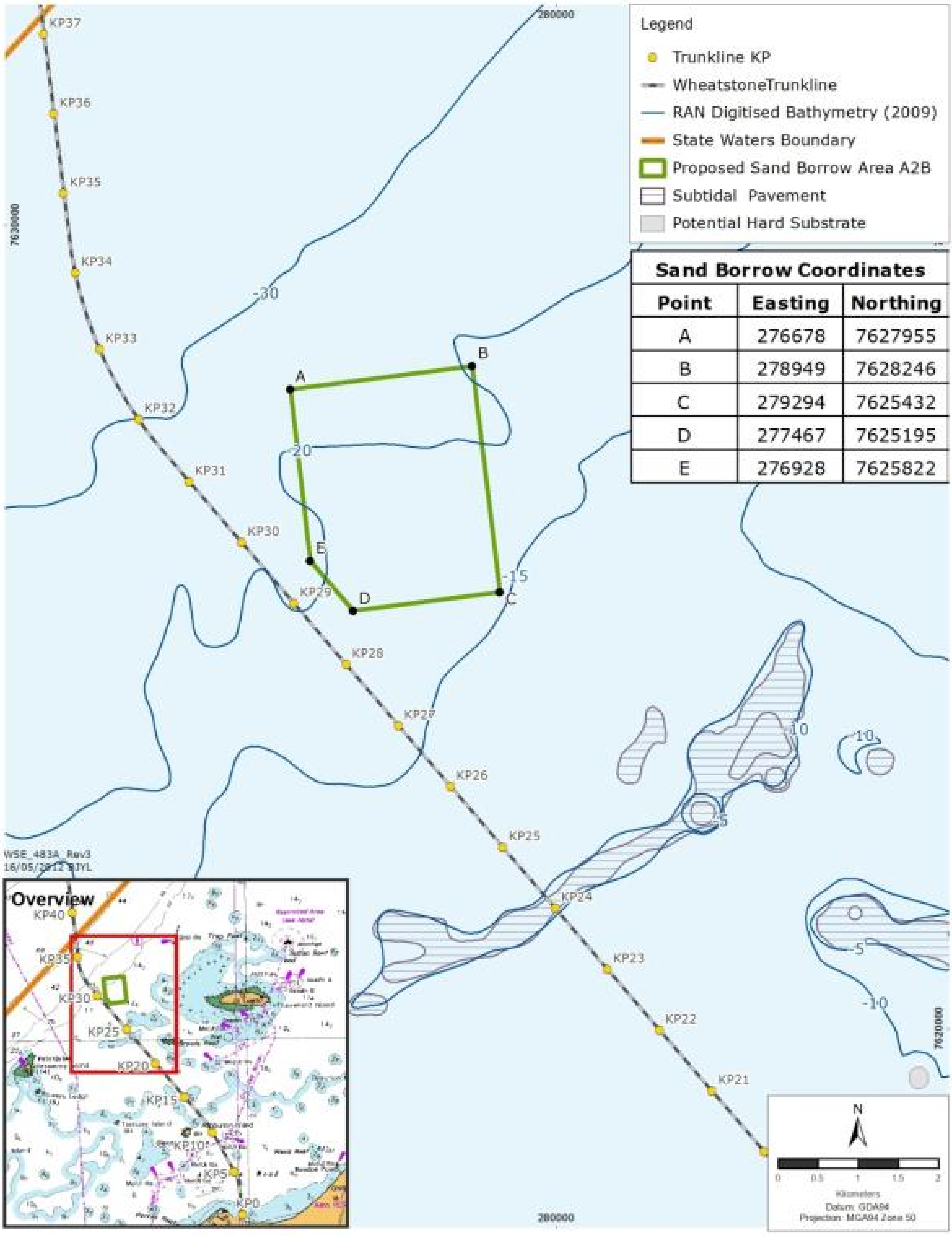
From (KP)	To (KP)	Activity	Execution Method
0.184	2.0	Sand Backfill	TSHD + Spreader Pontoon
2.0	4.0	Sand Backfill	TSHD
7.1	8.6	Sand Backfill	TSHD
9.0	26.9	Sand Backfill	TSHD
31.6	36.3	Sand Backfill	TSHD
0.184	2.0	Stitch rock dump	Side Stone Dumping Vessel
2.0	4.0	Stitch rock dump	SSDV
4.0	7.0	Rock dump	SSDV
8.8	NA	Rock Dump Roller Skate Pipeline Crossing	SSDV
27.1	31.4	Rock Dump	Fall Pipe Vessel

Note: Distances for each execution method have been determined based on the water depth, metocean conditions, surveyed seabed properties and anticipated trench dimensions. Conditions experienced in the field may require or invite variations to the above table however all activities will be undertaken in accordance with the relevant regulatory approvals envelope.

2.2.5.1 Sand Backfill

Sand backfill along the trunkline will be for secondary stabilisation purposes and protection of the trunkline. A typical sand backfill profile cross section is illustrated in Figure 2.20. The primary equipment intended to perform the sand backfilling operation are TSHDs with sufficient operating depth and UKC to dredge sand from Borrow Area A2B (Figure 2.19) and allow access to the trench. Up to 2.5 Mm^3 will be dredged from this sand borrow area. Sand Borrow Area A2B was selected to source engineered backfill material as the sediment is relatively homogenous, comprising uniform fine to medium carbonate sands with occasional coarser shell fragments. The depth of dredging within the sand borrow area will vary dependent on the anticipated quality and sediment depth.

Where UKC permits, backfilling activities will be performed by a TSHD by reverse pumping through its suction pipe and draghead held as close to the trunkline as is deemed safe. This is the conventional TSHD method and requires a high level of precision involving close control and coordination of sand re-fluidisation, discharge velocity and vessel tracking speed. The accuracy and efficiency of the operation is significantly enhanced by the vessels DT capability used as required.



Sand Borrow Coordinates		
Point	Easting	Northing
A	276678	7627955
B	278949	7628246
C	279294	7625432
D	277467	7625195
E	276928	7625822

Figure 2.19: Sand Borrow Area A2B

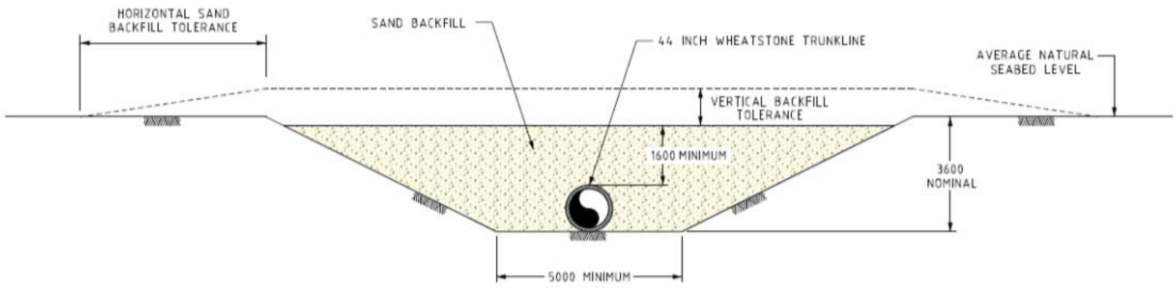


Figure 2.20: Typical Sand Backfill Profile Cross Section

In water shallower than approximately -6 to -8m Lowest Astronomical Tide (LAT), BHDs, split hopper barges or TSHDs may be used to place the backfill material and/or a pipeline and spreader pontoon configuration can be used in conjunction with a TSHD to place the material.

The spreader pontoon is positioned by deploying a four to eight anchor spread or may be held and positioned by another vessel moored or using DP alongside. The spreader pontoon is connected to the TSHD by a dredge pipeline. The TSHD will sit in sufficient water depth and pump sand from its hopper through the dredge pipeline. The dredge pipeline can be floating, submerged or a combination of the two. The use of a spreader pontoon provides a velocity reduction of the pumped material / mixture at the spreader head exit which may result in less turbidity and a better sediment distribution compared to an open ended pipe. In case of an unforeseen occurrence where the spreader pontoon is unable to work or unavailable or where an acceptable alternative exists; the material will temporary be discharged via an alternative spreading device.

Progress surveys will be undertaken during backfill operations to assess the effectiveness and accuracy of the placement.

2.2.5.2 Rock Dumping

Rock installation along the trunkline will be for secondary stabilisation purposes and protection of the trunkline. Filter and armour rock may be used in varying combinations to optimise the trunkline stabilisation (Figure 2.21 to Figure 2.23). Rock will be dumped within the DDF primarily using either a Side Stone Dumping Vessel (SSDV) or a Fall Pipe Vessel (FPV). In shallower water, a Grab Dredge (GD) or BHD may also be utilised for rock installation activities. Transfer of rock to these vessels or barges may either be via dedicated load-out facility or vessel to vessel in the Project area.

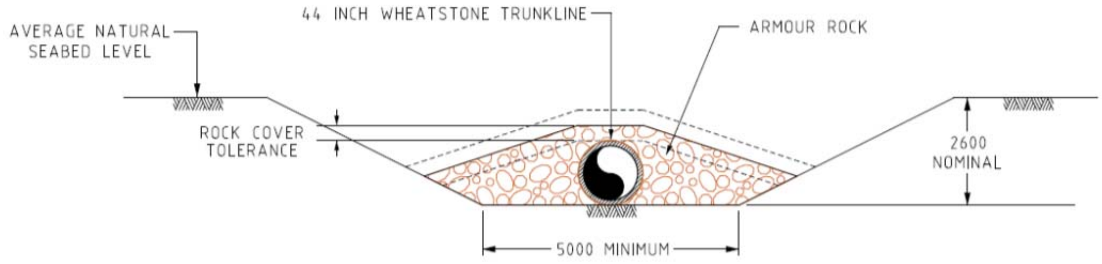


Figure 2.21: Typical Rock Stability Design Cross Section

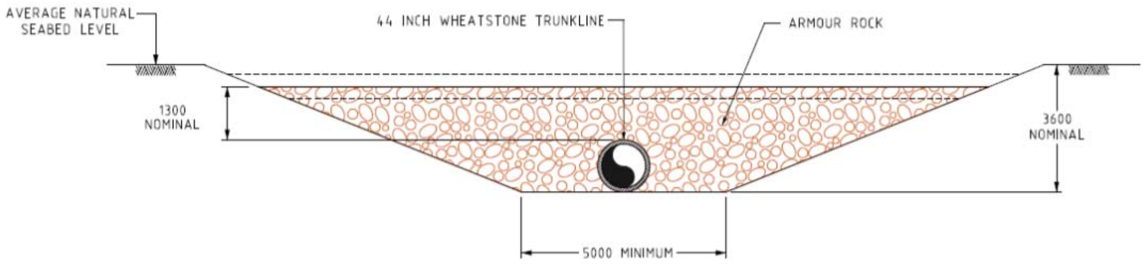


Figure 2.22: Typical Stitch Rock Stability Design Cross Section

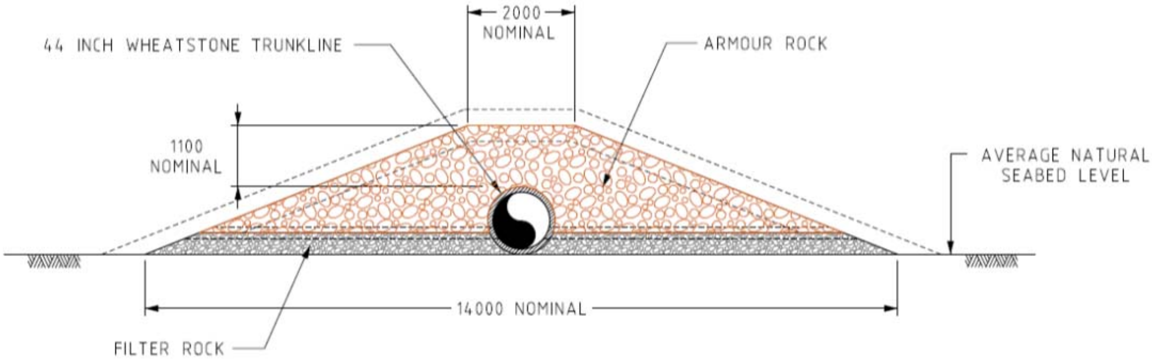


Figure 2.23: Typical Rock Berm Stability Design Cross Section

Side Stone Dumping Vessel

SSDVs arrange their rock in bays on the deck and push the rock over the side while tracking in DP mode. This method places little restriction on the grade size and is ideal for armour placement. Vessels have a DP system to ensure accurate installation of the rock. Real time current speed and direction data are continually fed into a dumping management system which enables positioning of the vessel to compensate for water depth, side drift and falling velocity. However, this dumping management system cannot prevent segregation or anomalies caused by extreme tracking angles. An advantage for this project is that water depths, being shallow over most of the nearshore trunkline, are ideal for this type of vessel.

A pre-rock placement survey will be carried out prior to the start of any rock placement activities. After execution of the rock placement operations, a post-survey will be executed to compare to the pre-rock placement survey to establish the fulfilment of the specifications.

SSDVs move under their own power without assistance from any attendant vessel, and do not employ any stationary fixtures in the seabed (Figure 2.24).

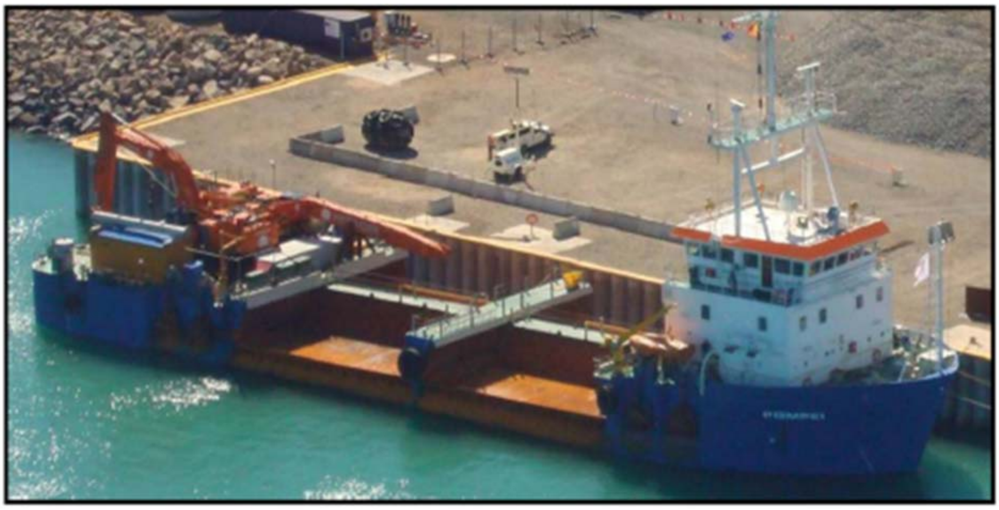


Figure 2.24: Example of a Side Stone Dumping Vessel

Fall Pipe Vessel

FPVs place rock through a pipe that extends close to the seafloor. This permits accurate placement at depths that can exceed a kilometre while achieving great accuracy through the use of a Remotely Operated Vehicle (ROV) pod built into the bottom of the fall pipe (Figure 2.25) combined with DP control of the vessel. An ROV on the end of the Fall Pipe can be fitted with thrusters for precise manoeuvrability and positioning of the Fall Pipe. In shallow water the FPV may be used with or without the ROV, the FPV can maintain accuracy with its own navigation systems when the ROV is not used.

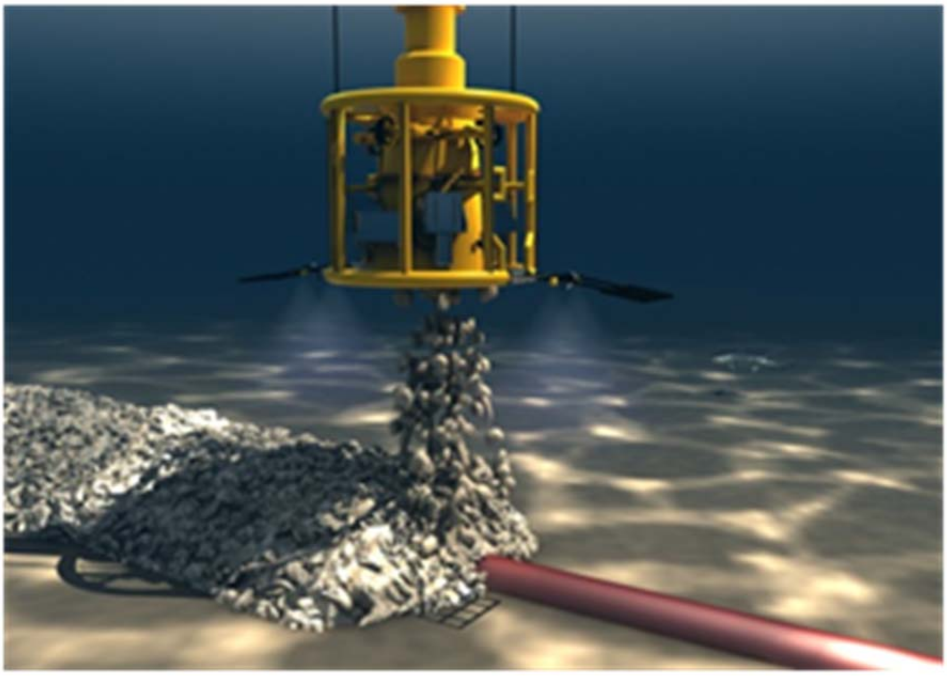


Figure 2.25: A Typical ROV Configuration on a Fall Pipe

The Fall Pipe consists of steel and/or polyethylene pipe sections that interlock, allowing the pipe length to be adapted according to the water depth required. A telescopic section at the upper end of the Fall Pipe allows for small adjustments in Fall Pipe length. In shallow water the Fall Pipe may not be used and the vessel will operate similar to a SSDV as the rock will be dumped via an excavator or the chute. The vessel moves under its own power without assistance from any attendant vessel, and does not employ any stationary fixtures in the seabed (Figure 2.26).

Rock dumping by FPV requires a high level of precision to control and coordinate rock discharge rates, vessel tracking speed, fall-pipe velocity and the time-lag between load out and seabed placement. Although most vessels have an advanced level of automation to assist in the process, parts of the process are manual and rely on the skill of the operator. The amount of rock placed per linear meter is a function of the rock flow rate and the vessel tracking speed. The rate can be controlled by adjusting the outflow (i.e. central hopper, shovelling speed) whereas with the DP system, the tracking speed can be adjusted and the rock placed per linear meter controlled.

Prior to the start of any rock placement activities a pre-rock dumping survey will be carried out. After execution of the rock placement operations, a post-survey will be executed to compare to the pre-rock placement survey to establish the fulfilment of the specifications.

Other Rock Dumping Vessels

Rock dumping nearshore may also be undertaken via alternate vessels, for example rock barges due to shallow water restrictions. A variety of methods may be employed to dump the rock including, but not limited to, a similar action to the SSDV, excavators, clamshell, bulldozer or hopper doors. The position of the rock dumping vessel will be determined by an attendant vessel and/or onboard navigation systems and the position is maintained by attendant vessel, under its own power or the deployment of anchors.

Figure 2.26: Example of Fall Pipe Rock Dump Vessel

2.2.6 Accommodation Vessels

Accommodation vessels may be required to support a proportion of personnel for some of the trunkline installation activities. Regulatory approval, mooring/anchoring location and environmental management of these vessels is not included in the scope of this plan and, if required will be addressed in the following documents:

- Upstream Offshore Accommodation Vessel Discharge Report and Offshore Accommodation Effluent Quality Validation Reporting Plan (*if required*)
- Marine Outfalls Mapping (WS0-0000-HES-PLN-CVX-000-00082-000)
  and
- Final Marine Infrastructure Plan (WS0-0000-HES-PLN-CVX-000-00089-000).

2.2.7 General Vessel Anchoring

Anchor placements for all vessels in the Project area (if required) will be undertaken within the boundaries of the approved DDF and ZoHI. If a vessel is required to anchor outside of these zones, this will only be done within an anchorage area approved by the appropriate authorative regulator body (e.g. the PPA or DoT) or in areas with no mapped filter feeders, seagrass or coral habitat as shown in Figure 3.2. Anchoring in these locations may be required, for example, to ensure safe navigation within the Project area, under the direction of the PPA or to provide safe anchorage for personnel, material or bunker transfers.

Vessel anchoring in any location under extenuating circumstances may also be required under the discretion of the Vessel Master if needed to ensure the safety of the vessel and/or personnel onboard. This may be required in cases where control of the vessel and/or navigation systems are lost, severe weather conditions such as a cyclone warrants it, there is a medical emergency requirement such as medivac or if the vessel has sustained damage.

To safely and effectively implement the marine environmental monitoring programme as detailed in the TIEMMP, monitoring vessels may be required to infrequently anchor for short durations at the monitoring sites outside of the DDF and approved impact zones. These vessels are small in size and only require small anchors to hold station. Where practicable, anchoring by the monitoring vessels will be undertaken in areas of soft sediment where any impacts to benthic primary producer habitat (BPPH) are anticipated to be negligible.

2.2.8 Trunkline Installation Support Vessels

The trunkline installation activities will be undertaken by a combination of support vessels and equipment. The following range of equipment may be employed to undertake the compliment of works:

- Crane and work barges/pontoons
- AHTs
- Multicats
- General supply and bunker vessels
- Towing tugs
- Pushing tugs
- Spreader pontoons/vessels and rock transport/placement barges
- Floating and submerged pipeline and riser pontoons
- Mass flow, jetting and suction excavation tools
- Survey and installation vessels
- Environmental survey and monitoring vessels with associated equipment
- Emergency response vessels
- Pipe haul/supply vessels
- Wire lay barge (shallow draft pontoon with anchors/spuds)
- Surface diving vessel
- Shorepull wire installation barge
- Crew transfers vessels
- Other ancillary equipment required to undertake the full SoW.

2.3 Key Environmental Benefits of Selected Execution Methodology

This section has been included to address the MS 873 Condition 8-4 (vii) requirement to describe the measures taken to execute the trunkline installation activities to minimise, so far as is reasonably practicable, the impacts to benthic habitats. The trunkline installation methods selected have been focussed on environmental impacts to benthic habitats, including:

- Microtunnelling minimises potential environmental impacts of the shore crossing as the tunnel allows the trunkline to run underneath the sensitive dune and mangroves systems eliminating direct disturbance to the coastal mangrove stand and other intertidal benthic habitats.
- Microtunelling will ensure coastal processes are not significantly altered as there is no physical surface presence (Chevron 2010).
- Microtunnelling minimises direct disturbance to the marine lagoon and the Ashburton Delta as the trunkline will emerge approximately 200 m seaward of the barrier spit. The benthic habitat at the exit pit location is characterised as bioturbated silty sands with no observed BPPH (Chevron 2010).

- The trench design and rock dump volumes using the selected methodology are estimated at 2.5 Mm^3 and 0.5 Mt respectively. These volumes are significantly less than estimates provided in the Draft EIS/ERMP (Chevron 2010), which were 3 Mm^3 and 1.85 Mt respectively.
- Trenching, sand backfill and rock placement over the trunkline minimises the impact to shipping (hull clearance), stabilises the trunkline under cyclonic conditions and protects it from other hazards (Chevron 2010), reducing risks vessel impacts and loss of containment.
- Trenching of, backfilling and rock dumping over the trunkline affords protection from, and for fishing trawlers that may be working in the area (URS 2011).
- Trunkline coating and secondary stabilisation provides protection against errant vessel anchoring, grounding or sinking (URS 2011; Chevron 2012b).
- The tender documentation that was provided to the potential Contractors specified strict environmental requirements in accordance with the Project approvals and the selected contractor had proposed the most optimised program from an environmental perspective.
- The dredging and dredge spoil placement and backfill accuracy and efficiency of modern TSHDs, CSDs, self-propelled and non-propelled hoppers is ‘high’ and will be operated by world class dredge contractors that are experienced in the environmental management of dredging operations in the waters off north-west Western Australia.
- The selected trenching methodology minimises or eliminates the need to sidecast material adjacent to the trunkline alignment reducing the requirement for subsequent trench maintenance.
- Larger sized TSHDs and CSDs have been selected where practicable, as opposed to smaller vessels, to minimise the duration of the dredging works and thus reduce the temporal extent of any environmental impacts.
- Larger TSHDs and CSDs are able to dredge along the trench alignment relatively quickly which minimises the duration BPPH are potentially influenced by resulting sediment plumes.
- The high mobility of the TSHDs and CSD allow these vessels to quickly alter their work plan and optimise the dredging programme to mitigate potential or actual impacts on sensitive receptors (details will be included in the TIEMMP).
- The BHD to be used in shallower waters results in localised turbidity so the size and Total Suspended Solids (TSS) concentration of the resulting sediment plume is reduced relative to alternative dredgers.
- The use of a CSD is anticipated to eliminate any requirement for pre-treatment of material via drilling and blasting.
- The use and location of the DSPSs provides the following environmental benefits (Chevron 2010):
  - Minimal interference with navigation
  - Relocated material should be comparable to the naturally occurring sediment
  - There is a low potential for secondary re-suspension after placement
  - Placement should not have a negative effect on the hydrodynamics within the area or the shoreline processes
  - Reduced potential for loss of BPPH as the DSPSs have been characterised as typically unvegetated soft substrate.
- The use of graded rock reduces the fines content thus reducing the resultant turbidity generation (Chevron 2010).

- The use of a pipelay vessel with a DP system in deeper water has the following environmental benefits:
  - No potential risk to impact benthic habitats with anchor configurations and chain scouring
  - Greater pipelay speed and efficiency results in reduced time required on site
  - No requirement for AHTs resulting in a reduced risk of vessel collision or interaction with marine fauna
  - No requirement for AHTs reduces the hydrocarbon spill risk during bunkering and eliminates greenhouse gas emissions from such vessels
  - Lower risk of interaction with other vessel activities due to reduced vessel spread
  - Use of a pipelay vessel with DP eliminates the requirement to install cyclone moorings as the vessel can effectively sail away from the field during a cyclone event.
- The use of an anchored 2nd generation lay barge, in shallower waters, significantly reduces the seabed disturbance created by “thruster wash” of a DP pipelay vessel, should the use thereof be technically feasible, i.e. sufficient water depth.
- The selected anchor pipelay vessel is one of the smallest available on the world market allowing for minimisation of the anchor pattern spread.
- The selected anchor pipelay vessel is capable of facilitating the shorepull operation through the microtunnel.
- The anchor pattern and lay barge movements will affect only discrete patches of seabed with the anchors and their wire sweep areas, i.e. impact is not contiguous.
- The pipelay barge anchors shall be of a type suitable for the expected seabed conditions along the trunkline route to reduce the risk of drag and to optimise the anchoring operation and reduce the need to retrieve and redeploy anchors.
- The lay barge anchors are “passive”, once deployed and set, during the installation of the trunkline (200 m per deployment), limiting seabed disturbance to discrete locations
- The trench depth and secondary stabilisation provides protection against uncovering of the trunkline by seabed mobility/erosion and coastal processes (Chevron 2010).
- The selection of trenching and backfill methodology should require minimum future intervention (e.g. span correction) for maintenance (Chevron 2012).

3.0 EXISTING ENVIRONMENT AND RELEVANT STUDIES

3.1 Overview

The characterisation of the marine environment within the region has been undertaken as part of the environmental impact assessment which underpins the environmental approvals process. This information provides context for determining the management strategies and monitoring programmes detailed in later sections. Full details of the existing marine environment can be found in Section 6.0 of the Draft EIS/ERMP (Chevron 2010).

3.2 Key Environmental Receptors

The key environmental receptors that could potentially be impacted by the proposed trunkline installation activities include:

- Hard corals
- Seagrasses
- Macroalgae
- Filter feeders
- Marine turtles
- Humpback whales
- Dugongs.

3.3 Marine Reserves and Conservation Areas

There are no protected areas in the immediate vicinity of the Ashburton North Site, although a number of marine parks and reserves occur within the Pilbara Nearshore and Pilbara Offshore bioregions. There is no evidence that the trunkline installation activities are likely to impact on any of these marine parks and reserves. The Ashburton North Site does not contain any World Heritage Properties or Ramsar Wetlands of International Significance.

3.4 Existing Physical Environment

3.4.1 Water Quality

A review of studies in the Onslow region (MScience 2009) indicate that the regional median turbidity was usually <1 Nephelometric Turbidity Units (NTU) and the 80th percentile was <3 NTU during non-cyclonic periods.

Across 30 sites daily median turbidity ranged from <1 NTU during winter up to 6 NTU during non-cyclonic periods in summer. Discharge from the Ashburton River during inland rainfall is the primary source for input of terrestrial sediments to the nearshore waters. These events can cause large-scale turbidity elevations in nearshore waters over a period of months. Spring and summer are times of the year when there are persistent westerly winds and increased runoff from rainfall as well as periodic cyclones.

The influence of cyclonic activity on turbidity is strong. During the passage of Tropical Cyclone (TC) Dominic in January 2009, daily median turbidity increased to approximately 80 NTU and remained above 20 NTU for at least ten days. Offshore waters in general tend to have lower turbidity levels.

More recently, turbidity results from the period January to March 2012 show the influence of TC Iggy. Site medians across all sites ranged from 0–3.4 NTU apart from a period of about one week in late January that coincided with the passing of TC Iggy (SKM 2012). Turbidity levels in the week following TC Iggy peaked at approximately 100 NTU at inshore and some eastern mid-shore sites; and 80 NTU and 60 NTU at western mid-shore and offshore sites, respectively.

During the January to March 2012 monitoring period, median daily photosynthetically active radiation (PAR)—a measure of light available to Benthic Primary Producers (BPP)—showed a general pattern of greater PAR at offshore sites than inshore and mid-shore sites. PAR also varies seasonally in waters off Onslow. The median total daily PAR across sites ranged from 1.8–16 mole/m^2/day in summer and 3.0–11.4 mole/m^2/day in winter (SKM 2012). Daily PAR decreased to 0.0 mole/m^2/day after the passing of TC Iggy. The return to normal PAR levels following this event was quicker at offshore sites (SKM 2012). Most monitoring sites showed a response to spring tides, with the added water depth resulting in reduced PAR.

Sediment re-suspension, mainly due to wind-driven waves, is common in the area immediately seaward of the intertidal zone and can lead to considerable turbidity (Forde 1985). This was evident in the January to March 2012 monitoring period and may be related to the generally smaller particle sizes that were found at the inshore sites (SKM 2012). Re-suspension further offshore is mainly due to internal or subsurface waves (Heywood et al. 2006).

Water temperature and salinity were similar across all sites during January to March 2012, indicating that the waters were well mixed. Contaminant levels within the water column are expected to be near background and representative of uncontaminated coastal and marine areas along the Pilbara coast (Chevron 2010).

3.4.2 Marine Sediments

The marine sediments in the region mainly consist of silt and sand sheets of varying thickness overlying Pleistocene limestone. Near the Ashburton Delta, sediments are generally fine silts and clays with high silica content.

Generalised ground conditions, within the trench depth along Trunkline route, can be split into two generalised zones. The materials likely to be encountered during the trenching programme consist of surficial seafloor Sands, Clays and Gravels, Alluvial Sands, Clays and Gravels and Rock (Calcarenite) in the sequences described below:

- Zone A (Figure 3.1) - Dominated by Holocene marine surficial seafloor sediments consisting of Clays, Sands and Gravels of varying thickness (generally <2 m thick) overlying Pleistocene Alluvial deposits consisting of Clays, Sands and Gravels
- Zone B (Figure 3.1) - Dominated by Holocene marine surficial seafloor Carbonate Sands of variable thickness (generally <7 m thick) overlying variably cemented late Pleistocene Calcarenites, which occasionally outcrop and sub-outcrop at the seabed surface.

The thickness and composition of the seafloor sediments are generally dominated by the associated depositional and erosional environments. The surficial seafloor sediment is generally considered to be a reworked *in-situ* material, meaning that the composition and thickness of the surficial seafloor sediment generally reflects the underlying / surrounding geology.

Figure 3.1 presents the summarised interpreted ground conditions, in terms of the assumed extent of Zone A and Zone B, and indicates relevant sample locations within the Trunkline route. The anticipated ground conditions, within the 3.50 m dredge depth zone, are summarised in Table 3.1. Notably, the ground condition summary provided is of those conditions considered likely to be encountered based on the available (limited) information.

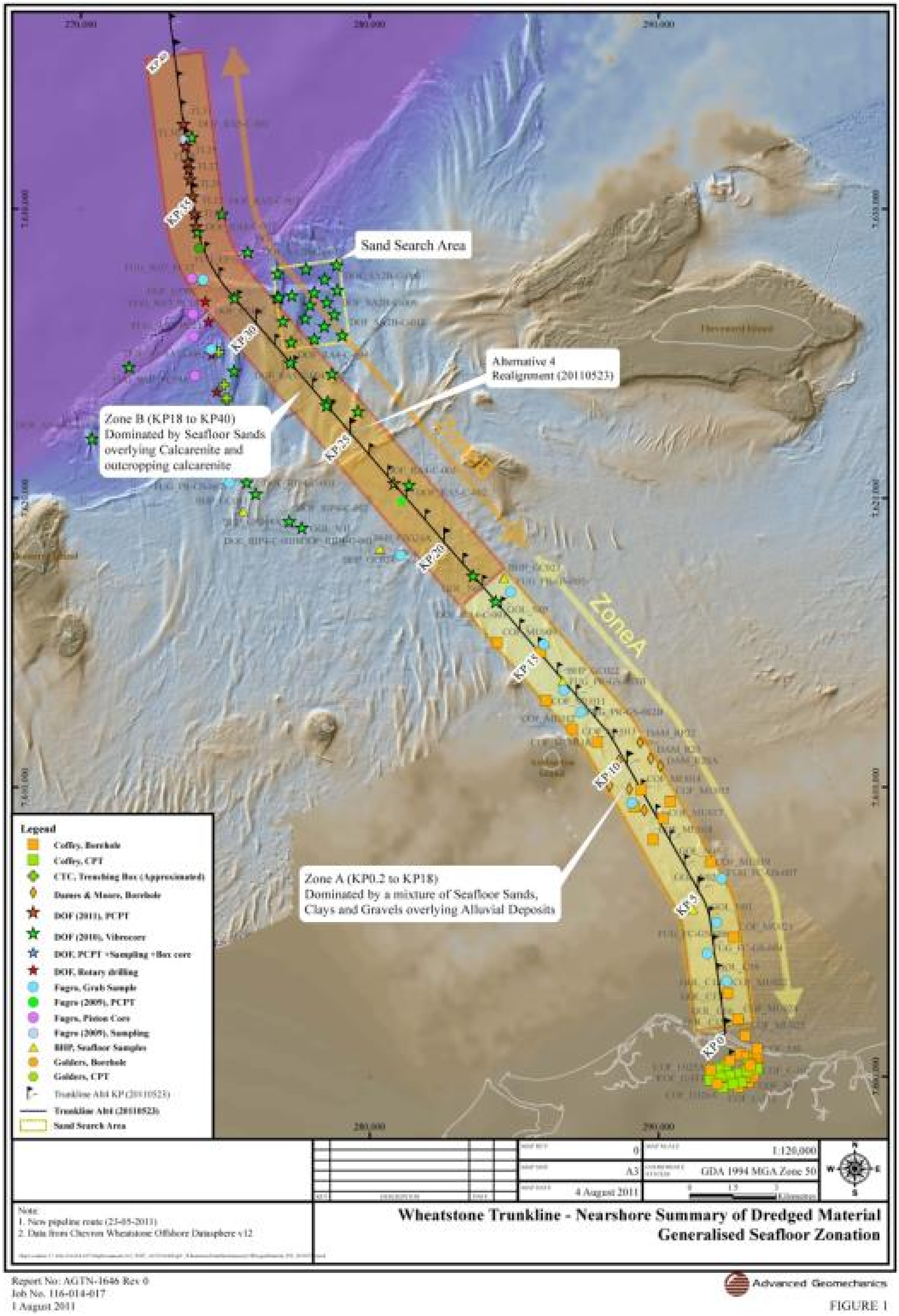


Figure 3.1: Nearshore Summary of Trunkline Trench Dredge Material – Generalised Seafloor Zonation

Table 3.1: Generalised Ground Conditions along the Trunkline Route

Zone	KP Range	Specific KP Locations	Summary of Ground Conditions (within dredge depth zone)	Approx. Thickness Seafloor Sediment (m)	Comments
A	~0.2 to ~18.0		Surficial seafloor sediments consisting of Clays, Sands and Gravels overlying Alluvial deposits consisting of Clays, Sands and Gravels	0.0 - 2.0	
		0.4 to 3.0	Seafloor Clays overlying Alluvial Sands and Clays	0.5 - 2.0	
		3.0 to 8.5	Seafloor Sands and Gravels overlying Alluvial Sands and Clays and Gravels	0.1 - 1.2	Gravels within this region may be part of thicker Palaeochannel materials
		8.5 to 12.2	Seafloor Sands overlying Alluvial Sands and Clays	0.4 - 2.5	
		12.2 to 18.0	Seafloor Sands and Gravels overlying Alluvial Sands and Clays	0.4 - 1.0	
B	~18.0 to 40.0		Surficial seafloor carbonate Sands overlying Calcarenites	0.0 - 7.0	
		18.0 to 20.0	Seafloor Sands with occasional isolated patches of gravel overlying Calcarenite	0.5 - 2.0	KP 18 to KP 20 appears to be the transitional zone between the two erosional/depositional environments. Sub-zone contains occasional isolated coral reefs
		20.0 to 24.0	Seafloor carbonate Sands overlying Calcarenite	>0.5 - 1.0	
		24.0 to 24.5	Calcarenite	N/A	Calcarenite Ridge ~3.0 m above surrounding seafloor
		24.5 to 26.7	Seafloor carbonate Sands overlying Calcarenite	0.5 - 7.0	Large sand waves up to ~5.0 m above surrounding seafloor (mega ripples up to 7.0 m thickness at ~KP 26.3) built up between two calcarenite ridges
		26.7 to 26.9	Calcarenite	N/A	Calcarenite Ridge ~2.5 m above surrounding seafloor
		26.9 to 40.0	Seafloor carbonate Sands overlying Calcarenite	0.5 - 7.0	Sub-outcropping Calcarenite at ~KP 31.2

The chemical characteristics of marine sediments in the vicinity of the Trunkline has been assessed on two previous occasions; once in 2005 by the DEC (DEC 2006) and more recently by URS in the vicinity of the trunkline route (URS 2009).

The DEC (2006) study recorded no discernible anthropogenic enrichment of contaminants (e.g. organotins, hydrocarbons, organochlorine pesticides and polychlorinated biphenyls) in sediments offshore of the Ashburton River mouth. The study also measured natural background concentrations of trace metals in the marine sediments, noting that, with the exception of arsenic, natural background concentrations of all metals were below the relevant Australia and New Zealand Environment and Conservation Council/Agricultural and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) (2000) screening levels (DEC 2006).

During the URS (2009) survey, marine surface sediments and deep cores in the area were sampled within and near the proposed trenching area and grab samples from the proposed nearshore DSPS. Detailed results of this study are provided within the Draft EIS/ERMP. The study recorded concentrations of all contaminants and trace metals as being below the laboratory limit-of-recording (LOR) or below the relevant National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia 2009d) screening levels, with the exception of arsenic and nickel (URS 2009).

The results of the sampling and analysis programme determined that the sediments to be dredged are suitable for unconfined ocean disposal in accordance with the NAGD.

3.4.3 Metocean Conditions

3.4.3.1 Waves

The coast around Onslow is sheltered from prevailing south-west swells (i.e. from the Indian Ocean) by the continental landmass of the North West Cape. Similarly, Barrow Island and the shoals of the Lowendal and Montebello Islands provide shelter from Timor Sea swells. Consequently, the nearshore wave climate is mainly influenced by locally-generated wind waves and occasional tropical cyclones (Damara 2009).

These effects were evident in wave conditions recorded via acoustic Doppler current profilers (ADCPs) and a directional wave rider in the nearshore area, by RPS Metocean (RPS Metocean Engineers 2009). Wave conditions from January to April 2009 were generally mild, with a median wave height of 0.2 m and wave period of 4 seconds. However, tropical cyclones and other low pressure systems generated elevated wave conditions. Other energetic conditions similarly occurred due to low pressure systems to the west of Onslow, producing onshore winds.

3.4.3.2 Winds

The region experiences dominant summer and winter conditions. The climatic conditions are governed by the alternation between the south-east trade winds and monsoonal flows. Tropical cyclones affect the area, particularly during the summer and autumn months. During the summer months () interaction between a low pressure system induced by heating of the continental land mass and the Asian monsoon tends to draw air toward the Australian continent. This leads to predominantly westerly and south-westerly winds at the site. During the winter months, the south-east trade winds bring cool dry air from over the Australian continent, leading to easterly to south-easterly winds at the study area.

3.4.3.3 Currents

In the nearshore, the local topography directs the coastal tidal currents with easterly flow on flood tide and westerly flow on ebb tide. This pattern can be interrupted by wind-driven currents during neap tides when tidal currents are weakest. West of the Ashburton Delta, the tidal current directions are controlled by the flow in and out of Exmouth Gulf with southerly flow into the gulf on flood tide and northerly flow out of the gulf on ebb tide.

Induced by wind stress and, to a lesser extent, gradients in pressure, net currents generally propagate along the coastline and can generate significant alongshore flow, particularly in shallower water. The net currents in shallower water are primarily driven by local winds. Magnitudes of simulated net currents are in the order of half the spring tidal current speeds in many areas. Field measurements (RPS Metocean Engineers 2009) confirm the simulations, including the wind-driven net currents, dominating over tidal currents during both neap and spring tidal conditions.

3.4.3.4 Tides

Tides in the nearshore are semi-diurnal with a spring tidal range of 1.9 m (mean high and low water spring tides of 2.5 m and 0.6 m, respectively). Tidal peaks occur near the equinoxes in March and September. The highest astronomical tide is 2.9 m. The tidal signal changes progressively along the North West Shelf (NWS) coastline with increasing tidal ranges from Exmouth to Broome.

Modelling of extreme cyclonic water levels for the Onslow town site and Onslow Salt (GEMS 2000, Nott & Hubbert 2005) has estimated the 100-year Average Recurrence Intervals (ARI) water level as 4.7 metres above Australian Height Datum (mAHD) (6.2 m Chart Datum - CD), including allowance for wave setup.

3.5 Existing Biological Environment

3.5.1 Marine Habitats

A marine habitat map has been developed for the area, including adjacent to the Trunkline route, and is shown in Figure 3.2. The majority of the seafloor in the vicinity of the proposed trunkline route is comprised of sandy sediments and limestone pavement. BPPH are sparsely distributed and the BPP present include sparse macroalgae, hard coral, seagrasses and mangroves.

On the basis of field surveys, URS (2009a) concluded that the most significant locations with respect to nature conservation value are the shallow fringing coral reefs and macroalgal platforms surrounding Serrurier, Ashburton, Thevenard, Direction, Mangrove, and the Mary Anne Group of Islands (Figure 3.2). However, please refer to Section 3.5.1.1 for recent changes to coral communities. The Mangrove and Mary Anne Group of Islands are the largest and most important nature conservation resources in the vicinity of the Project and are important foraging areas for turtles and dugongs.

Ward Reef is an unusual inshore reef almost completely composed of the genus *Montipora* and characterised by high coral cover. Ward Reef is a locally important recreational fishing and due to its uniqueness may have some conservation value. However, during 2011, coral bleaching and impacts from a tropical cyclone have drastically reduced the percentage cover of coral on this reef and throughout the region in general (see SKM 2012 for a detailed description).

Four major ecosystem units (ECU) were derived from the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) hierarchical ecosystem classification framework and further development by Lyne et al. (2006) for the North West Shelf and these units are detailed within the Draft EIS/ERMP (Chevron 2010):

- ECU0 – Onslow Onshore encompassing intertidal habitats.
- ECU1 – Onslow Nearshore encompassing waters between LAT and up to 10 m depth in relatively complex bathymetry, covering mainly soft substrates but including a ridge of scattered patch shoals which support corals and sponges.
- ECU2 – Onslow Offshore encompassing waters between 10–20 m depth and including most offshore islands and coral reefs and algal-dominated shoals.
- ECU3 – Onslow Inner Shelf incorporating the relatively steep gradient shelf break from 20–70 m depth.

These ECUs are shown in Figure 3.3. Subsequently, Local Assessment Units (LAU) were identified within the ECUs based on bio-geomorphic attributes and the distribution of various types of BPPH. Additionally the nearshore (ECU1) LAUs have been developed in recognition of the administrative boundaries (i.e. Environmental Protection Authority (EPA) Guidance Statement 1, Onslow Port Limits). These LAUs were the basis of the BPPH loss assessment described in Section 5.0. Within the defined ECUs there are a number of key sensitive receptors, details of which are provided in Section 6.0.

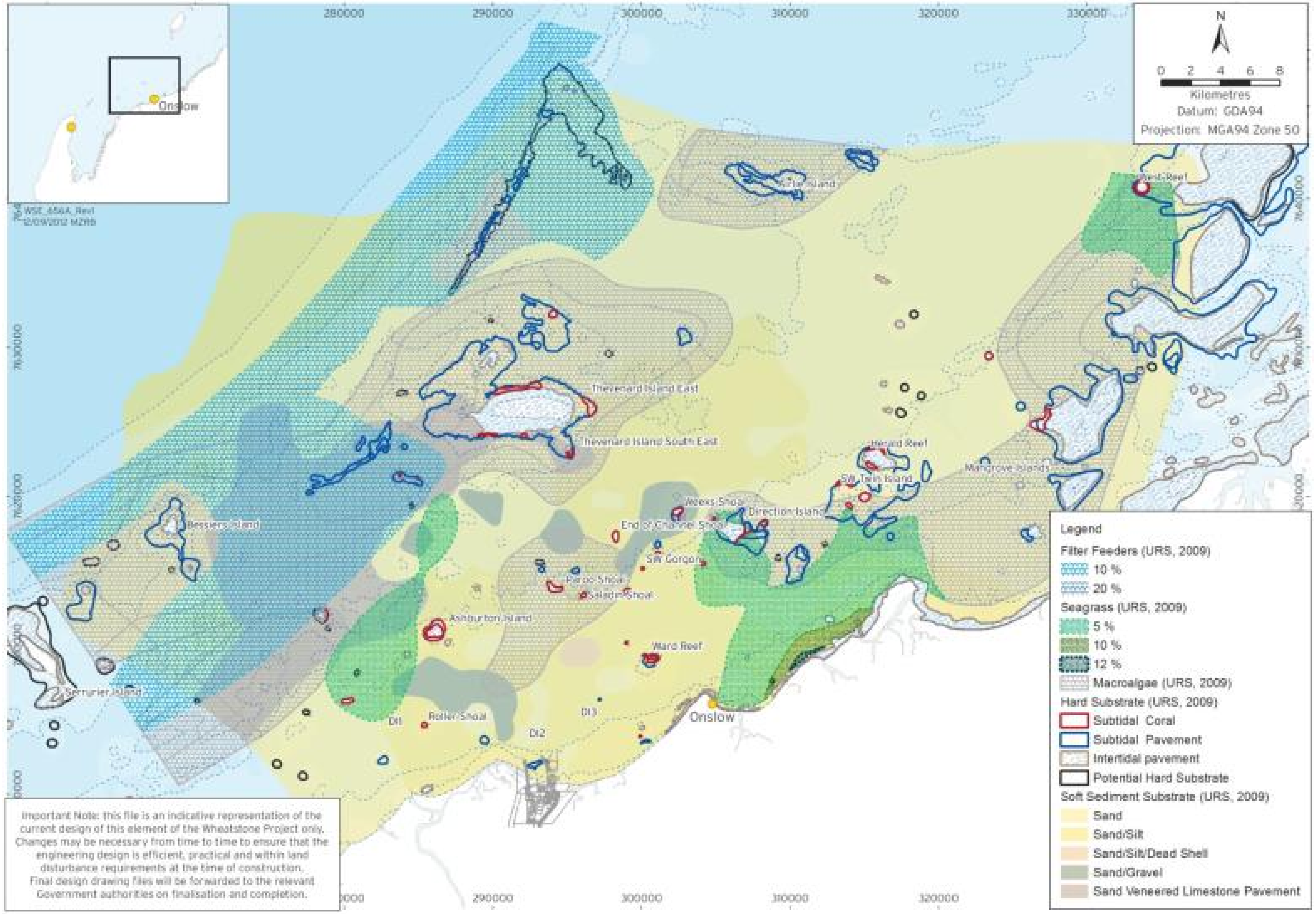


Figure 3.2: Marine Habitat Map

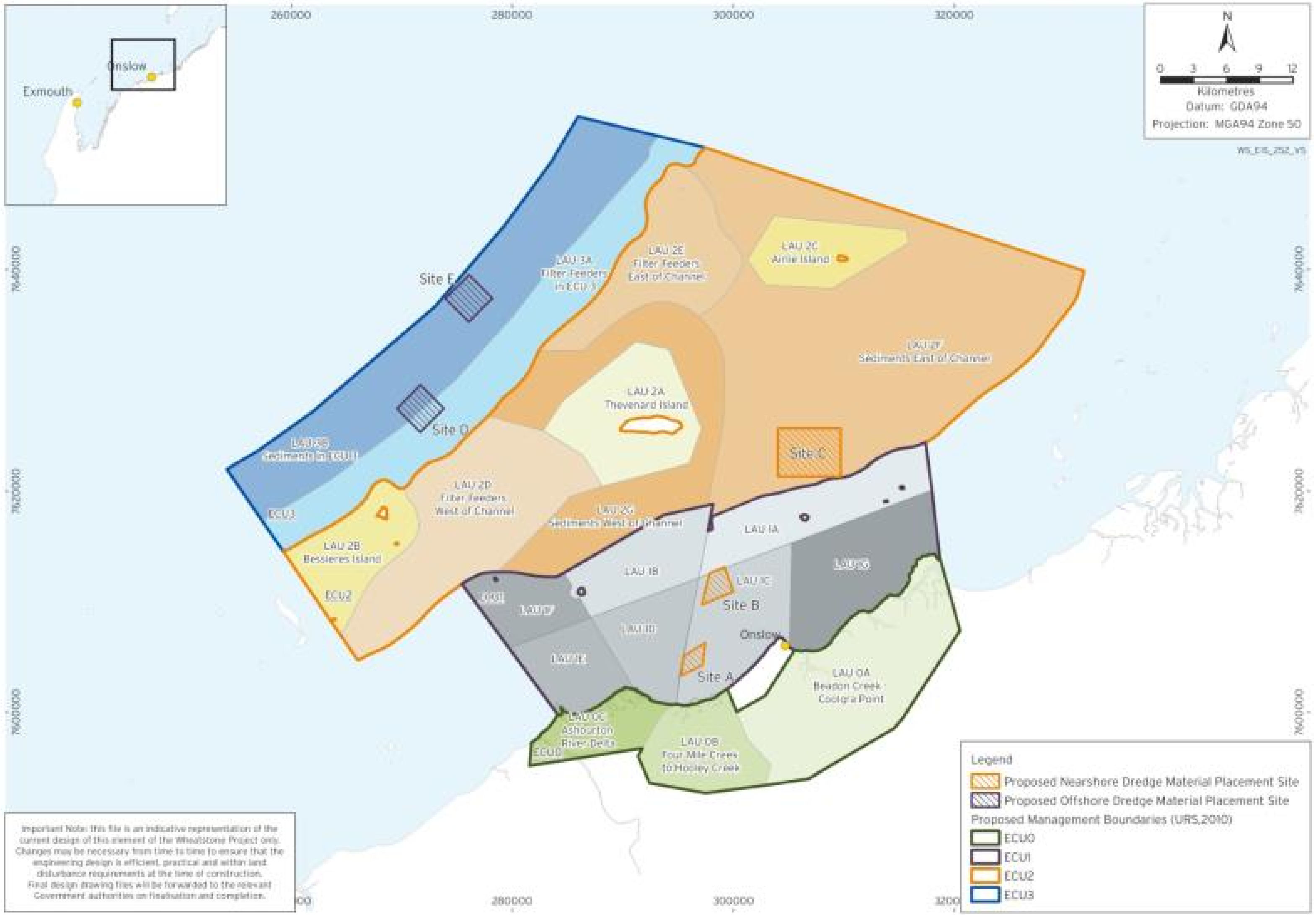


Figure 3.3: Ecosystem Units Defined for the Wheatstone Project

3.5.1.1 Hard Coral

The coral-health based EPOs in MS 873 were based on the status of coral communities prior to April 2011 when coral cover ranged from 29–68% (mean 45%) across reefs in the region. Dominant hard coral genera included *Montipora* and *Acropora*, with *Porites* and various *Favidae* genera as sub-dominant groups. Subsequent surveys indicated that hard coral cover in the vicinity of the trunkline has declined considerably, linked to thermal mass bleaching and the impact of TC Carlos in February 2011 (Figure 3.4; SKM 2012a). Mean coral cover across monitored reef formations in June 2012 was reported to be ~5%, and is <10% at >90% of those reefs monitored during the baseline surveys (Figure 3.5).

Recovery of coral communities may be affected by numerous factors. Corals remaining, or new corals settling, must compete with turf algae and other biota for substrate. Bare available substrate is less than 1% at most sites. Corals may also be subject to further natural disturbances, such as thermal bleaching and cyclones that may also inhibit recovery. January 2012 water temperatures were relatively high and indicate potential further stress and bleaching in February or March 2012. In addition, the passing of TC Iggy in January 2012 and TC Lua significantly affected metocean conditions in the region and may have caused further damage to the remaining corals. Further baseline monitoring prior to the commencement of trunkline installation activities will be able to ascertain whether any changes have occurred in coral communities since November 2011.

Based on studies of recovery elsewhere it is likely that recovery of coral communities will be slow in the short-medium term. In other regions where coral cover has been reduced significantly due to bleaching events and other stressors, recovery has taken up to ten years, or in some cases, reefs have still not fully recovered (Baker et al. 2008, Graham et al. 2011). On the Great Barrier Reef, while one reef was reported to recover within a year following the 2006 bleaching event (Diaz-Pulido et al. 2009), the resulting community was dominated by one species and was not representative of the community that existed prior to the bleaching event (Diaz-Pulido et al. 2009).

Continued monitoring prior to commencement of trunkline installation activities is critical to document surviving hard coral and to determine whether and when the system has shifted from one of decline to recovery. However, there is no historical evidence to indicate whether corals present pre-2011 were a ‘stable’ community type or whether these were high-cover, *Acropora*-dominated communities due to an unusually quiet period of limited cyclone activity (2008-2010). Therefore, there is no way of predicting what the recovery trajectory might be for corals and whether recovery to levels observed in 2010 will even occur.

Coral communities are unlikely to recover prior to the commencement of trunkline installation activities. When, and if, recovery does commence, it is likely to be slow (Graham et al. 2011) and corals are unlikely to reach moderate levels (such as those observed in 2010) prior to the commencement of trunkline installation activities.

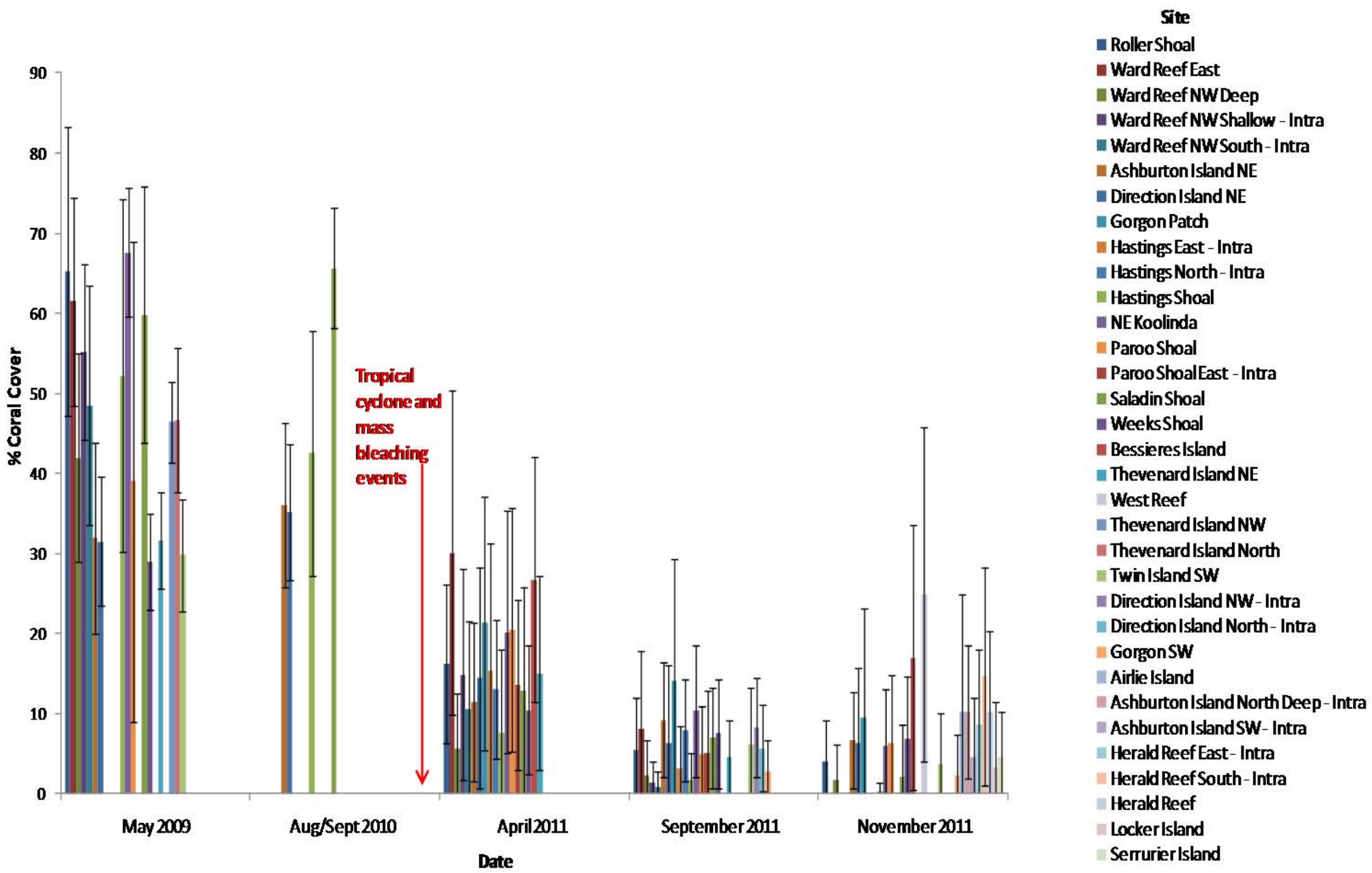


Figure 3.4: Mean Percent Live Hard Coral Cover (+95%CI) at Wheatstone Monitoring Sites prior to and following 2011 Bleaching and Cyclone Events

Note: Some reefs include established intra-sites and hence multiple sites per reef are shown in the figure.

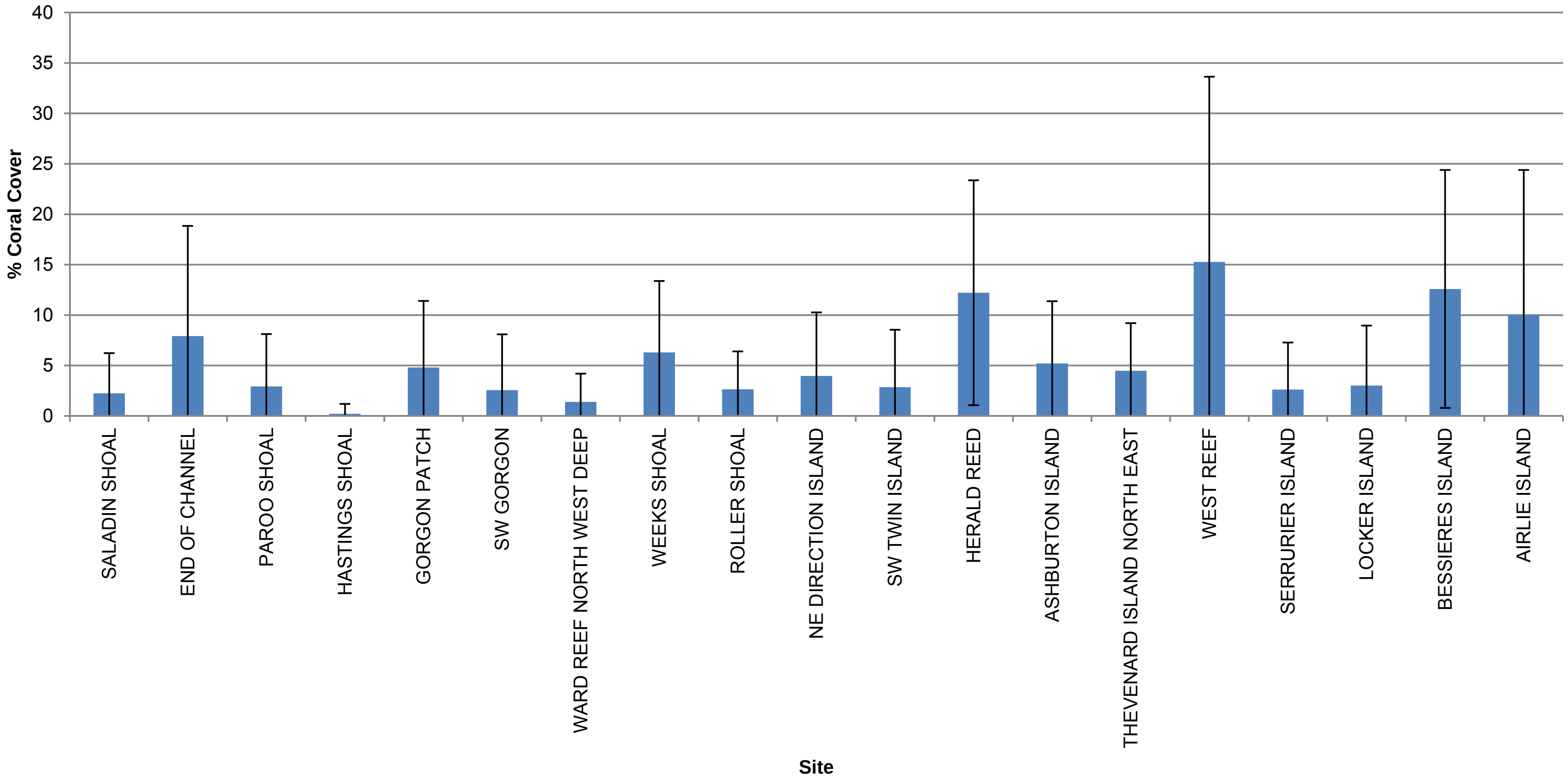


Figure 3.5: Mean Percent Live Coral Cover (±95% CI) at Wheatstone Monitoring Sites during June 2012 (Post-Bleaching and Cyclones)

3.5.1.2 Seagrass

Temporal variability in distribution, density and biomass of seagrass can occur as a result of seasonal cycles and inter-annual change due to sporadic environmental events and natural variation. The abundance and distribution of tropical seagrass species can vary greatly in response to seasonal changes in water quality (turbidity, light penetration) and conditions (wave action, temperature) (Lanyon and Marsh 1995; Short et al. 2001; Loneragan et al. 2003; Duarte et al. 2006). Inter-annual differences in seagrass biomass, distribution and abundance can be attributed to regional-scale changes in climate (Collier and Waycott 2009) and also to smaller scale disturbances (Rasheed 2004).

Paling (1990) surveyed subtidal areas off Onslow and found seagrass was absent from most sites. He noted only ‘rare’ patches of *Halophila decipiens*. More recent surveys, conducted in 2011, show that *Halophila minor and Halophila spinulosa* are the most abundant species in subtidal environments of the Project area (RPS 2012). In September and December 2011, towed video data was captured along 60 transects within 12 potential seagrass zones, ranging in depth from 4–13 m (RPS 2012). Seagrass habitat accounted for approximately 5% of towed video observation points, with 76% of points designated ‘un-vegetated’. Compared to results from September 2011, seagrass cover had increased in deeper water and declined in shallower water near the coastline, likely due to light availability linked to nearshore turbidity (RPS 2012).

Additionally, grabs and drop camera images were gathered from 37 locations to inform the relationship between above and below ground biomass; and percent cover. Seagrass represented <0.4% as analysed from drop camera images. Above and below ground biomass was strongly correlated ($R^2 = 0.93$) and there appeared to be a linear relationship between percent cover and total biomass, although this was based on a small sample size. Seagrass seed stock was assessed from a subsample of each grab; only three seeds were found.

Around the islands offshore from Onslow, species of a number of genera (e.g. *Halophila*, *Halodule* and *Syringodium*) have been reported from intertidal platforms and in the lee of small reefs, while *Thalassodendron* was reported from shallow macroalgal meadows west of Thevenard Island (URS 2009a). The only recent report of intertidal seagrasses in the Project area was sparse seagrass (taxa not described) from Beadon Point (URS 2010).

3.5.1.3 Macroalgae

For the most part, macroalgae in Western Australia do not exhibit a pronounced seasonality. However the brown algal genus, *Sargassum*, is reported to undergo annual growth and reproductive cycles and based on observations in nearby Pilbara locations, it is likely that intertidal and shallow subtidal *Sargassum* species undergo a seasonal succession with peak growth and reproduction over summer (URS 2009).

Macroalgae are present on many shallow shoals and platforms that surround the offshore islands (e.g. Thevenard, Twin Islands). Macroalgae in the region includes large brown algae of the genera *Sargassum*, *Padina* and *Dictyopteris*, and red algae of the genera *Gracilaria* and *Laurencia*. Less common are green algae of the genera *Halimeda* and *Caulerpa* (URS 2009a).

In December 2011, towed video footage was captured to depths of 32 m along 99 transects considered likely to support macroalgae. Macroalgae was present in 28% of the approximately real time 6,600 observations with unvegetated substrate accounting for 58% of the observations. Analysis of still images from the towed video footage using Coral Point Count with Excel Extensions (CPCe) determined macroalgae cover to be 11% and bare substrate 83% (RPS 2012). Macroalgae cover and distribution was highly variable across water depth and proximity to the coastline.

3.5.1.4 Sessile Filter Feeders

During a December 2011 survey, sessile filter feeders (including soft corals, sponges and ascidians) were recorded from 12% of approximately 1000 observations from towed video footage along 15 transects (RPS 2012). Analysis of still images determined the percent cover of sessile filter feeders along theses transects ranged from 0–12%, with soft corals the dominant class.

3.5.1.5 Intertidal Habitats

Two major types of BPPH are recognised in the intertidal marine areas, namely mangroves (and associated high tidal mudflat) and algal mats. Within the nearshore area, mangroves occupy the mainland intertidal zone between the high neap- and spring-tide levels. Mangroves in the area occur mostly within river mouth and tidal creek systems, where they form nearly continuous ribbons of vegetation fringing the channels. These mangroves are protected and partially isolated from the sea by barrier dune systems. Areas of mangroves also occur along the outer, coastal shoreline on the western and northern sides of Coolgra Point (URS 2009b).

Landward of the mangroves, large areas of high tidal mudflats commonly extend to the hinterland margin or merge with supra-tidal salt flats. These mudflats areas are not inundated by daily tides. Two habitat types were recorded on the high tidal mudflats:

- Bioturbated mudflats, devoid of macro-vegetation
- Samphire flats, dominated by halophytic shrubs and with some crab burrows.

3.5.2 Marine Fauna

3.5.2.1 Overview

Fifteen EPBC listed marine fauna species occur, or could occur, in the nearshore or offshore area. These include one bird, five marine mammals, six reptiles and three sharks/rays as shown in Table 3.2. These species are the relevant matters of National Environmental Significance (NES) to which this Plan applies. Of these, 13 species are afforded protection status under the Western Australian *Wildlife Conservation Act (1950).*

In addition to these species, a number of migratory marine mammals and birds that are also protected under the EPBC Act may occur in the nearshore and offshore areas including cetacean species (whales and dolphins), dugongs, migratory seabirds and wetland birds.

3.5.2.2 Marine Mammals

The Pilbara region supports migratory, transient and resident marine mammals such as whales, dolphins and dugongs, all of which are EPBC listed. Many of these are protected under Commonwealth law because they are listed on international treaties to which Australia is a signatory.

Baleen Whales

Four species of cetaceans, including humpback whales (*Megaptera novaeangliae*), pygmy blue whales (*Balaenoptera musculus brevicauda*), Bryde's whales (*Balaenoptera edeni*) and minke whales (*Balaenoptera acutorostrata*) are known to occur in the region.

Humpback whales are known to move through the region on their northern and southern migrations to and from the Kimberley between June and October. Aerial surveys beginning in

May 2009 found northbound humpback whales were concentrated seaward of Thevenard Island and over the continental slope, on average 49 km offshore (CWR 2009). The southbound migration found whales on average 36 km offshore; around the 50 m depth contour. Cow and calf pods were found predominantly inshore of the 50 m depth contour resting in areas nearshore. Although the data indicate that the area does not have the same importance for resting as Exmouth Gulf, or for calving as Camden Sound, the humpback population transiting through the area (Southern Hemisphere Breeding Stock D) has increased. A recent population estimate concluded that the Breeding Stock D humpback whale population has been increasing as much as 10–12% annually (Salgado et al. 2012).

Noise loggers identified pygmy blue whales, dwarf minke whales and Bryde's whales in the offshore waters although none of the species were recorded in the shallow waters in the region. Antarctic minke whales, blue whales and southern right whales were not recorded during the field surveys and are unlikely to be present within the region due to their preference for colder waters.

Dolphins and Toothed Whales

Coastal dolphin species that could occur in the region include the Indo-Pacific humpback dolphin (*Sousa chinensis*) and bottlenose dolphins (*Tursiops* sp.). Little is known of the population structure, movement patterns or ecology of these species within the region. Recent aerial surveys recorded dolphin species within the region although positive identification of dolphins to species level was not possible. However, it is inferred that the Indo-Pacific humpback dolphin and bottlenose dolphins were present (CWR 2009). It can be expected that these coastal dolphin species may be present in shallow and nearshore waters of the region at any time. All coastal species typically occur in low numbers and are widely dispersed, which is in accordance with previous documentation of these species in the Pilbara region (Prince 2001). It is likely that the Indo-Pacific humpback dolphin will move between different shallow water estuaries and inlets along the coast.

Dugongs

Dugongs (*Dugong dugon*) are found within the region. Dugongs tend to occur in wide shallow bays, mangrove channels and in the lee of large inshore islands. Shallow waters such as tidal banks and estuaries have also been reported as sites for calving (Oceanwise 2005).

From the available aerial survey data, it is expected that at least some dugongs are resident in the area year-round but with seasonal variation in densities (CWR 2010, RPS 2010a, Murdoch 2012 and Murdoch 2012a). Low numbers of dugongs were sighted offshore from Onslow predominantly near inshore islands including Ashburton, Direction and Thevenard Island. To the north east of the Project site, in waters between Barrow Island and the Mangrove Passage, larger numbers of dugongs have been sighted. Dugongs were also sighted in areas within and near Exmouth Gulf including close to Serrurier and Muiron Islands. Predominantly dugongs were sighted in water depths less than 10 m and often over or near to known areas of seagrass and macroalgae, as identified during benthic surveys of the area (URS 2009a).

3.5.2.3 Marine Turtles

Green (*Chelonia mydas*) and flatback turtles (*Natator depressus*) are known to occur in the region during sensitive life-history phases (e.g. mating, nesting and inter-nesting) and may be present in the area year-round (RPS 2010b). Loggerhead (*Caretta caretta*) and hawksbill turtles (*Eretmochelys imbricata*) are less abundant and their distribution in the area is not well known. Leatherback turtles (*Dermochelys coriacea*) have not been recorded in the region, nor are they known to nest in the general area.

Surveys have recorded nesting activity by a combination of flatback and green turtles on the large (Serrurier and Thevenard) and moderate sized (Bessieres, Locker and Ashburton) islands. Smaller islands such as Tortoise Island have very small areas of suitable nesting habitat, and very low density nesting activity. Other smaller islands such as Flat, Table, Direction and the Twin Islands have small areas of suitable habitat, with moderate levels of nesting activity (Pendoley Environmental 2009). There was low density of nesting activity observed on the mainland beaches, with large sections of beach presenting no evidence of nesting activity at all (Pendoley Environmental 2009; RPS 2010b).

Juvenile green turtles were observed around the islands. These animals are likely to be residents at their foraging grounds. Foraging green turtles are likely to be found in seagrass and algal habitats and may also utilise coastal mangrove habitats (Pendoley Environmental 2009). A total of 1091 turtles were sighted during the aerial surveys from mid-May to late December off the west Pilbara conducted by CWR (2009).

3.5.2.4 Sawfish

The green sawfish (*Pristis zijsron*) and freshwater sawfish (*Pristis microdon*) are found within the region. Survey work was conducted during 2011 to gain a better understanding of the distribution of sawfish populations in the Onslow area. Passive tracking of sawfish was carried out to study movement patterns (Murdoch 2011). A total of 12 individuals were captured comprising ten green sawfish and two freshwater sawfish. The area appears to be a nursery area for the green sawfish and provides habitat for adult freshwater sawfish which were found near the mouth of the Ashburton River. Nursery habitat for green sawfish appears to be widespread along the Western Australian coast.

Table 3.2: Conservation Status of Marine Fauna Which Occur or May Occur in the Region

Scientific Name	Common Name	EPBC Act *(Cth)* Conservation Status	Wildlife Conservation Act Status
Birds			
Macronectes giganteus	Southern giant petrel	Endangered	Rare or likely to go extinct
Mammals			
Balaenoptera musculus	Blue whale	Endangered	Rare or likely to go extinct
Balaenoptera musculus brevicauda	Pygmy blue whale	Endangered	
Eubalaena australis	Southern right whale	Endangered	Rare or likely to go extinct
Megaptera novaeangliae	Humpback whale	Vulnerable	Rare or likely to go extinct
Dugong dugon	Dugong	Listed marine and listed migratory species	Specially protected
Reptiles			
Caretta caretta	Loggerhead turtle	Endangered	Rare or likely to go extinct
Chelonia mydas	Green turtle	Vulnerable	Rare or likely to go extinct
Dermochelys coriacea	Leatherback turtle	Vulnerable	Rare or likely to go extinct
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	Rare or likely to go extinct
Natator depressus	Flatback turtle	Vulnerable	Rare or likely to go extinct
Crocodylus porosus	Saltwater crocodile	Protected	Specially Protected
Sharks			
Rhincodon typus	Whale shark	Vulnerable	
Pristis zijsron	Green sawfish	Vulnerable	Rare or likely to go extinct
Pristis microdon	Freshwater sawfish	Vulnerable	Rare or likely to go extinct

3.5.3 Migratory Waterbirds

A review of Faunabase (now Fauna Map [WA Museum]), the Birds Australia Atlas Database, the DEC Threatened and Priority Fauna Database, and the EPBC Protected Matters Search Tool indicate that up to 38 migratory waterbird species may frequent the Onslow locality. Bamford (2009) has recorded 26 of these species in the Onslow locality, and those not observed are likely to only occur as infrequent visitors to the area. Of these 26 species, the counts for numbers of waterbird species are all well below any criterion of international significance, except for the common tern (*Sterna hirundo*). The subspecies *Sterna hirundo* ssp. *longipennis* breeds in northern Asia and spends the non-breeding period in south-eastern Asia and northern Australia, and has a minimum population estimate of 25 000 (Scott and Delaney 2002). Three migratory species, the whimbrel (*Numenius phaeopus*), eastern curlew (*Numenius madagascariensis*) and sanderling (*Calidris alba*), may be present in regionally important numbers at the Ashburton River delta, Beadon Creek and Town Beach. However, these are again based on uncertain and conservative estimates of regional populations (Bamford et al. 2008).

3.6 Social and Economic Environment

The land and sea area surrounding the Project has a number of uses and values, including commercial, heritage, environmental conservation, and recreational. The following section provides a brief overview of the sea use and recreational values.

3.6.1 Sea Use Values

3.6.1.1 Commercial Fisheries

The waters off the Pilbara coast are home to many managed commercial fisheries including prawn, demersal scalefish, demersal finfish, mackerel, oyster and several types of tuna. The fisheries in closest proximity to Onslow are managed by the Department of Fisheries (DoF), and include:

- Onslow and Nickol Bay Prawn Managed Fisheries (ONPMF)
- Pilbara Managed Trap Fishery
- North Coast Blue Swimmer Fishery
- Pearl Oyster Managed Fishery
- Pilbara Line Fishery
- Mackerel Managed Fishery
- Specimen Shell Managed Fishery
- Marine Aquarium Fish Managed Fishery.

The ONPMF is a combination of three areas and four associated Size Management Fish Grounds (SMFG) totalling 39 748 km^2. Construction of the proposed Project, including dredging of the trunkline, would most directly affect the Zone ‘Area 1’, which is near the mouth of the Ashburton River, which also includes the Ashburton SMFG.

3.6.1.2 Pearling

Onslow was one of the earliest commercial pearling centres in WA since the commencement of the State’s commercial pearling industry during the nineteenth century. Since 1992, the health of wild oyster stock (the basis for pearl farm production) and the market price of WA pearls have been controlled by a production (output) quota. Quota units are allocated to licence holders (572 units existed in 2006) with one quota unit normally allowing 1000 shells (though there may be annual variations). The major licence and quota holders operate out of Broome.

3.6.1.3 Oil and Gas Production Facilities

Oil is produced from a number of small fields in shallow waters offshore from Onslow. These include the Saladin, Coaster, Roller and Skate fields. Further offshore, are the BHP Billiton operated Griffin oilfield, the Chevron Australia operated Barrow Island facility and the Gorgon gas field development, as well as Apache’s Varanus Island operations.

Key island facilities for oil and gas processing, storage and shipping facilities are located on Barrow, Thevenard, Airlie and Varanus Islands. Gas gathering pipelines from the Griffin and Roller fields come ashore west of Onslow, near Urala Station. A new structure plan is being developed for Onslow to complement the proposed ANSIA, which was endorsed in December 2008 to support further opportunities for gas processing plants development in the area. The ANSIA would cover approximately 8000 ha and include the proposed Project, BHP Billiton/Apache Macedon Domgas plant and the ExxonMobil/BHP Billiton Scarborough LNG plant. The ANSIA would have optimal access to the coast, a buffer of about 12 km from the Onslow town site and would accommodate various gas-related industrial land uses.

3.6.1.4 Shipping

Onslow and the surrounding area is currently not a high density shipping channel. Greater shipping activities occur in neighbouring locations including Exmouth, Dampier and Port Hedland (Australian Maritime Safety Authority 2008).

3.6.2 Recreational Values

Coastal recreational value, within and adjacent to the area, has been determined by a values and land use assessment study (URS 2009c). The areas of highest value and/or use identified in this study included the Ashburton River, Four Mile Creek, Hooley Creek, Sunset Beach, Sunrise Beach, Onslow Town Beach and Beadon Creek. The high value areas that may be affected by changed coastal processes include the Hooley to Four Mile Creek complex (fishing, boating and crabbing); Sunset Beach (four-wheel driving); and Onslow Town Beach (walking). It is important to note that not all of the values identified in the high value areas by the values and land use study (URS 2009c) would be adversely affected.

4.0 ENVIRONMENTAL RISK ASSESSMENT AND PERFORMANCE MEASUREMENTS

4.1 Overview

A series of environmental risk assessments have been completed to identify the most significant risks. These risk assessments, along with the EPOs and MOs, will be the focus of environmental management and monitoring. The risk assessments have addressed each aspect of the Project including the turbidity-generating activities for the trunkline installation. The risk assessments have been undertaken in two phases:

- Phase 1 – An environmental risk assessment was conducted during the scoping phase of the Project to identify key areas of environmental risk requiring detailed assessment.
- Phase 2 – A detailed environmental risk assessment was conducted during the preparation of the Draft EIS/ERMP and this Plan. This assessment reviewed the environmental acceptability of the Project, identified key areas of risk and developed potential monitoring and management strategies.

4.2 Risk Assessment Method

The risk assessment completed for the Draft EIS/ERMP was undertaken in accordance with the principles and guidelines contained in the AS/NZ 4360:2004 – Risk Management and the EPA draft guidelines ‘Application of risk-based assessment in EIA’ (EPA 2008). The process evaluates the likelihood and consequence of environmental impacts occurring as a result of a factor’s (receptor) exposure to one or more aspects (project activities) to assess the environmental risk levels.

‘Consequence’ has been defined by the EPA as an indication of the magnitude of an environmental impact resulting from an environmental aspect. The ’likelihood’ is defined as the probability or frequency of the defined consequence occurring and takes into consideration the probability and frequency of the following:

- The environmental aspect occurring;
- The environmental factor being exposed to the environmental impact; and
- The environmental factor being affected.

Subsequent investigations and sediment plume modelling provided additional data upon which the previous risk assessments conducted in the scoping phase (Phase 1) could be refined. The risks have been assessed assuming the application of mitigation and management measures and therefore indicate the residual risk levels posed to each key environmental factor.

4.3 Risk Assessment Outcomes

The results of the environmental risk assessment of the trunkline installation activities are provided in Chapter 8 of the Draft EIS/ERMP (Chevron 2010).

Environmental risks associated with trunkline installation that have been assessed as posing a residual risk include impacts to BPPH, changes to marine water quality and sediment, and impacts to marine fauna as detailed in the following sections.

4.3.1 Benthic Primary Producer Habitat

Potential impacts to subtidal BPPH is predicted to occur through both direct removal and indirect impacts from trunkline installation activities.

- The potential for direct loss of subtidal BPPH through removal and damage of BPPH at the DSPSs and the trunkline route was assessed as low risk.
- The potential for indirect impacts on BPP and habitats due to increased turbidity, sedimentation and light attenuation leading to loss of habitat in excess of acceptable levels as defined in EPA Guidelines (EPA 2009) associated with trunkline trenching and stabilisation was assessed as high risk.
- Microtunnelling at the shore crossing was not predicted to have any impacts to BPP and/ or BPPH.

4.3.2 Marine Water Quality and Sediments

Potential short-term increased turbidity and light attenuation exceeding agreed water quality targets (which were defined in the Draft EIS/ERMP as the ANZECC/ARMCANZ water quality guidelines) as a result of trunkline trenching operations was assessed as medium risk. Microtunnelling at the shore crossing was not predicted to result in detectable changes to background water quality within the lagoon and was assessed as a low risk.

4.3.3 Marine Fauna

All residual impacts to protected marine fauna, including entrainment, loss of critical habitat, vessel collisions and changes to behaviour, were assessed as a low to very low risk.

4.4 Performance Measurements

The environmental risk assessment detailed in Chapter 8 of the Draft EIS/ERMP (Chevron 2010) has been used to assist the development of the monitoring, management and reporting described in Sections 6.0 to 12.0.

5.0 POTENTIAL IMPACTS TO BENTHIC PRIMARY PRODUCERS

The impact zones for the trunkline installation activities are based on the interrogated outputs of the sediment plume dispersion modelling. The sediment plume dispersion modelling was undertaken to provide predictions of the potential turbidity and sedimentation associated with the proposed trenching, dredge placement and backfill activities. Modelling outputs were then interrogated with the developed tolerance limits which provided an indication of the size and distribution of each impact and influence zone arising from the modelled programme.

To avoid differences and inconsistencies between this Plan and the TRIP, this section is intended to be a duplication of the TRIP and may be amended from time to time if the TRIP is amended. If the TRIP is amended the same amendments will be taken to be made as part of the TIEMMP and an updated copy will be prepared and provided to OEPA and DotE as soon as practicable. If the TRIP amendments also require a review of the TIEMMP the review will be in accordance with Section 12.0. In the event of any inconsistencies or differences between the two plans, within Section 5.6, the TRIP takes precedence to the extent of any difference or inconsistency.

5.1 Modelling

5.1.1 Model Setup and Climatic Parameters

The model established and applied for the EIS/ERMP (DHI 2010) has been applied for the trunkline trenching, dredge spoil placement and sand borrow/backfill activities. Use of the same model takes advantage of the comprehensive calibration and validation exercise carried out and extensively reviewed for the EIS/ERMP and furthermore ensures that model results from the present programme are comparable to the results from the EIS/ERMP (DHI 2012).

The representation of the dredge spoil in terms of settling velocities and re-suspension potential has been maintained from the EIS/ERMP, while the definition of dredge and climatic parameters as well as the model processing has been adapted to the trenching and backfill activities (DHI 2012). The EIS/ERMP identified 2007 as a year with appropriate data availability and is representative of strong climatic conditions. Thus the 2007 data have been retained as the representative year for the modelled scenarios (DHI 2012).

As per the EIS/ERMP, sediment plume modelling has considered two climatic conditions (strong and representative drift), three seasons (summer, winter and transitional periods) and two spill estimates (conservative and worst case) covering the full range of relevant equipment and activities. For each of the three seasons, two 14 day periods representing “average” and “stronger” net current conditions have been processed statistically and compared to established tolerance limits to assess the potential impacts.

The modelling for the EIS included two full sets of modelling applying Onslow winds and MesoLAPS winds, respectively. The EIS modelling demonstrated that the simulated wind and pressure maps of the MesoLAPS data provided the best wind representation during winter with off-shore directed winds that increase in strength when transiting from land to ocean. Measured winds from Onslow would tend to underestimate wind speeds over the ocean. The MesoLAPS wind fields, however, do not fully resolve the sea breezes which can be an important component in the near-shore area, in particular during the summer months. Wind measurements from Onslow provide a better direct resolution of the sea breezes. The MesoLAPS winds therefore tend to be slightly non-conservative for the near-shore area for summer conditions, while the Onslow winds tend to be slightly non-conservative for winter conditions. During the transitional period the winds are generally weaker and more variable, which seems to be captured fairly well by the MesoLAPS winds which better account for the spatial variability. To maintain consistency with the EIS approach of adopting the worst of the two wind fields, the MesoLAPS winds have been applied for the winter and transitional climatic scenarios, while the Onslow wind has been applied for the summer climatic scenarios.

The assessment scenarios, as described in Section 5.1.2, have been used to model the resultant turbidity plume extent, suspended solids concentration and sedimentation levels. This assessment represents a conservative case of the key turbidity generating activities associated with the trunkline installation and is therefore likely to represent the extent of environmental impacts.

5.1.2 Modelled Scenarios

A combination of two modelling approaches has been adopted for the definition of the model scenarios as detailed in Sections 5.1.2.1 and 5.1.2.2. Modelling has allowed the consideration of different dredging mitigation measures to reduce impacts to coral reefs, mapped seagrass beds or other dugong habitat[4]. The mitigation measures considered include different dredge production rates and different climatic scenarios (Section 5.2.2). The modelled outputs were considered and are detailed in the following sections and Section 5.2.

5.1.2.1 Base Case Scenario

The modelling of the base case methodology involved simulation of the full dredge and backfill base case campaigns as accurately as practicable in terms of methodology, schedule and production, but with conservative assumptions of spill rates and dredger movements to achieve a best estimate of a reasonably conservative footprint of the works per the base case execution plan.

The indicative dredger type and schedule along different channel sections are outlined in Table 2.3 and Figure 5.1. The base case methodology involves the use of a BHD in the shallower water out to approximately KP 2, a small/medium TSHD from KP 2 to KP 16, a CSD with barge loading from KP 16 to KP 27 due to the presence of harder material which may not be dredgeable with a TSHD, and the use of a large TSHD from KP 31 to KP 36.

[4] No ‘other dugong habitat’ has been identified in the vicinity of the dredging activities.

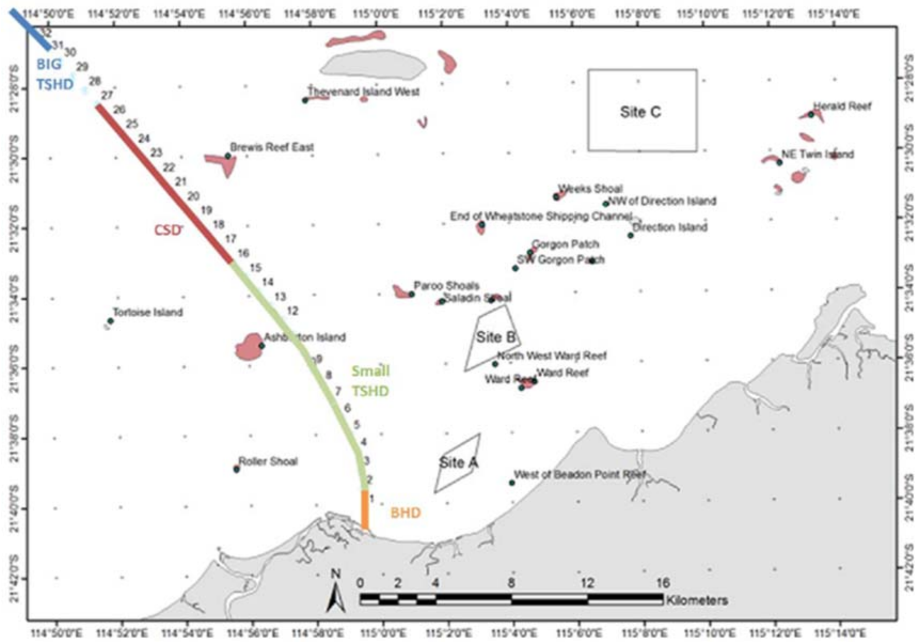


Figure 5.1: Indicative Trenching Methodologies along the Trunkline Route

Note: Modelling based on the assessment of soil conditions and available water depths.

The full dredge and backfill campaign scenario models were set up to accommodate approximately 14-day statistical evaluation periods to provide consistency with previous modelling (DHI 2010; DHI 2012). The full dredge simulations for the trenching and the backfill campaign have been divided into 19 (trenching and spoil placement) and seven (sand borrow and backfill) assessment periods respectively (Table 5.1 and Table 5.2). These assessment periods run approximately from neap tide to neap tide to avoid any bias in the calculated sedimentation rates due to re-suspension during spring tide (DHI 2012).

Table 5.1: Assessment Periods and Key Activities for Base Case Trenching and Dredge Spoil Placement

Period No	Period (2013)*	Activities
1	February	Small TSHD dredging KP 2 – 5
2	February	Small TSHD dredging KP 2 – 5 & Large TSHD dredging KP 31 – 36
3	March	Small TSHD dredging KP 2 – 5 & Large TSHD dredging KP 31 – 36
4	March	Small TSHD dredging KP 2 – 5
5	June	CSD dredging KP 16 - 27
6	June	CSD dredging KP 16 - 27
7	June/July	CSD dredging KP 16 - 27
8	July	CSD dredging KP 16 - 27
9	July/August	CSD dredging KP 16 - 27
10	August	CSD dredging KP 16 – 27 & Small TSHD dredging KP 12 - 16

Period No	Period (2013)*	Activities
11	August/September	Small TSHD dredging KP 12 - 16
12	September	Small TSHD dredging KP 12 - 16
13	September/ October	Small TSHD dredging KP 5 – 7.5
14	October	Small TSHD dredging KP 5 – 7.5
15	October/ November	Small TSHD dredging KP 5 – 7.5 & BHD dredging KP 0.18 - 2
16	November	Small TSHD dredging KP 7.5 - 12 & BHD dredging KP 0.18 - 2
17	November/ December	Small TSHD dredging KP 7.5 – 12 & BHD dredging KP 0.18 - 2
18	December	Small TSHD dredging KP 7.5 - 12 & BHD dredging KP 0.18 - 2
19	December	Small TSHD dredging KP 7.5 - 12 & BHD dredging KP 0.18 - 2

*these assessment periods have been included based on the indicative schedule for the purposes of the initial risk assessment.

Table 5.2: Assessment Periods and Key Activities for Sand Borrow and Backfilling Activities

Period No	Period* (2014)	Activities
1 & 2	June	Medium/Large TSHD sand borrow from Borrow Area A2B then backfilling at KP 9 - 27
3	June/July	Medium/Large TSHD sand borrow from Borrow Area A2B then backfilling at KP 9 - 27
4	July	Medium/Large TSHD sand borrow from Borrow Area A2B then backfilling at KP 31.6 – 36.3, Small/medium TSHD sand borrow from Borrow Area A2B then backfilling at KP 7.1 – 8.6
5	July/ August	Small/medium TSHD sand borrow from Borrow Area A2B then backfilling at KP 0.18 – 2 with spreader pontoon
6	August	Small/medium TSHD sand borrow from Borrow Area A2B then backfilling at KP 0.18 – 2 with spreader pontoon
7	August/ September	Small/medium TSHD sand borrow from Borrow Area A2B then backfilling at KP 2 - 4

*These assessment periods have been included based in the indicative schedule for the purposes of the initial risk assessment.

5.1.2.2 Climatic Scenarios

The individual assessment periods for the full dredge scenario modelling demonstrated that the climatic conditions play a significant role in the potential impact prediction. To test the risk of impacts to the key reefs at Ashburton Island and Brewis Reef, variable climatic conditions have been tested through the climatic scenario modelling. This was done by modelling dredging in the vicinity of Ashburton Island and Brewis Reef for the six climatic scenarios used in the Draft EIS/ERMP which included:

- Strong summer
- Representative summer
- Strong winter
- Representative winter
- Strong transitional
- Representative transitional

Additionally this included the simulation of climatic scenarios for dredging in identified critical locations, Ashburton Island and Brewis Reef, with increased production rates (as compared to the base case execution plan). Inclusion of increased production rates allowed an assessment of the environmental risks associated with potential schedule and production changes to the base case execution plan.

5.1.2.3 Sediment Spill Source Terms

Dredge speeds, production rates, spill rates and fines content used for the model have been determined based on engineering design, data provided by the contractor undertaking the works, experience and professional judgement of the modelling contractor (DHI) and geotechnical surveys undertaken to date. As there is considerable uncertainty in spill term estimation prior to the start of the trenching campaign, conservative spill rates have been applied to account for this.

5.2 Modelling Results

5.2.1 Base Case Scenario

Combining all the periods modelled for the base case, including trenching and backfill, illustrates the largest anticipated turbidity plume extent along the trunkline route within State waters. A composite mean Suspended Sediment Concentration (SSC) plot is presented in Figure 5.2 which shows that the resultant plume will generally contain 1–3 mg/L SSC on average. Note that this represents the base case programme mean SSC arising during all corresponding seasons using the climatic data as described in Section 5.1.

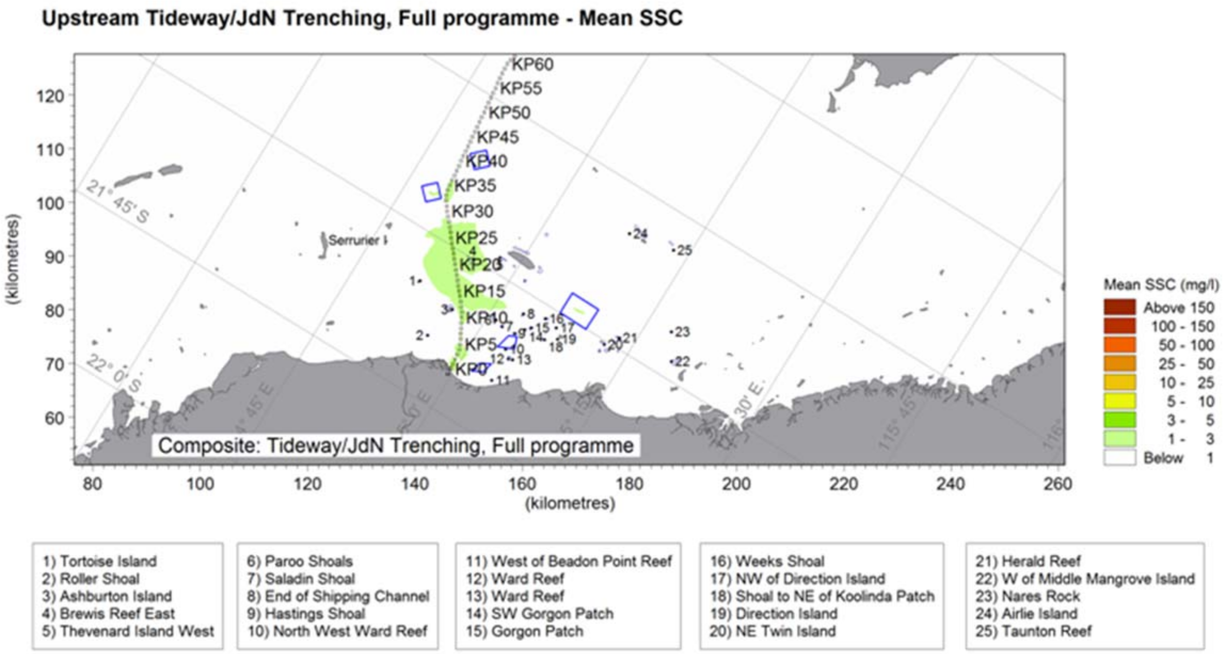


Figure 5.2: Mean Excess SSC Concentration for the Full Trenching Programme

5.2.2 Climatic Scenario

Modelling to assess the effects of different climatic scenarios, e.g. seasons, for dredging adjacent to Ashburton Island and Brewis Reef did demonstrate varying results relative to the base case however SSCs and frequencies (e.g. frequency of exceedence of SSC levels) are still considered as low. Figure 5.3 and Figure 5.4 shows modelled frequencies in excess of 5 mg/l at Ashburton and Brewis Reef respectively.

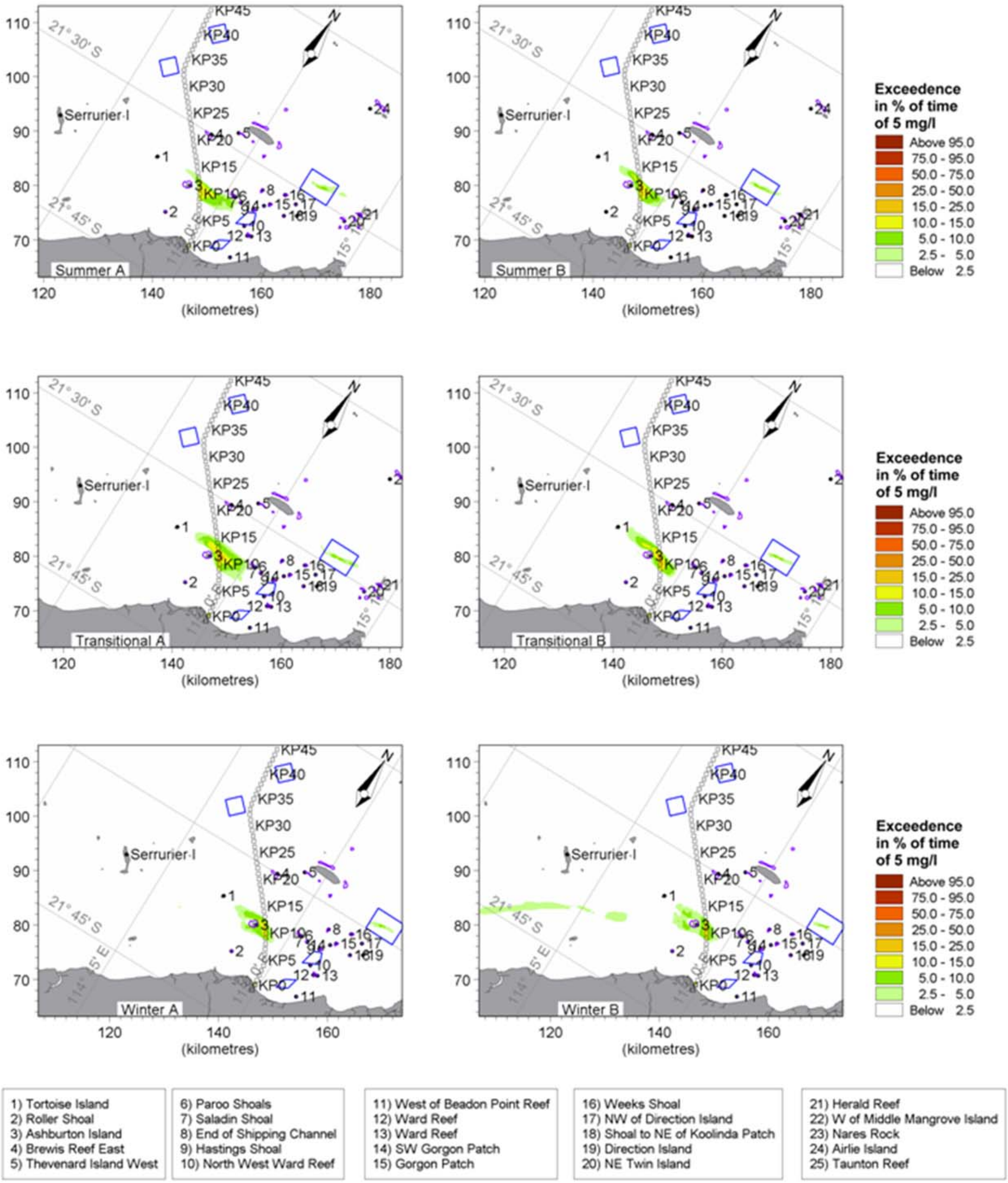


Figure 5.3: Exceedence of 5 mg/L for 2 Summer, 2 Transitional and 2 Winter Climatic Scenarios for TSHD Dredging adjacent to Ashburton Island

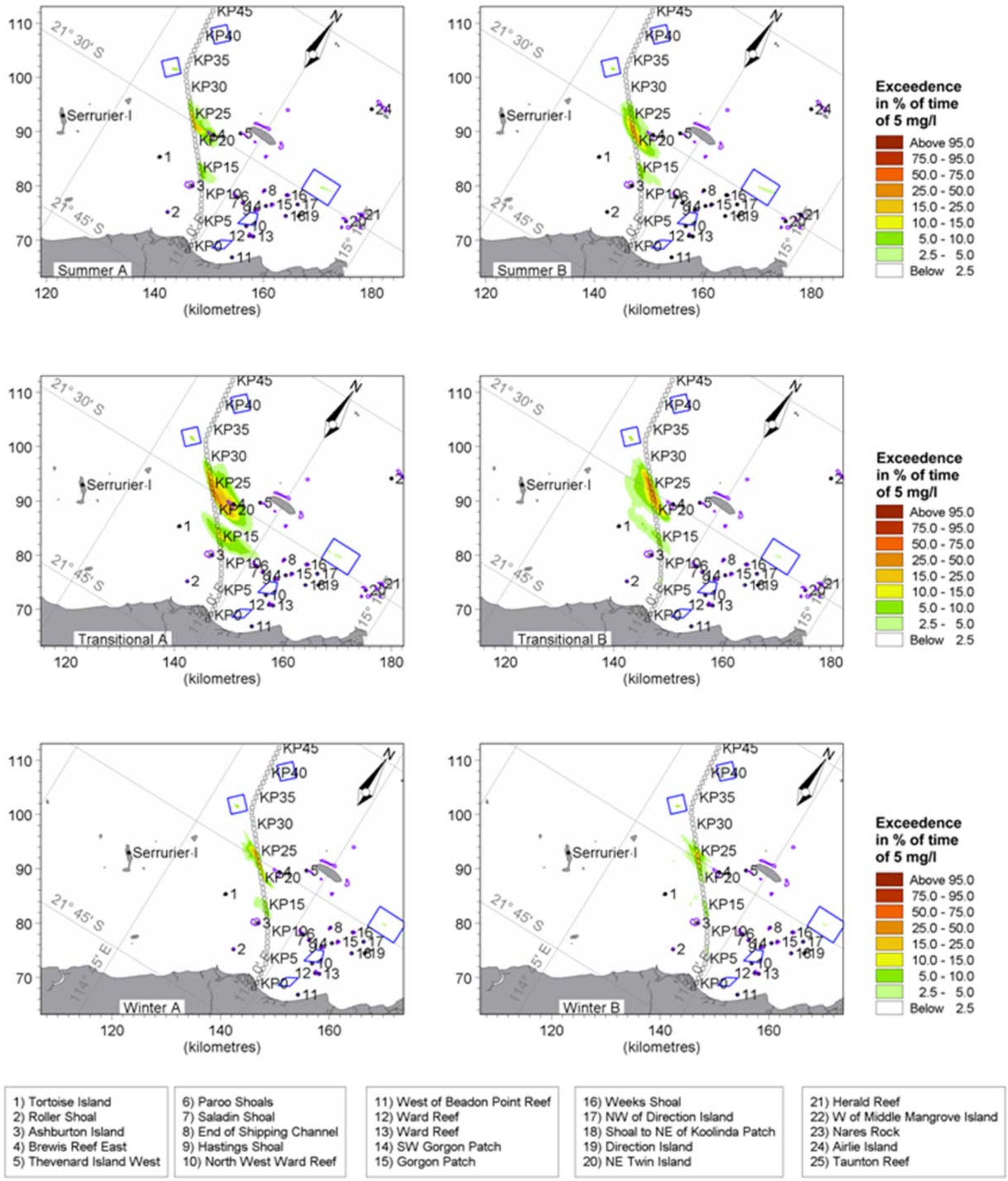


Figure 5.4: Exceedence of 5 mg/l for 2 Summer, 2 Transitional and 2 Winter Climatic Scenarios for CSD Dredging adjacent to Brewis Reef

5.3 Impact Zones

Impact zones for turbidity-generating activities were initially developed based on the recommended approach of the OEPA Marine Ecosystem Branch (MEB) in Guidance Statement 29 (EPA 2004), which uses four categories of classification. A description of the impact zones initially developed is provided in Table 5.3 (columns 1 and 2). Refer to the Draft EIS/ERMP for further details on the establishment of these zones (Chevron 2010).

There are slight differences between the zones presented in the EIS/ERMP and the zones presented in this plan which were developed in accordance with Environmental Assessment Guideline (EAG) 3 (EPA 2009) and EAG7 (EPA 2011) (columns 3 and 4 of Table 5.3) which supersede Guidance Statement 29 (EPA 2004). Generally the Zone of Total Mortality and Partial Mortality correspond to the ZoHI and Zone of Moderate Impact (ZoMI) respectively and the Zone of Influence (ZoI) and Zone of No Impact correspond exactly between definitions used in the EIS/ERMP and those used in this Plan.

Table 5.3: Definition of Impact Zones for Turbidity-generating Activities

EIS/ERMP Definitions (as per GS29)		Revised Definitions in Final EIS/RTS (as per EAG3 and EAG7)	
Zone	**Definition**	**Zone**	**Definition**
Zone of Total Mortality	An area within which key receptors are predicted to suffer total or substantial mortality (>50%), and where loss of structural function is predicted to occur.	Zone of High Impact	An area within which BPPH or the BPP communities that they support are predicted to suffer permanent impacts (not recoverable within 5yrs) as a result of direct or indirect impacts attributable to dredging or placement activities.
Zone of Partial Mortality	An area within which key receptors are predicted to suffer partial mortality (up to 50% loss close to the channel and <1% loss at the extremes). Mortality will occur within the area, but will not include all individuals. The outer border will be drawn so that no mortality will be predicted to occur immediately outside of this zone.	Zone of Moderate Impact	An area within which non-permanent impacts (recoverable within 5 yrs) are predicted to occur as a result of dredging or placement activities. In order to provide a quantifiable level of impact, this zone has been defined within this Plan as an area within which 70% of hard corals will remain unimpacted (up to 30% mortality of corals may occur). For seagrass/macroalgae the original definition of the Zone of Partial Mortality has been used to provide a quantifiable level of impact.
Zone of Influence	Outside the outer boundary of the Zone of Partial Mortality there may be influence from the dredge plume at low levels (for example sub-lethal impacts on key receptors, turbidity may be visible or very light sedimentation may occur) but this is predicted to be unlikely to have any material and/or measurable impact on the key receptors.	Zone of Influence	Outside the outer boundary of the Zone of Moderate Impact there may be influence from the dredge plume at low levels (for example sub-lethal impacts on key receptors, turbidity may be visible or very light sedimentation may occur) but this is predicted to be unlikely to have any material and/or measurable impact on the key receptors.

EIS/ERMP Definitions (as per GS29)		Revised Definitions in Final EIS/RTS (as per EAG3 and EAG7)	
Zone	Definition	Zone	Definition
No Impact	Beyond the outer boundary of the Zone of Influence, there will be an unbounded area where there is no detectable influence on turbidity and sedimentation rates from the dredging. This area would be suitable for locating reference reefs.	No Impact	Beyond the outer boundary of the Zone of Influence, there will be an unbounded area where there is no detectable influence on turbidity and sedimentation rates from the dredging. This area would be suitable for locating reference reefs.

5.3.1 BPPH Tolerance Limits

Tolerance limits for both turbidity and sedimentation rates have been established for hard coral and seagrass. Tolerance limits have been established for both the nearshore Ecosystem Unit (ECU1) and offshore waters (ECU2) to reflect the different natural turbidity climate of these areas (DHI 2010; DHI 2012).

The initial tolerance limits for corals were developed based on the definition of Impact Zones for the draft EIS/ERMP and thus the tolerance limits for the ZoHI were based on substantial mortality (defined as >50% mortality) and the tolerance limits for the ZoMI were based on partial mortality (defined as up to 50% mortality close to the channel and <1% mortality at the extremes). These tolerances limits were refined to achieve the revised definitions of impact zones in accordance with EAG3 and EAG7. Substantial mortality was defined as >70% mortality (ZoHI) and partial mortality was defined as <30% mortality (ZoMI). These new tolerance limits are detailed in Table 5.4 to Table 5.7. Refer to the Draft EIS/ERMP for the original tolerance limits. These same revised tolerances limits were applied to filter feeders as per the logic described in the draft EIS/ERMP (Chevron 2010). There were no refinements following changes to the definition of the impact zones for the seagrass and macroalgae tolerance limits since the Draft EIS/ERMP (Chevron 2010) which are presented in Table 5.8 to Table 5.11.

Table 5.4: Definition of Impact Zones for Suspended Sediment Impacts on Corals Applicable for Nearshore Waters within 5 m isobath in ECU1 during Summer and Winter Only

Zone of Impact	Definitions
Zone of High Impact *EPO: total mortality allowed*	♦ Excess SSC >25 mg/l for more than 14% of the time OR ♦ Excess SSC >10 mg/l for more than 38% of the time OR ♦ Excess SSC >5 mg/l for more than 63% of the time
Zone of Moderate Impact *EPO: <30% mortality*	♦ Excess SSC >25 mg/l for 5-14% of the time OR ♦ Excess SSC >10 mg/l for 20-38% of the time OR ♦ Excess SSC >5 mg/l for 50-63% of the time
Zone of Influence *EPO: 0% mortality*	♦ Excess SSC >25 mg/l for 1-5% of the time OR ♦ Excess SSC >10 mg/l for 1-20% of the time OR ♦ Excess SSC >5 mg/l for 5-50% of the time
No Impact	♦ Excess SSC >25 mg/l for less than 1% of the time OR ♦ Excess SSC >10 mg/l for less than 1% of the time OR ♦ Excess SSC >5 mg/l for less than 5% of the time

Table 5.5: Definition of Impact Zones for Suspended Sediment Impacts on Corals Applicable for Offshore Waters (beyond 5 m isobath) for all seasons and for Nearshore Waters (within 5 m isobath) during Transitional Periods Only

Zone of Impact	Definitions
Zone of High Impact *EPO: total mortality allowed*	♦ Excess SSC >25 mg/l for more than 7% of the time OR ♦ Excess SSC >10 mg/l for more than 19% of the time OR ♦ Excess SSC >5 mg/l for more than 40% of the time
Zone of Moderate Impact *EPO: <30% mortality*	♦ Excess SSC >25 mg/l for 2.5-7% of the time OR ♦ Excess SSC >10 mg/l for 10-19% of the time OR ♦ Excess SSC >5 mg/l for 25-40% of the time
Zone of Influence *EPO: 0% mortality*	♦ Excess SSC >25 mg/l for 0.5-2.5% of the time OR ♦ Excess SSC >10 mg/l for 0.5-10% of the time OR ♦ Excess SSC >5 mg/l for 2.5-25% of the time
No Impact	♦ Excess SSC >25 mg/l for less than 0.5% of the time OR ♦ Excess SSC >10 mg/l for less than 0.5% of the time OR ♦ Excess SSC >5 mg/l for less than 2.5% of the time

Table 5.6: Definition of Impact Zones for Sedimentation Impact on Corals Applicable for Nearshore Waters within 5 m isobath in ECU1 during Summer and Winter Only

Zone of Impact	Definitions
Zone of High Impact *EPO: total mortality allowed*	Sedimentation more than 34 mg/cm^2/day (more than 11.9 mm/14 days)
Zone of Moderate Impact *EPO: <30% mortality*	Sedimentation 10-34 mg/cm^2/day (3.5-11.9 mm/14 days)
Zone of Influence *EPO: 0% mortality*	Sedimentation 2.5-10 mg/cm^2/day (0.9-3.5 mm/14 days)
No Impact	Sedimentation less than 2.5 mg/cm^2/day (less than 0.9 mm/14 days)

Table 5.7: Definition of Impact Zones for Sedimentation Impact on Corals Applicable for Offshore Waters (beyond 5 m isobath) for all Seasons and for Nearshore Waters (within 5 m isobath) during Transitional Periods Only

Zone of Impact	Definitions
Zone of High Impact *EPO: total mortality allowed*	Sedimentation more than 14 mg/cm^2/day (more than 4.9 mm/14 days)
Zone of Moderate Impact *EPO: <30% mortality*	Sedimentation 5-14 mg/cm^2/day (1.7-4.9 mm/14 days)
Zone of Influence *EPO: 0% mortality*	Sedimentation 1-5 mg/cm^2/day (0.3-1.7 mm/14 days)
No Impact	Sedimentation less than 1 mg/cm^2/day (less than 0.3 mm/14 days)

Table 5.8: Suspended Sediment Impact on Seagrass for Offshore Waters (beyond 5 m isobath), and for Nearshore Waters (within 5 m isobath) during Transitional Periods Only

Zone of Impact	Definitions
Zone of High Impact *EPO: total mortality allowed*	♦ Excess SSC >25 mg/l for more than 25% of the time OR ♦ Excess SSC >10 mg/l for more than 50% of the time
Zone of Moderate Impact *EPO: <50% mortality*	♦ Excess SSC >25 mg/l for 2.5 – 25% of the time OR ♦ Excess SSC >10 mg/l for 10 – 55% of the time OR ♦ Excess SSC >5 mg/l for more than 25% of the time
Zone of Influence *EPO: 0% mortality*	♦ Excess SSC >25 mg/l for 0.5 – 2.5% of the time OR ♦ Excess SSC >10 mg/l for 0.5 – 10% of the time OR ♦ Excess SSC >5 mg/l for 2.5 – 25% of the time
No Impact	♦ Excess SSC >25 mg/l for less than 0.5% of the time OR ♦ Excess SSC >10 mg/l for less than 0.5% of the time OR ♦ Excess SSC >5 mg/l for less than 2.5% of the time

Table 5.9 Suspended Sediment Impact on Seagrass for Nearshore Waters (within 5 m isobath) during Summer and Winter only

Zone	Definitions
Zone of High Impact *EPO: total mortality allowed*	♦ Excess SSC >25 mg/l for more than 50% of the time
Zone of Moderate Impact *EPO: <50% mortality*	♦ Excess SSC >25 mg/l for 5 – 50% of the time OR ♦ Excess SSC >10 mg/l for 20% of the time
Zone of Influence *EPO: 0% mortality*	♦ Excess SSC >25 mg/l for 1 – 5% of the time OR ♦ Excess SSC >10 mg/l for 1 – 20% of the time OR ♦ Excess SSC >5 mg/l for more than 5% of the time
No Impact	♦ Excess SSC >25 mg/l for less than 1% of the time OR ♦ Excess SSC >10 mg/l for less than 1% of the time OR ♦ Excess SSC >5 mg/l for less than 5% of the time

Table 5.10: Net Sedimentation Impact on Seagrass for Offshore Waters (beyond 5 m isobath), and for Nearshore Waters (within 5 m isobath) during Transitional Periods only

Zones	Definitions
Zone of High Impact *EPO: total mortality allowed*	Sedimentation >70 mg/cm2/day (>17 mm/14day)
Zone of Moderate Impact *EPO: <50% mortality*	Sedimentation 20 – 70 mg/cm2/day (7 – 17 mm/14day)
Zone of Influence *EPO: 0% mortality*	Sedimentation 3 – 20 mg/cm2/day (1 – 7 mm/14day)
No Impact	Sedimentation <3 mg/cm2/day (<1 mm/14day)

Table 5.11: Net Sedimentation Impact on Seagrass for Nearshore Waters (within 5 m isobath) during Summer and Winter only

Zones	Definitions
Zone of High Impact *EPO: total mortality allowed*	Sedimentation >100 mg/cm2/day (>24.5 mm/14day)
Zone of Moderate Impact *EPO: <50% mortality*	Sedimentation 30 – 100 mg/cm2/day (10 – 24.5 mm/14day)
Zone of Influence *EPO: 0% mortality*	Sedimentation 4 – 30 mg/cm2/day (1.5 – 10 mm/14day)
No Impact	Sedimentation <4 mg/cm2/day (<1.5 mm/14day)

5.4 Modelling Outputs

The modelling for both the dredging and the backfill campaigns has been carried out for the full programme with realistic but conservative estimates of production and associated spill rates. The model shows the ZoI stretching up to 10 km from the trench alignment in some areas but overall indicated that the full campaign (including both dredging and sand backfill) should achieve the EPOs (Figure 5.5 to Figure 5.11).

Modelling to assess against the climatic scenarios did demonstrate some sensitivity of the results to the applied climatic conditions relative to the base case. Although the ZoI from some of the climatic scenarios extended further from the dredge corridor relative to the base case simulations Figure 5.7 to Figure 5.9, this did not lead to any exceedence of the tolerance limits beyond the specified zones of impact. Therefore dredging in accordance with the climatic scenarios (worst case) should also achieve the EPOs (DHI 2012).

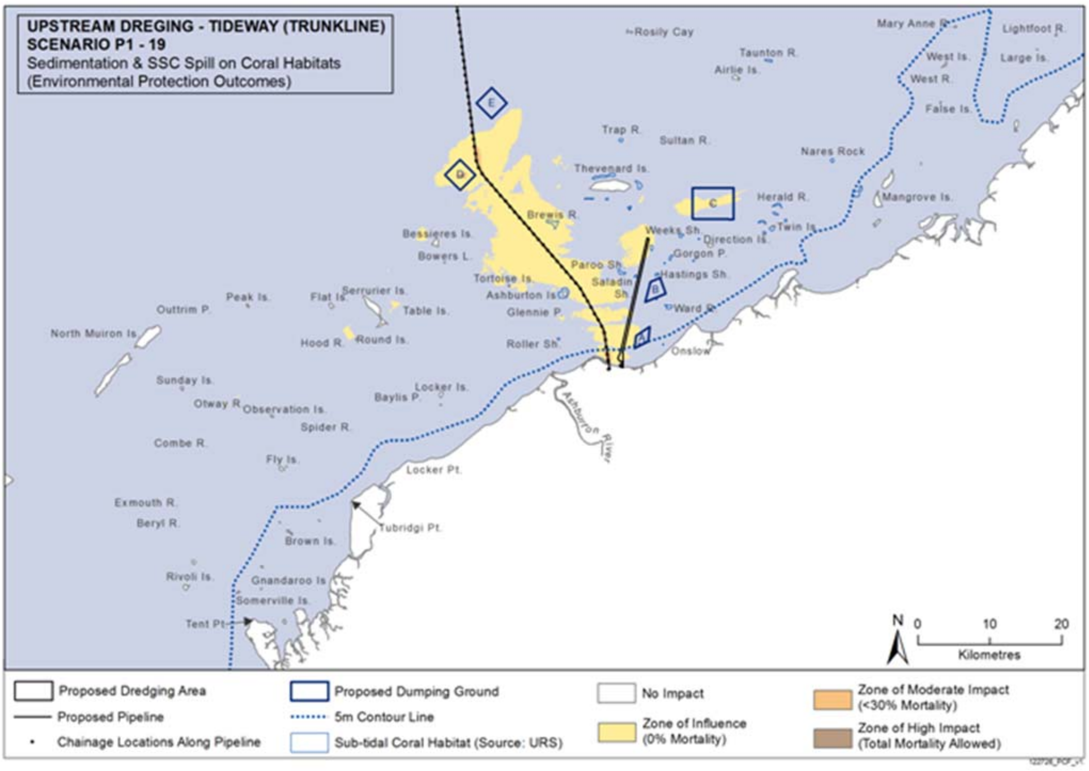


Figure 5.5: Predicted Impact Zones for Corals based on Full Base Case Scenario Simulation

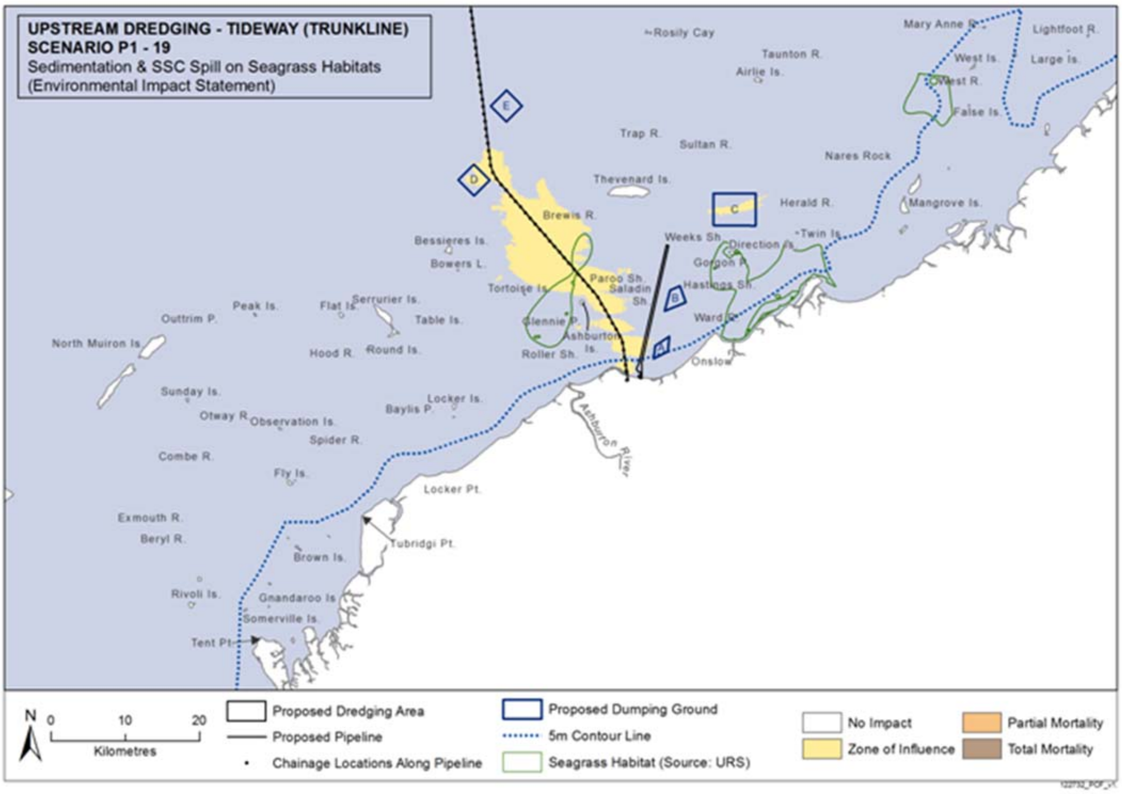


Figure 5.6: Predicted Impact Zones for Seagrass based on Full Base Case Scenario Simulation

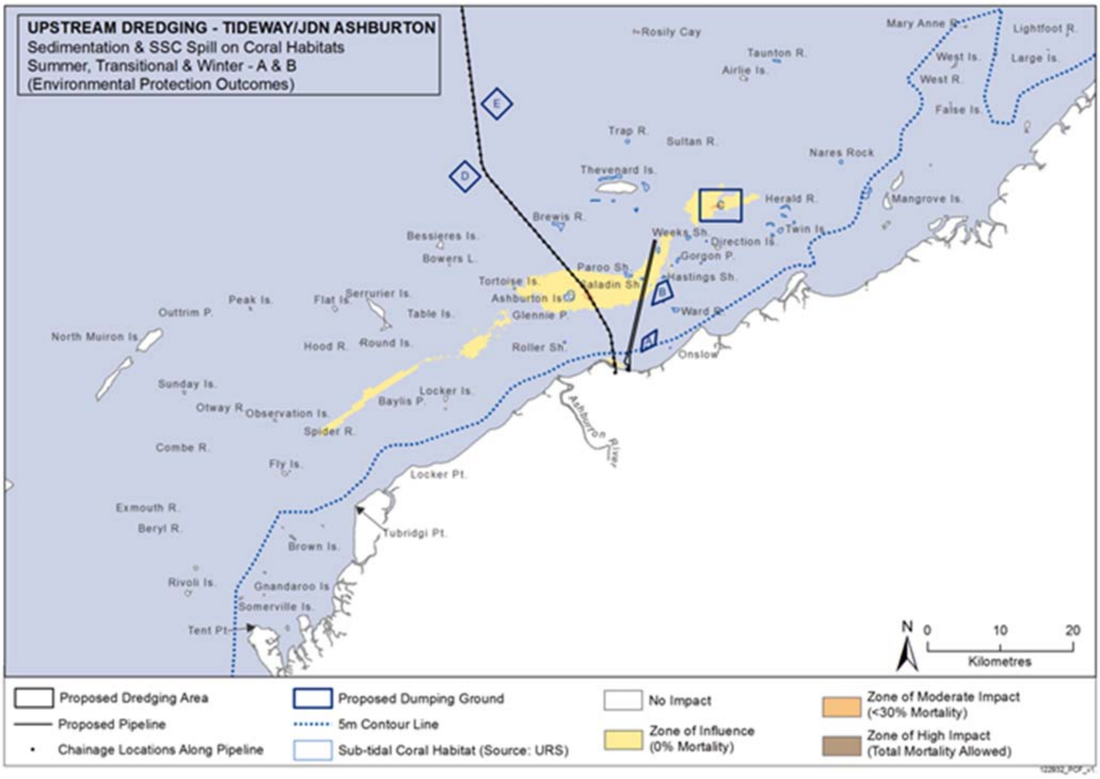


Figure 5.7: Predicted Impact Zones for Corals for Climatic Scenario for Dredging adjacent to Ashburton Island

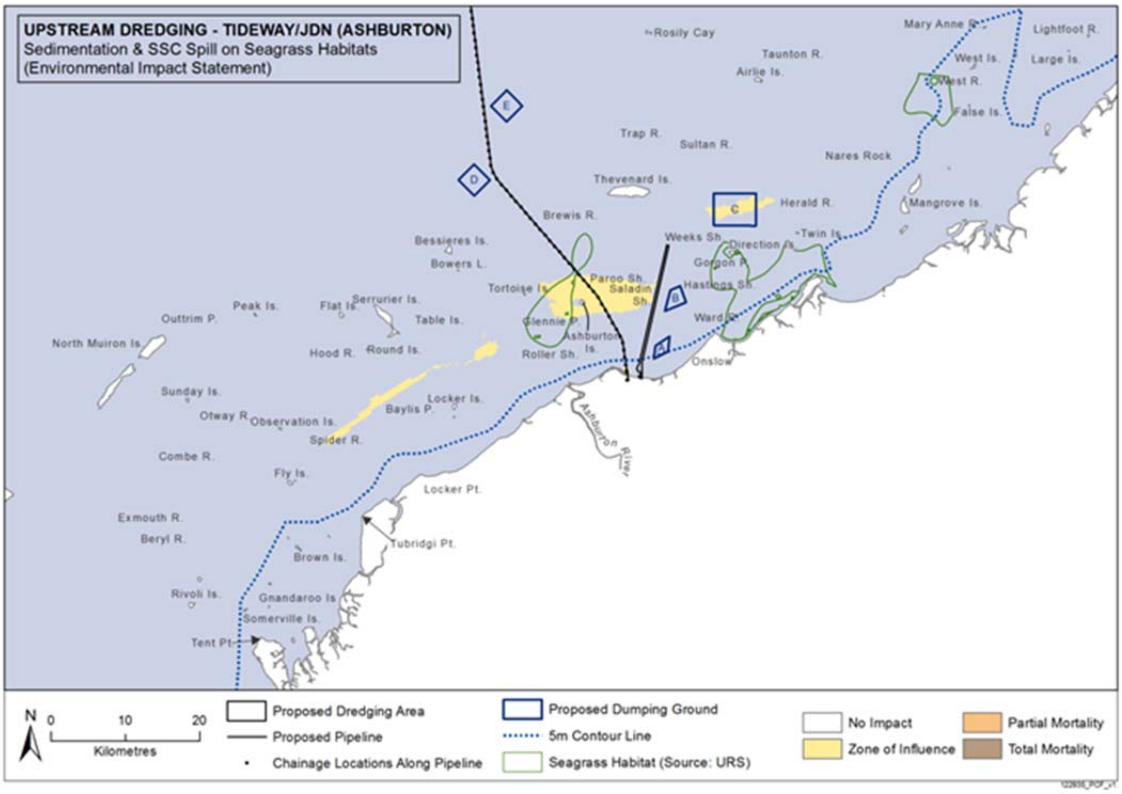


Figure 5.8: Predicted Impact Zones for Seagrass for Climatic Scenario for Dredging adjacent to Ashburton Island

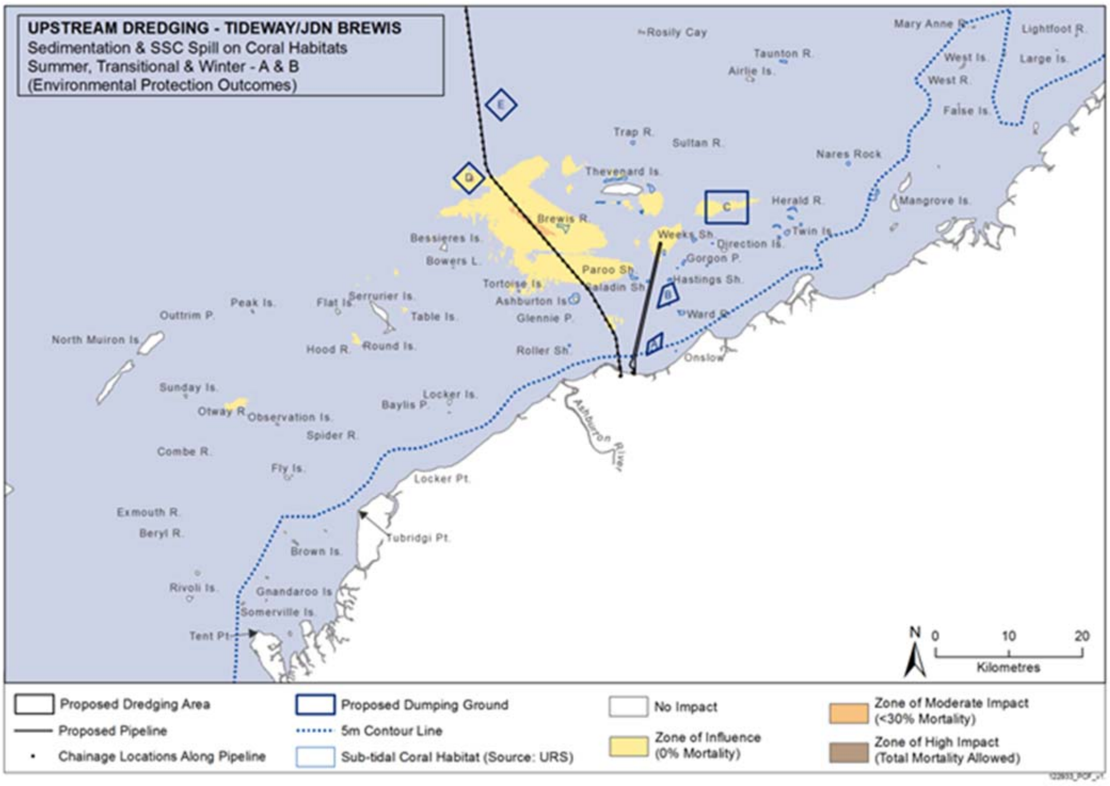


Figure 5.9: Predicted Impact Zones for Corals for Climatic Scenario for Dredging adjacent to Brewis Reef

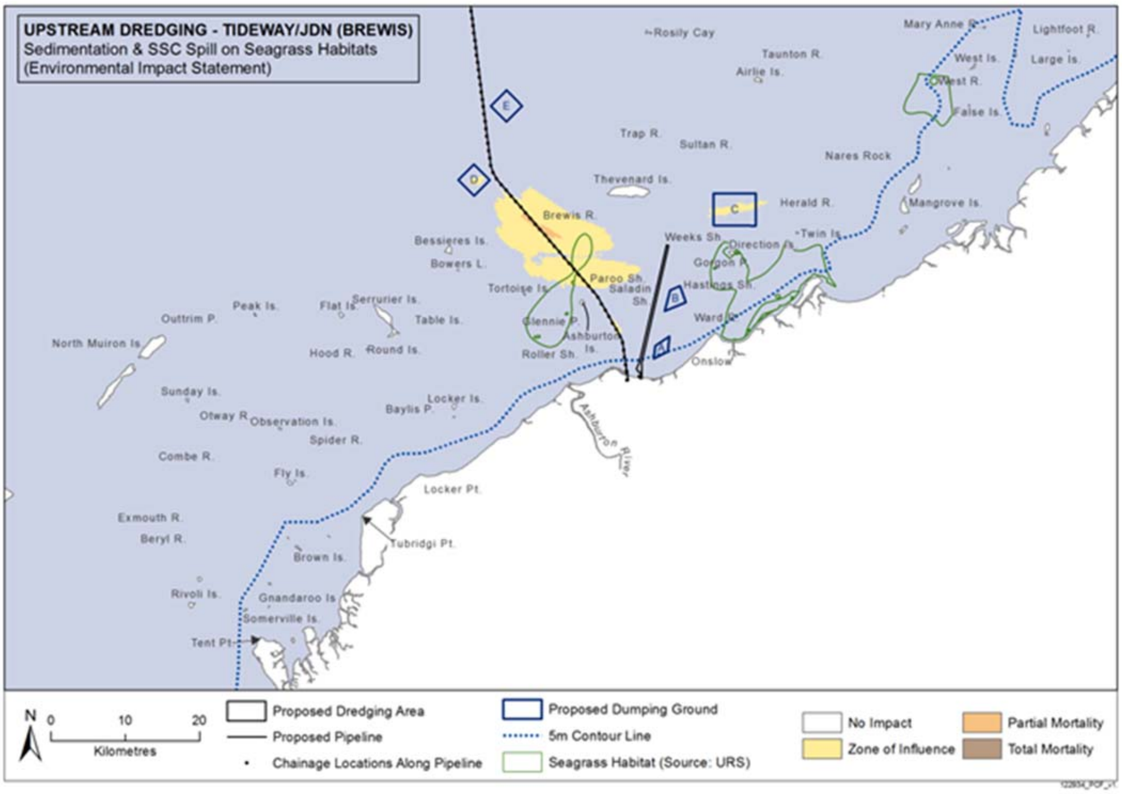


Figure 5.10: Predicted Impact Zones for Seagrass for Climatic Scenario for Dredging adjacent to Brewis Reef

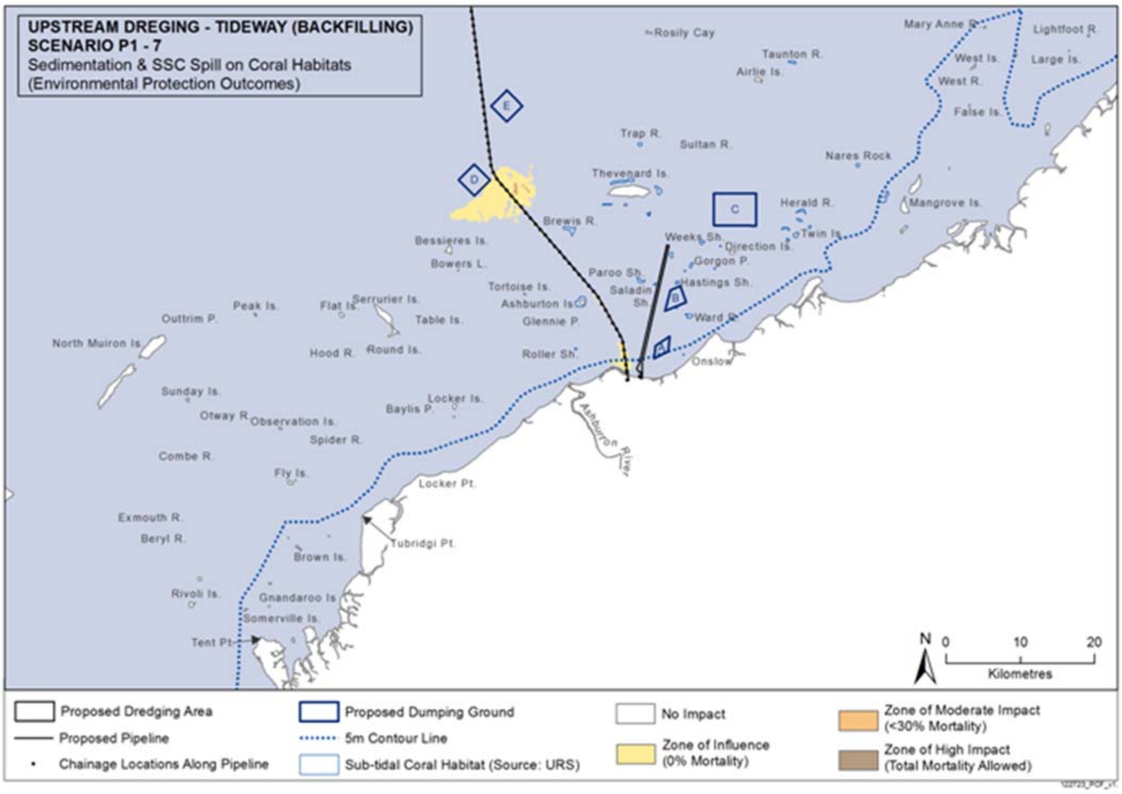


Figure 5.11: Predicted Impact Zones for Corals based on Full Sand Borrow and Backfill Simulation

5.5 Benthic Habitat Characterisation

5.5.1 Hard Coral

In the general vicinity of the trunkline route, coral communities are typically low in abundance and restricted to a small number of reefs on the fringes of shoals and the platforms that surround some of the offshore islands. Coral coverage at baseline survey monitoring sites in the vicinity of the trunkline route have significantly reduced since these surveys began in 2009 with a corresponding increase in turf and macroalgae cover (SKM 2012). Baseline monitoring has documented the steady decline of coral cover to below 10% at the majority of monitored sites close to the trunkline route, which is a result of the combined impact of the mass bleaching event and tropical cyclone Carlos in early 2011 (SKM 2011; SKM 2012).

5.5.2 Seagrass Habitat

Transects surveyed in 2011 within the seagrass habitat that intersects the trunkline route as shown in Figure 5.12 characterised this area as sandy sediments with low density, patchy distributions of seagrass, macroalgae and filter feeders. Where observed, seagrass cover was typically <5% consisting of the genus *Halophila* (RPS 2012).

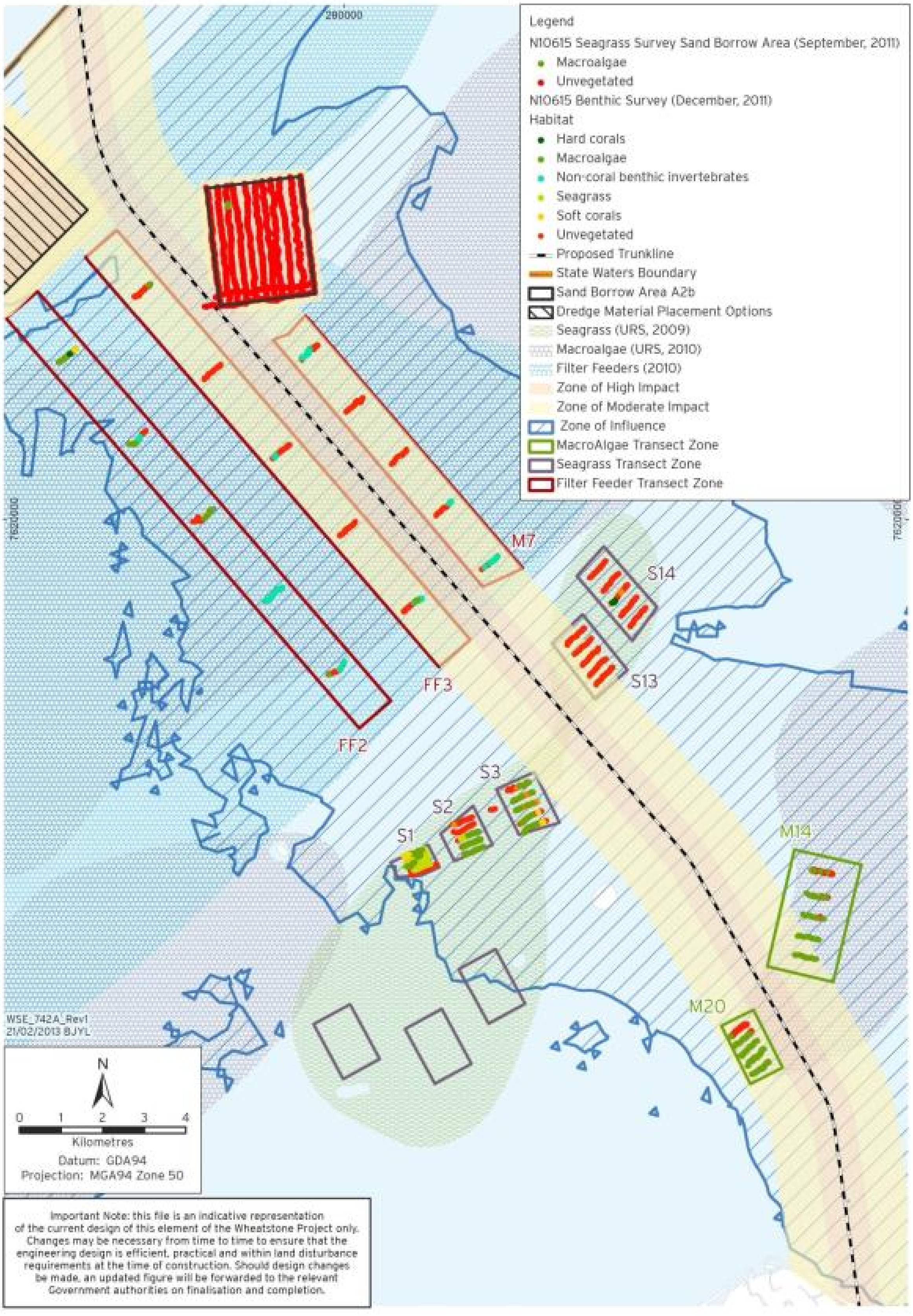


Figure 5.12: BPP Transect Observations from along the Trunkline

RPS (2012) described considerable variability in seagrass cover between surveys undertaken in September and December 2011 which demonstrates the ephemeral nature of seagrass and the ability of seagrass to rapidly recolonise. Temporal variability in distribution, density and biomass can occur as a result of seasonal cycles and inter-annual change due to sporadic environmental events and natural variation. The abundance and distribution of tropical seagrass species can vary greatly in response to seasonal changes in water quality (turbidity, light penetration) and conditions (wave action, temperature) (Lanyon and Marsh 1995). Inter-annual differences in seagrass biomass, distribution and abundance may also be experienced due to regional-scale changes in climate.

5.5.3 Filter Feeder Habitat

Sessile filter feeders (including soft corals, gorgonians, sponges, hydroids and ascidians) are common on the sand veneered and exposed pavements that dominate the inner continental shelf and consequently are one of the most widespread sessile benthic communities in the Pilbara region. RPS (2012) observed that filter feeder habitat intersecting the trunkline route in 2011 (as shown in Figure 5.12) is generally comprised of bare sandy substrate with some patchy distribution of low density soft corals with an average <5% coverage. The limited extent of filter feeder coverage in the surveyed areas indicates that this area does not constitute regionally significant habitat (RPS 2012).

Soft corals (gorgonians, sea whips and sea pens) are the most common filter feeders in this area, followed by sponges (RPS 2012). Filter feeder groups observed typically require hard substrate for attachment, with groups able to colonise mobile substrate (sand/silt) such as crinoids and sea pens being largely absent (RPS 2012).

5.5.4 Macroalgae Habitat

Macroalgae are generally present on shallow shoals, fringing reefs and limestone platforms in the region. The macroalgae habitat intersecting the trunkline route encompass a wide range of habitat and substrate categories (RPS 2012). As indicated in Figure 5.12, some surveyed areas of this habitat exceeded 20% macroalgae coverage which is consistent with the previous habitat mapping undertaken for the EIS/ERMP (RPS 2012; URS 2010). Given macroalgal habitats are widely represented in the Pilbara region and there is relatively low coverage in the vicinity of the trunkline route, any patches of macroalgae likely to be impacted by trunkline installation activities are highly unlikely to be of regional significance.

5.6 Predicted Zones

The Zones of High Impact, Moderate Impact and Zone of Influence set out in Figure 3, Figure 4 and Figure 5 of Schedule 1 of MS 873 are not applicable to the trunkline installation activities. The Zones applicable to the trunkline installation activities are detailed in Section 5.6.1 to 5.6.3.

5.6.1 Direct Disturbance Footprint

In accordance with MS 873, as amended by MS 931, Condition 8-5 (i), the DDF does not extend beyond 80 m about the trunkline, to approximately 5000 m in a straight line distance from the trunkline shore crossing, after which it does not extend beyond 25 m either side of the trunkline centre-line. (Figure 5.13).

5.6.2 ZoI

The ZoI for the actual trunkline route and the methods for the associated turbidity-generating activities, based on modelling outputs, is illustrated in Figure 5.13. The model setup and outputs are discussed in Section 5.4.

5.6.3 ZoHI and ZoMI

The Sand Borrow Area A2B has been included in the ZoHI (with edge effects contained in the ZoMI), which is consistent with EAG7 which states that 'areas within and immediately adjacent to proposed dredge and disposal sites are typically within zones of high impact' which is also consistent with the definition of the dredge placement sites in MS 873.

The inclusion of Sand Borrow Area A2B in MS 873, Attachment 3, requires that the ZoHI and the ZoMI be extended beyond that prescribed in MS 837 (ii) and (iii), (ZoHI and ZoMI do not extend beyond 525 m and 1,525 m respectively either side of the centre-line for the length of the trunkline in State waters).

In accordance with MS 873 Condition 8-5, an alternative ZoHI and ZoMI may be approved if the:

> "*Proponent justifies, to the requirements of the CEO on the advice of the Dampier Port Authority, that having exercised all practicable means to minimise the impacts of trunkline installation activities, an alternative Zone of High Impact and/or Zones of Moderate Impact are warranted.*"

In addition to the key environmental benefits of the general trunkline installation activities detailed in Section 2.3, the "practicable" means that the following activities to minimise the environmental impacts from sourcing backfill material from an offshore borrow area include:

- Three different options for backfill material were considered however sourcing of sand backfill (comprising sand with the effective particle size (or D10[5]) ≥100 µm and the median particle size (or D50) ≥200 µm) from an offshore sand borrow area remains the only feasible option.
- Impacts to benthic habitats were minimised by the fact that dominant benthic habitat within Borrow Area A2B consisted of unvegetated rippled sand with a sparse cover (<5%) of mobile crinoids and sessile sea pens.
- Since the majority of Borrow Area A2B is comprised of unvegetated sand, excavation of sediment from Borrow Area A2B is not expected to have any ecologically significant impacts to benthic communities in the region.
- The closest mapped corals to Borrow Area A2B are at Brewis Reef and Thevenard Island which are approximately 6 km and 9.7 km respectively from Borrow Area A2B.
- Only the ZoI extends beyond Borrow Area A2B (Figure 5.11).
- The duration of dredging in Borrow Area A2B will be short and not expected to exceed four months.

The proposed alternative ZoHI and ZoMI, as determined via the inclusion of Sand Borrow Area A2B, ensure the EPOs are achieved as illustrated in Figure 5.13. The approval of this plan will mean that Chevron Australia has justified the alternative zones to the satisfaction of the CEO (on the advice of the PPA), and that the alternative impact zones above may be implemented.

In addition to the ZoHI and ZoMI as set out in Figure 5.13, the Minister approved that an area of 400ha of BPP habitat in the ZoMI be able to be disturbed by pipelay vessel anchor

[5] There is maximum 10% weight of fines smaller than 100 microns

disturbance activities. The level of impact in the ZoHI and the ZoMI for turbidity-generating activities associated with trunkline installation activities are set out in Condition 8-7. However the Minister has approved the pipelay vessel anchor disturbance of 400ha of BPP habitat within the ZoMI in light of the fact that the impacts would actually be greater than the current ZoMI (which is prescribed for turbidity-generating activities associated with trunkline installation activities), and therefore the ZoMI parameters for pipelay anchor disturbances now need to be accounted for. Therefore the level of impact for pipelay vessels within the ZoMI has been defined as irreversible loss due to the nature of the impact e.g. direct disturbance. For the purposes of predicting the level of impact, it has been assumed that recovery of filter feeder habitat in the ZoMI will not occur within five years and is considered "permanent loss" given the considerable size of some of the individual colonies observed (RPS 2012b). Management of this activity is included in the TRIP.

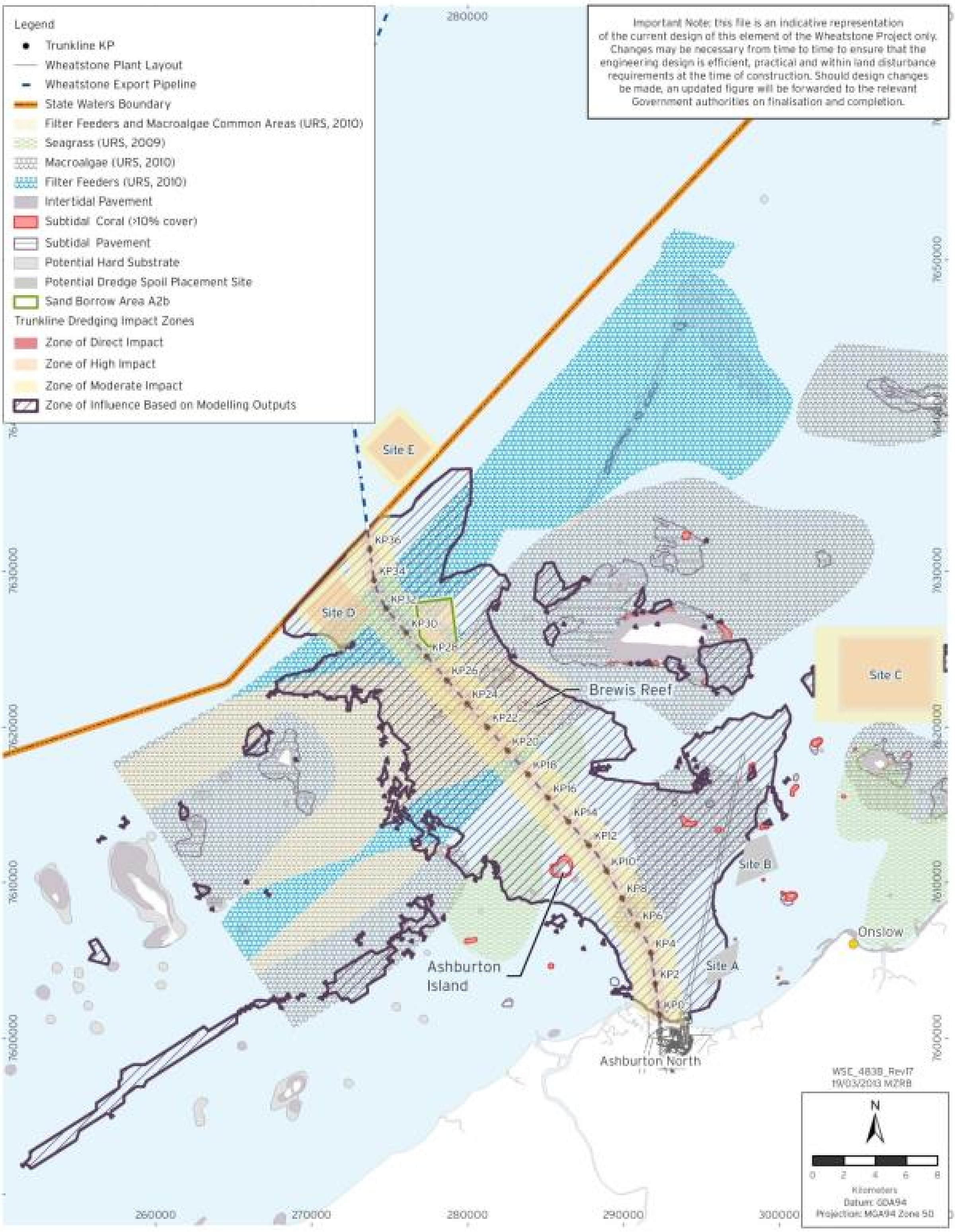


Figure 5.13: Distribution of different BPPHs coincident with the ZoHI, ZoMI and ZoI

Note: As approved by the Minister an additional 400ha of BPP habitat in the ZoMI may be disturbed by anchors for the pipelay vessels and result in permanent loss.

5.7 Predicted Losses

Table 5.12 details the area where the DDF, ZoHI and ZoMI intersect with the benthic habitats (macroalgae, seagrass and filter feeders). While the predicted permanent and reversible losses for the macroalgae, filter feeders and seagrass are detailed in Table 5.13. The predicted habitat losses for each benthic habitat type are described in Section 5.7.1 to Section 5.7.4. An additional 400 ha of anchor disturbance (to BPPH) from pipelay vessels will occur, as approved by the Minister, in the ZoMI from the pipelay operations. However, because habitat type has not been specified these impacts have not been included in Table 5.13 or described in the following Sections (5.7.1 to 5.7.4).

Table 5.12: Areas (in hectares) of BPPH within the DDF, ZoHI and ZoMI

BPPH Type	Area (ha) of Impact Zones		
	DDF	ZoHI	ZoMI
Macroalgae	12	248	453
Seagrass	4	88	292
Filter Feeders	76	1916	3079

Table 5.13: Predicted BPPH losses in relevant LAUs compared to the previous estimates from the EPA (2011a) Report

BPPH Type / Loss Assessment Unit (LAU)	EPA (2011a) Report – Initial BPPH Loss Estimates Based on Potential Dredging Impacts					Revised Losses Based on BPPH within Impact Zones				
	Total Area	Permanent Loss		Reversible Loss		Total Area	Permanent Loss		Reversible Loss[1]	
		%	Ha	%	ha		%	ha	%	ha
Macroalgae										
LAU 1B	4023	0	0	0.3	13	4023	0	0	0.3	13
LAU 1D	1511	0	0	22.7	343	1511	0	0	22.7	343
Seagrass										
LAU 2G	1451	0.7	10	0	0	1451	0	0	3.2	48
Filter Feeders										
LAU 2D[2]	20289	6.3	1278	6	1217	20028[4]	5.3	1057	5.0	1013
LAU 3A[3]	19908	4.9	990	2.9	577	19642[4]	1.1	859	2.6	526

[1] Loss estimates for reversible loss are not an estimate of the total amount of habitat "at risk of < 50% mortality" but represent half of the area actually "at risk" within the confines of the relevant zones.
[2] Any macroalgae identified in LAU 2D has not been included in the loss assessment as this habitat is considered primarily filter feeder habitat based on RPS (2012b).
[3] Calculations are inclusive of DSPS D

[4]Based on the results on the survey undertaken in 2011 it was determined that the sand borrow area is unvegetated sand and therefore this area was removed from the filter feeder habitat total area in both LAU 2D and 3A resulting in a reduction of the predicted BPPH losses.

5.7.1 Coral Habitat Loss

Figure 5.13 shows that there are no known coral assemblages, as defined in Chevron (2010), within the DDF, ZoHI or ZoMI. Therefore no irreversible loss of, or serious damage to, coral habitats outside the ZoHI in accordance with MS 873 is anticipated to occur as a result of the trunkline installation activities. Figure 5.13 also shows that reef formations at Ashburton Island and Brewis Reef are not contained within either the ZoHI or ZoMI as required by MS 873 Condition 8-6.

5.7.2 Seagrass Habitat Loss

The seagrass habitat within 525m of the trunkline centreline (Figure 5.13) is likely to experience short term net negative change from the baseline state of seagrass habitat so this area has been classified as a ZoHI. However, any loss of seagrass within this habitat zone is likely to be temporary and reversible within five years and this section of trunkline trench will be backfilled with sand, providing suitable habitat for recolonisation. As indicated in Figure 5.12, the small section of seagrass habitat observed along the trunkline route (Chevron 2010; RPS 2012) consists of relatively sparse coverage (in the order of <5%) mostly of the genus *Halophila*, which is expected to quickly regenerate and re-colonise an area following disturbance (Birch & Birch 1984; Lanyon & Marsh 1995; Rasheed 2004). In addition, previous work demonstrates that *Halophila* is capable of complete recovery from a natural storm event within six to eight months (Williams 1988).

Up to 48[6] ha of seagrass habitat within the ZoHI and DDF may experience net negative change from the baseline state however no permanent loss is anticipated from the trunkline installation activities, which is a reduction compared to the 10 ha of permanent loss predicted in EPA (2011a). No detectible net negative change is predicted in the ZoMI.

5.7.3 Filter Feeder Habitat Loss

Table 5.13 shows that permanent losses of 1057 ha and 859 ha of filter feeder habitat within LAU 2D and 3A (Figure 3.3) respectively have been accounted for which is less than the permanent loss of this habitat type in these two LAUs described in EPA (2011a) (Table 5.13). For the purposes of the BPPH loss predictions described in this report, it has been assumed that recovery of filter feeder habitat in the ZoHI (Figure 5.13) will not occur within five years and is considered “permanent loss” given the considerable size of some of the individual colonies observed (RPS 2012). However, recovery is likely to occur within a ten year period given the rapid growth rate of some filter feeders such as sponges (URS 2011).

It has been assumed that DSPS D contains filter feeders although RPS (2012) found that these areas are predominantly characterised by bare unvegetated sandy substrate. Any loss of BPPH at DSPS D is expected to recover within a relatively short timeframe but for the purposes of this assessment these areas are considered to be within the ZoHI. BPPH loss estimates for DSPS C have not been included as these have been accounted for in the Dredging and Dredge Spoil Placement Environmental Monitoring and Management Plan (DDSPEMMP).

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[6] While 88 ha of seagrass intersect with the ZoHI all loss within this zone is predicted to be reversible. To be consistent with the methods used to calculate reversible loss in the Final EIS/RTS (Chevron 2011) and EPA report (EPA 2011a), the same method has been applied (<50% mortality)

Given the very large extent of filter feeder habitat in the region, it is considered unlikely that marine biodiversity will be adversely affected as a result of the loss and that there is ample breeding stock available in surrounding non-affected filter feeder habitat which indicates that a full recovery will occur (URS 2011). It is also expected that sections of exposed rock used to stabilise the trunkline will offer suitable habitat for filter feeders such as soft corals, sponges, ascidians, seawhips and gorgonians to colonise over time which may provide a net environmental benefit.

Ecological filter feeder communities respond to disturbance based on the spatial extent and duration/frequency of that disturbance (URS 2011). Since the Project area is a cyclone prone area with relatively shallow waters, benthic filter feeders are likely to periodically be impacted due to large scale mobilisation of sediments under cyclonic conditions. Under these conditions the landscape is expected to be stable but exhibit large variance (Turner *et al*. 1993). This dynamic is explained by the ratio-based model that predicts that a disturbance is dependent upon the ratio between the frequency of a disturbance versus recovery time and the size of the disturbed area in relation to the overall habitat (Turner et al. 1993). Since the trunkline installation activities are a once-off event, the frequency will be inconsequential and the spatial scale at which the disturbance will occur is not large compared to natural events such as cyclones. Since reproduction in many marine tropical benthic filter feeders occurs annually or semi-annually and can be sexual or asexual, community level recovery is likely to occur relatively quickly (URS 2011).

5.7.4 Macroalgae Habitat Loss

There is expected to be no permanent loss of macroalgae habitats and temporary losses are considered to be reversible and likely to recover rapidly (URS 2011). A total of 222 ha of macroalgae habitat has been predicted to have reversible loss as shown in Table 5.13, which is a reduction compared to EPA (2011a) which estimated a loss of 356 ha. In addition, it is expected that sections of exposed rock used to stabilise the trunkline will offer suitable habitat for macroalgae to colonise relatively quickly which may provide a net environmental benefit.

5.8 Summary and Conclusions

The outputs from the base and worst case scenario modelling indicate that the EPOs can be achieved within the existing impact zones for trenching, spoil placement and backfill activities. The losses calculated for the impact zones (Table 5.13) are considerably conservative as the BPPs within these defined habitats are known to be patchily distributed and have low density cover (RPS 2012). The BPPH loss calculations have also assumed that there will be permanent loss within the entire ZoHI and reversible loss within the entire ZoMI which is highly unlikely.

6.0 WATER QUALITY MONITORING AND MANAGEMENT

This monitoring and management programme has been based on the revised modelling of turbidity-generating activities associated with trunkline installation, as detailed in Section 5.0.

6.1 Background

Dredging and dredge spoil placement (trenching and backfill) activities have the potential to affect benthic communities through the direct removal of habitat (such as the removal of coral habitat). There is also the potential for indirect impacts as a result of a reduction in light availability, caused by elevated turbidity, and smothering due to the subsequent deposition of the sediments suspended by dredging and the placement of dredge spoil. Conditions 8.7 (MS 873; as detailed in Section 1.5) provides EPOs to protect benthic communities from the turbidity-generating activities associated with trunkline installation. This section only applies to turbidity-generating activities, as these are the only trunkline installation activities relevant to impacts on water quality.

This monitoring and management section details the water quality management strategy which will be implemented with the aim to achieve the MOs and EPOs and has been based on the revised modelling as detailed in Section 5.0. This section is structured under the following four broad components:

- The EPOs and MOs
- The water quality based adaptive management and monitoring approach undertaken to achieve the EPOs and MOs
- The coral monitoring programme designed to assess if the EPOs are being achieved
- Verification and sedimentation monitoring programmes designed to support the above three key tasks by providing data to assist with interpretation and to verify the water quality criteria are working.

Although the emphasis here is on achieving the EPOs that relate to corals, the water quality management approach and verification monitoring described in this section is also designed to protect non-coral benthic communities (discussed further in Section 7.0).

6.1.1 Environmental Protection Outcomes

As per the requirements of Ministerial Condition 8-7, the EPOs for hard corals applicable to turbidity-generating activities associated with trunkline installation are:

- No irreversible loss of, or serious damage to, coral habitats outside of the ZoHI
- No detectable reduction of net live coral cover within the ZoI including reef formations at Ashburton Island and Brewis Reef.

Given the recent natural decline in coral cover (see Section 3.5.1.1 and Section 6.2) a management and monitoring programme based on water quality (turbidity) is considered the best approach to ensure that the EPOs are achieved and to facilitate adaptive management of the turbidity-generating activities associated with trunkline installation. In addition to the water quality monitoring to inform adaptive environmental management, the EPOs will be directly measured by monitoring coral at the following times[7]:

1) At the mid-term of marine works and post-development [8], by which time, a long time-series of data will be available to provide supporting evidence to coral EPO assessments through an examination of temporal trends in coral cover; and

2) In the event of a Level 3 water quality trigger being exceeded during turbidity-generating activities associated with trunkline installation, which would provide evidence to support the notion that a detected change in coral cover was more likely to be the result of an increase in turbidity resulting from trenching or backfill activities, rather than a natural event or anomalous change.

In both instances, multiple lines of evidence, based on examination of additional parameters and information on recent conditions and activities, will be used to assist in determining whether the detected change was ‘real’ and attributable to turbidity-generating activities, associated with trunkline installation (see Section 6.4.1.3).

6.1.2 Management Objectives

In addition to the prescribed EPOs, as per the requirements of Ministerial Condition 8-8, *the proponent shall design and execute trunkline installation activities in State waters with the aim of achieving the following MOs:*

- Irreversible loss of, and serious damage to, benthic habitats is restricted to the area within the Trunkline DDF (excluding macroalgal habitats to which there shall be no irreversible loss or serious damage).
- Impacts to the marine environment within the Zones of Moderate Impact are minimised to the greatest extent practicable.
- Cumulative impacts from turbidity generating activities associated with the trunkline installation undertaken simultaneously with turbidity generating activities associated with the construction of the nearshore and offshore marine facilities are managed so as to achieve the EPOs set in Condition 8-7 and Condition 6-1 (or any revised EPOs). (For details on this MO refer to Section 11.0).

Trunkline installation activities will aim to achieve the MOs described in Condition 8-8 (i) and (ii) through design optimization (refer to Section 2.3 and Section 5.5) and implementation of adaptive management during turbidity-generating activities associated with trunkline installation (described in Section 6.3.1).

There is no irreversible loss or serious damage to benthic habitats (see Section 5.5), excluding filter feeders, predicted for the trunkline installation activities. Achievement of restricting irreversible loss of, and serious damage to, benthic habitats outside the direct Trunkline DDF can only be measured 5 years after Trunkline Installation activities, since the definition of ‘irreversible loss or serious damage to benthic habitats’ within EAG7 is ‘not

[7] Due to the definition of ‘no irreversible loss of, or serious damage to’ condition 8-7 (iii) will only be assessed at the post-development surveys.

[8] This has been defined under the SoW and will be undertaken under the SoW as detailed in Section 1.6

recoverable within 5 years'. For example, fine sediments may be temporarily deposited on benthic habitats outside the Trunkline DDF but may be subsequently removed through wave action, allowing the habitat to be recolonised by biota within a 5 year period. However, an indication of whether this MO is likely to be achieved will be assessed based on the mid-term surveys.

6.2 Management of Water Quality

Since the release of MS 873 there has been a major reduction in the mean percent cover of corals in the area, due to thermal mass bleaching and the effects of cyclones which occurred between January and March 2011. Reefs that were once dominated by hard coral (average coral cover 45%) are now dominated by turf algae, which averages about 70% cover per reef, while average coral cover is now ~5% on reefs.

Since coral communities are in a low and unstable condition within the region, detecting a change in coral cover and inferring the cause of this change at any single point in time during trunkline installation may be problematic. As such, it is proposed that water quality (turbidity) criteria are used to manage the trenching and backfill programmes (Section 6.3.2). Water quality criteria have been developed to afford protection to corals, however, criteria are also predicted to afford protection to other BPP and to filter feeders (described in Section 7.0).

Water quality criteria have been derived from the most recent and relevant information available, including outcomes from the Chevron Australia Gorgon Marine Monitoring Programme and data from other dredging projects and experimental studies. The Gorgon Marine Monitoring Programme provides one of the most comprehensive datasets known on the relationship between water quality and coral health during a dredging programme, and is the first dredge monitoring programme in the Pilbara where net mortality of corals (all of which were within limits of allowable loss prescribed within Gorgon Ministerial Conditions) attributable to dredging-related elevations in turbidity were recorded. For a discussion of how these criteria are predicted to afford protection to other benthic habitats, see Section 7.0.The use of the Gorgon data set to derive water quality criteria is consistent with best practice to continually derive improved dredging management measures.

Relationships between water quality and coral health data were derived from Gorgon data where net mortality in corals was detected and attributable to decreases in water quality resulting from dredging. Observed relationships between water quality and coral health were, therefore, used to develop criteria that would prevent no net detectable mortality of corals (directed towards achieving Condition 8-7 (iii) and (vi)).

Water quality criteria are based on the observed frequency of elevations of turbidity above background conditions (measured against concurrent water quality measurements at reference sites) and the duration over which these elevations occurred. These criteria capture any potential long-term (chronic) elevations above the 50th percentile of background conditions that may result in impacts to corals, and any medium-term (moderate) elevations above the 80th percentile of background conditions or the potential cumulative impact of several short events of elevated turbidity. There was no evidence in Gorgon data of any single, short-term elevation in turbidity that resulted in a subsequent response in corals and such a response is not expected during Wheatstone if dredging programmes are similar.

Due to similarities in coral communities and water quality environments, the water quality criteria derived from Gorgon data were considered appropriate for use as management triggers for Wheatstone corals, with only minor modifications required. Relevant information from other dredging programmes and laboratory experiments also supported the application of Gorgon-derived water quality criteria to Wheatstone. Gorgon-derived water quality criteria are considered conservative when applied to Wheatstone, since net mortality was only detected at Gorgon sites deeper than 7.5 m (no net mortality was detected at Gorgon shallow sites), and the criteria were derived from a Gorgon site that was at 8.9 m depth. In contrast, the majority of Wheatstone sites are shallower than 7 m. Therefore, less stress would be expected for corals within the Project area if water quality is managed using Gorgon-derived criteria, since the shallower reefs at Wheatstone are less likely to be affected by elevated turbidity and subsequent light reduction. Further, any settled sediments from dredging are more likely to be naturally resuspended by wave action at shallow Wheatstone sites than was the case for deeper Gorgon reefs where impacts were detected.

Table 6.1 sets out the management and monitoring approach for water quality for turbidity-generating activities associated with trunkline installation, which includes trenching of the trunkline and backfill activities.

6.2.1 Adaptive Management Approach

Since Wheatstone dredging and trunkline installation activities are spread over a lengthy period, the TIEMMP is designed to be adaptive to allow for refinements based on feedback from monitoring during installation activities highlighting risk of dredge impacts and increased confidence in the protection of receptors. Section 1.2 of the TIEMMP states: “This Plan adopts an adaptive approach for the environmental management of trunkline installation activities, which reflects the EPOs and MOs detailed in MS 873 Condition 8-7 and 8-8 or any approved revised EPOs.” In addition, it is a Commonwealth requirement that the TIEMMP is regularly reviewed for adaptive management purposes as per Section 12.3.1 which states that: “In accordance with Condition 17 and 21 of EPBC Reference 2008/4469 the role of DTAP is to undertake reviews for adaptive management purposes.”

Therefore following the completion of the trenching activities[9] a review was undertaken of the environmental performance, in accordance with Section 12.0, to re-asses the environmental risk of the remaining turbidity-generating activities associated with trunkline installation, prior to their commencement:

1) Maintenance/clean-up siltation that may have occurred within the trench prior to pipelay activities

2) Minor dredging works (~18,000 to 23,000m^3) using a BHD for i) material remaining in the ‘transition zone’ between the main trench and the microtunnel exit pit and ii) material required to be excavated where the Wheatstone trunkline crosses the Roller Skate pipeline

3) Pipeline stabilisation using rock and sand backfill

<u>Environmental Risk Assessment of Maintenance/clean up and Minor Dredging works</u>

It was determined that the risk from maintenance/cleanup activities and the minor works was negligible (i.e. very low risk of contact from plumes and if contact occurs it will be of insufficient magnitude or duration to pose a risk to receptors). This is due to the fact that the material removed for trenching activities was at least an order of magnitude more than the material removed for maintenance and minor works and did not result in any Level 1, 2 or 3 management triggers being reached (Section 6.3.2). Therefore it is not foreseeable that any management triggers would be reached during these activities. Additionally the verification

[9] trenching activities were considered the main turbidity-generating activity during trunkline installation since they involved the use of a combination of CSD, TSHD and BHD to remove 1.49 Million m^3 of material.

surveys undertaken during the trenching activities have found no evidence that trenching has contributed to any changes in BPPH at the monitoring sites.

Therefore due to the negligible environmental risk from these activities the comprehensive monitoring program implemented during trenching (Section 6.4) is no longer considered necessary nor is it deemed useful for management purposes. During these turbidity-generating activities, maintenance/clean up and minor dredging works, there will be no water quality or BPPH monitoring[10].

Environmental Risk Assessment of sand and rock backfill

It was determined that the risk from sand backfill dredging and rock placement activities and the minor works was negligible (i.e. very low risk of contact from plumes). This is due to the fact that the material removed for sand backfill dredging will be courser grain size and contain fewer fines than trunkline dredging, which did not result in any Level 1, 2 or 3 management triggers being reached (Section 6.3.2). Modelling of predicted plume movement for both sand backfill dredging and rock placement showed plumes never reached sensitive receptors and were contained within 1 km of the borrow area A2B. Therefore it is not foreseeable that any management triggers would be reached during these activities.

Due to the negligible environmental risk from these activities in-situ water quality loggers at Seagrass and Filter Feeder sites will be removed and the data from Brewis logger will not be telemetered. An additional in-situ water quality logger site, Thevenard West, will be established, but data will not be telemetered. Mobile monitoring using a Wave Glider will be used to test water quality on a daily basis adjacent to Brewis and Thevenard West and data compared against reference sites (a second Wave Glider or *in-situ* logger site data). These data will be used to examine Level 1, 2 or 3 management triggers as per Section 6.3.2. The monitoring program will be reviewed after a minimum 20-day validation period, and with DTAP endorsement the mobile monitoring will be removed, with *in-situ* loggers being maintained for the duration of sand backfill dredging. No monitoring will occur when rock placement activities occur in isolation to sand backfill dredging.

[10] Please note that while there will be no monitoring under the TIEMMP the Responsive Water Quality and BPPH Verification Monitoring at 22 sites under the DDSPEMMP will be ongoing.

Table 6.1: Management and Monitoring for Water Quality and Coral

Management Area:	Management of water quality and coral
Performance Objective:	To manage impacts from turbidity-generating activities associated with trunkline installation activities to achieve the EPOs described in Condition 8-7 and with the aim of achieving the MOs described in Condition 8-8 (i) and (ii).

Management:	The water quality management framework is described below. Additionally Figure 6.1 illustrates the monitoring and management components of the water quality management framework for Conditions 8-7 (vi).
	<u>Overview</u>
	The management of water quality and associated potential impacts on monitored reef formations will be managed via:
	♦ Preventative management including, where practicable:
	  ▪ Management measures to be applied, where practicable, during the turbidity-generating activities associated with trunkline installation
	♦ The use of modelling and/or near field monitoring for adaptive management and optimisation of the trenching execution scenarios
	♦ Responsive monitoring and management, including:
	  ▪ water quality monitoring data collected approximately every 30 minutes at monitored reef formations along with an associated tiered management response
	  ▪ Coral EPO assessment following an exceedence of the Level 3 management trigger
	♦ Verification of the appropriateness of water quality criteria through quarterly benthic community monitoring and refinement of water quality criteria, if required (Section 6.4.2).

Preventative Management	**<u>Preventative Management</u>** *<u>The following management measures may be applied to reduce excessive levels of suspended sediment reaching benthic communities. These measures will continue to be implemented during turbidity-generating activities associated with trunkline installation, where relevant and practicable, and may be applied even where additional responsive management measures (see the following description on responsive management) might apply.</u>* ♦ Global Positioning System (GPS), monitoring and automation systems on specified equipment ♦ Well-maintained, repaired and properly calibrated equipment ♦ Adaptive management strategy ♦ Flexibility within the dredge execution programme allows adaptive management of turbidity-generating activities – trenching and sand backfill, associated with trunkline installation ♦ Route selection to minimise turbidity caused by vessel props, where practicable **TSHD and Split-Hopper Barges** ♦ Raising the overflow pipe to avoid spillage during transit, where equipment permits ♦ Overflow pipes equipped with a turbidity-reducing green valve ♦ Ensure TSHD bottom doors and split-hopper barges hull seals inspected

Management Area:	**Management of water quality and coral**
	prior to mobilisation ♦ Transiting via designated corridors to Dredge Spoil Placement Site C ♦ Maintaining an approximate 0.5 nautical mile buffer zone around coral reefs to the east of the approach channel to limit stress associated with sediment re-suspension from propeller wash **CSD** ♦ Employing appropriate cutter heads for differences in soil types to reduce suspended solids generation
Responsive Monitoring	**<u>Responsive Monitoring and Management Procedures</u>** Responsive water quality and coral health monitoring and associated tiered responsive management will be implemented to manage any potential impacts that increased turbidity may have on monitored reef formations. *<u>Water Quality Monitoring</u>* Water quality measurements will be logged at approximately 30 minute intervals at monitored reef locations throughout the duration of the trenching and backfill operations. Water quality monitoring will be achieved through the use of *in-situ* water quality data logging instruments. Refer to Section 6.4 for further details of the water quality monitoring programme. The results of the water quality monitoring will be: ♦ Assessed against management triggers, as detailed in Section 6.4.1.2 ♦ Used to assist in inferring the cause of any observed impacts to BPPH health. *<u>Coral EPO Assessment Monitoring</u>* Coral cover will be surveyed at the ‘affected reef formation’ following an exceedence of a Level 3 management trigger. Refer to Section 6.4.1.3 for further details of the EPO assessment monitoring programme. The results of this monitoring will be used to assess if net live coral cover at the affected reef, had declined as a result of turbidity-generating activities, associated with trunkline installation, and if this decline was greater than the EPOs defined in MS 873 Condition 8-7. *<u>Verification Monitoring</u>* Monitoring will consists of: ♦ Quarterly routine monitoring of benthic communities to provide verification of the effectiveness of the water quality criteria ♦ Monitoring of benthic communities triggered by an exceedence of the Level 2 management trigger at the affected site(s) and at associated reference sites Note: Data collected under this monitoring programme will not be used to assess achievement of the EPOs or MOs.
Responsive Management	**<u>Responsive Management Actions</u>** Management measures will be implemented once a Level 2 management trigger is exceeded (see Section 6.3.2), dependent on the applicability of the measure and the severity for environmental impact. Notably, no change in trenching, placement, or backfill operations may be required to reduce potential environmental impacts attributed to the trigger if, for instance, metocean conditions change and the water quality criteria value returns to a

Management Area:	Management of water quality and coral
	level which does not lend itself to concern, especially below the intensity of the water quality criteria value. The chosen measure(s) will take into account current and forecast metocean conditions, proximity of sensitive receptors, flexibility in the dredge execution plan and the adaptive management strategy. While the optimal measures will be employed given the specific situation, additional measures will still be available in case the initial measures are found to be ineffective. Management measures that may be considered include: ♦ Optimising the monitoring programme including the monitoring frequency, parameters, and area to more closely scrutinise the cause and possibility of recurrence of the exceedence ♦ Refining trenching and/or backfill operations based on sediment plume model results, current and forecasted metocean conditions and/or results from the water quality monitoring. Implement the refined trenching and/or backfill operations until the exceedence resolves. These refined operations may include modifying: ▪ Scale of operations and resulting potential area of influence ▪ Location of trenching, type of dredging technique, overflow, and/or dredge spoil placement activities ▪ Dredging practice including overflow operations and production rate and/or volume ▪ Disposal technique including discharge rate and/or volume ▪ Redefining transit routes ▪ Reduce or ultimately cease trenching and/or backfill activities ***Exceedence of a Level 3 management trigger*** If a Level 3 management trigger is exceeded, turbidity-generating activities, associated with trunkline installation, which could reasonably be expected to have caused or contributed to the exceedence will cease and the Level 3 Exceedence Procedure (detailed in Section 6.3.2 and Figure 6.2) is required to be followed for the site where the exceedence was reported.

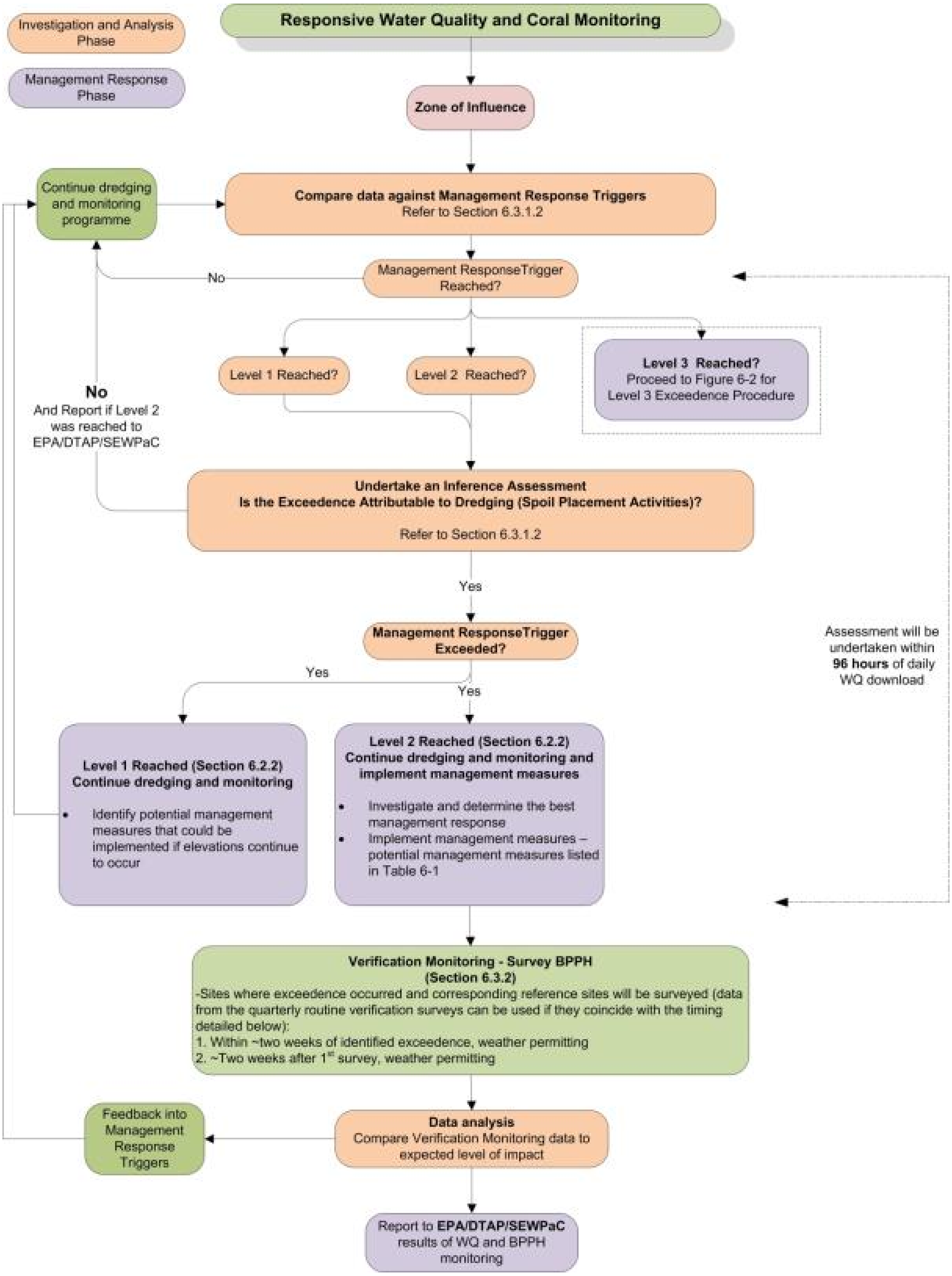


Figure 6.1: Water Quality Management Procedure

Note: This figure presents a summary of the monitoring and management required by the conditions that will be applied during trenching and placement and backfill operations.

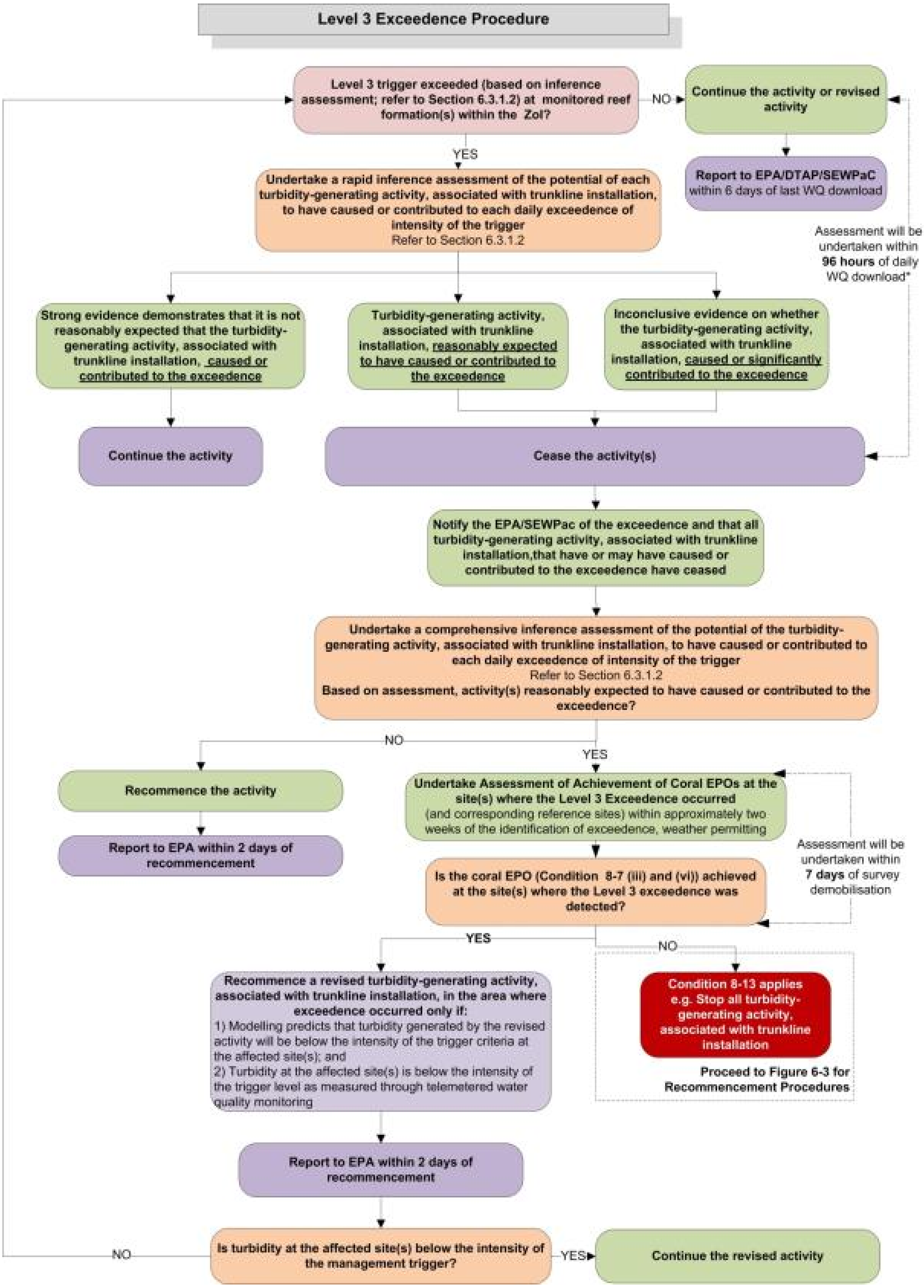


Figure 6.2: Level 3 Exceedence Procedure

** This 96 hour timeframe is the maximum timeframe in which the inference assessment must be completed and relevant management measures implemented. This timeframe will be reviewed following the completion of a Level 3 exceedence procedure to determine if the 96 hours can be reduced.*

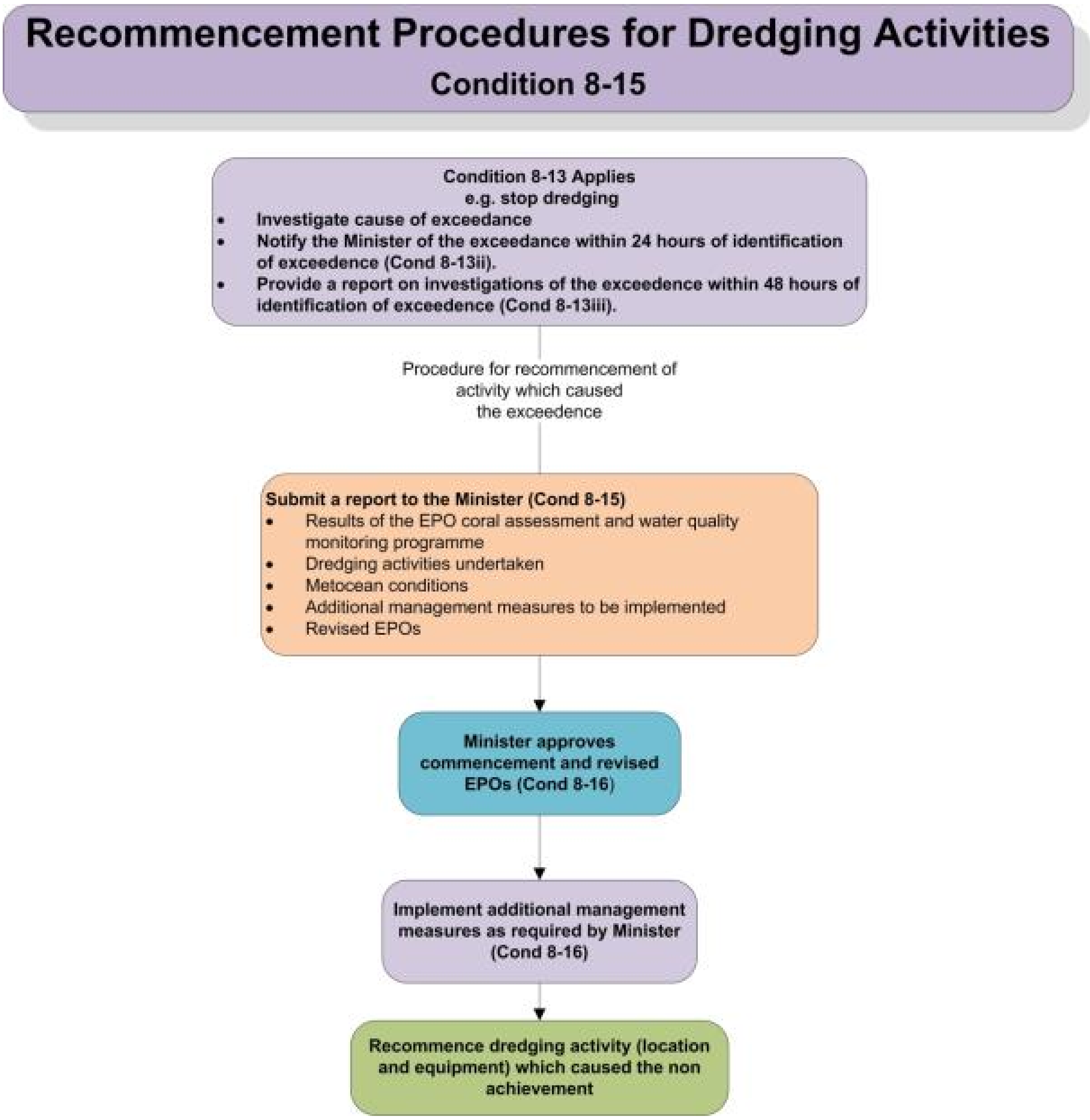


Figure 6.3: Recommencement Procedure in the event that Condition 8-13 Applies

6.3 Management Strategy for Water Quality

During trenching[11] operations initial management of operations will be assisted by near-field monitoring and hindcast modelling. This approach is based on the latest dredge environmental practice where modelling is used to predict environmental effects and steer the trenching operations. The use of the model during execution enables the dredge contractor to use field measurements and the most updated hydrodynamic conditions to manage the trenching operations. This will be supported by a responsive management programme based on water quality (turbidity) at identified receptor sites and a tiered approach to management of the turbidity-generating activities associated with trunkline installation (Section 6.3.2).

[11] Near field plume monitoring and hindcast modelling will not be undertaken during sand or rock backfill as it is unlikely to create a significant turbidity plume which could impact benthic communities.

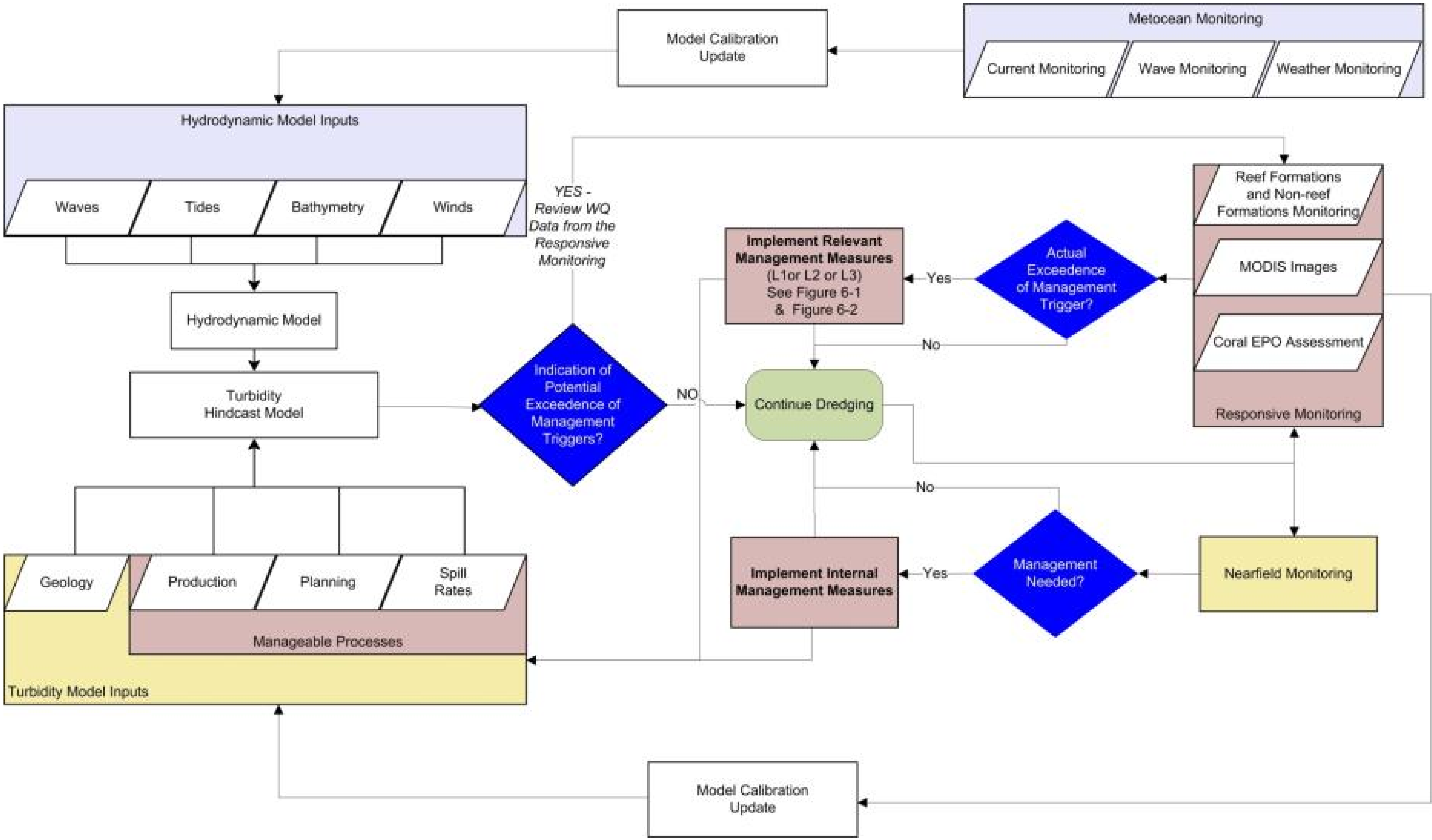


Figure 6.4: Linkages between Near-field Management and Responsive Monitoring

6.3.1 Near-field Management and Monitoring

Near-field monitoring and management procedures will be used to assist with management of the potential environmental impacts of the resultant sediment plume from the trenching operations. This program will be undertaken in order to characterise and track the resultant plume, define the suspended sediment characteristics for various locations (e.g. different geological layers) and equipment, validate the model and ensure that the outputs from the modelling are accurate. Near-field plume monitoring will be undertaken, this may be with a mobile monitoring vessel, and the results will be used to inform the adaptive management process to ensure achievement with the EPOs.

Dredge operational information and data collected from the monitoring may be used to assist with performing and verifying hindcast modelling. Hindcast modelling will be based on the recorded metocean conditions (Section 6.4.1.2) that occurred during the trenching period. Hindcast modelling can provide information to assist with optimisation of the trenching planning to reduce SSC load into sensitive areas to ensure the EPOs are not exceeded. If the model indicates a potential dredge attributable exceedence of the management triggers has occurred, then water quality data from the responsive monitoring programme (Section 6.4.1) will be reviewed and adaptive management measures can be implemented to reduce the SSC loading in that location, if required.

Near-field monitoring and management will also be used to assess whether the MO of minimising impacts in the ZoMI is being achieved within the first three months of trenching. The hindcast modelling outputs in the ZoMI will be compared to the Level 3 water quality trigger for the ZoI. If the Level 3 water quality trigger (for the ZoI) is exceeded, management actions may be implemented to reduce the SSC levels produced by the dredge or the location or conditions under which they are released may be changed.

6.3.2 Responsive Management

No responsive management is applicable for the ZoHI or ZoMI as i) there are no coral habitats within either of these zones, and ii) the MOs and EPOs for these zones refer to impacts which can only be measured over the long-term (i.e. minimising the extent of areas of irreversible loss within the ZoHI or minimising impacts to the greatest extent practicable within the ZoMI). However, modelling and nearfield management will occur within these zones as described in Section 6.3.1.

Responsive management of turbidity-generating activities associated with trunkline installation within the ZoI will occur through the use of a tiered management system based on water quality criteria aimed at achieving the EPOs within this zone. These triggers have been designed to guide the management of trenching and backfill activities to achieve the coral EPOs and to manage the impacts of activities with the aim of achieving MOs.

Management triggers were developed from observed, dredging-related impacts to water quality (turbidity elevations) and decreases in coral health during Gorgon dredging. Observed relationships between water quality and coral health were used to develop criteria that would indicate that ongoing dredging pressure at that site is reasonably likely to result in the EPOs not being achieved and therefore direct monitoring of coral would need to commence. These criteria were adopted for Level 3 triggers. Shorter-term Level 1 and 2 triggers were developed that, if exceeded, would prompt a management response to afford protection to corals and other benthic communities a considerable length of time prior to reaching Level 3 triggers. Provided effective management is implemented at Level 2, it is anticipated that the Level 3 management trigger would not be exceeded and coral EPOs will be achieved.

The basis for setting durations for Level 1, 2, and 3 triggers is that if - over short durations - water quality can be kept consistently below either the levels of NTU (or the increase above background NTU) that were observed to be associated with a certain level of mortality at Gorgon during dredging, then cumulatively, water quality will remain below the levels above background that would lead to the appropriate level of protection being afforded to corals at Wheatstone. Just as 'background' water quality conditions, over the long term, can be expressed as an average of percentiles across Reference reefs, background turbidity can also be calculated on a day to day basis as the (geometric) average of turbidity across Reference reefs. A geometric average is necessary here because NTU data are typically log-normally distributed (and so arithmetic averaging is not appropriate). Thus, the water quality criteria for Levels 1, 2, and 3 management triggers presented here are essentially increasingly longer duration tests of how frequently water quality at a monitoring site is elevated above the long-term difference between background and water quality that is predicted to result in a certain level of net mortality (as observed at Gorgon during dredging).

Essentially, the criteria assess how often a daily allowable level of turbidity above background (Reference reefs) has been exceeded during a rolling assessment period at the assessed reef formation. The aim of triggers is to keep turbidity at levels that did not lead to a certain level of mortality, based on the observations from Gorgon during dredging. Whenever the assessment shows that water quality exceeds *either* chronic *or* moderate criteria, the associated management responses are required.

Whilst these criteria have been derived from, and are applied to the protection of coral habitats, the criteria are also predicted to afford protection to other benthic habitats, including macroalgae, filter feeders and seagrasses but with less certainty (see Section 7.0).

This section describes coral receptor sites (monitored reef formations) and associated water quality and coral management at these sites. For monitoring and management of other benthic communities (non-reef sites) see Section 7.0.

6.3.2.1 Hierarchy of Trigger Levels

The assessment of water quality data against management triggers is comprised of two equally important parts:

1. The exceedence of a numeric value for water quality over a defined frequency within a set time period (following the procedure described in Section 6.4.1.2); and

2. An inference assessment of metocean conditions, trenching characteristics, satellite imagery and other factors to determine if turbidity-generating activities associated with trunkline installation, can reasonably be expected to have contributed to or caused each daily exceedence of the intensity of the trigger (Section 6.4.1.2).

Both parts of the assessment are required before it can be determined that an exceedence of a management trigger has occurred. For example, if turbidity is above the intensity of the management trigger but the inference assessment indicates that the elevated turbidity level for a particular day is not attributable to turbidity-generating activities associated with trunkline installation, that day would not contribute toward the trigger being exceeded.

Level 3 management triggers are based on water quality criteria directed towards achieving the coral EPOs in MS 873 Condition 8-7 (i.e. 'no net detectable change in live coral cover'). If Level 3 management triggers are exceeded, this would indicate that ongoing turbidity-generating activities, associated with trunkline installation, at a site may result in the coral EPOs not being achieved and would require the **Level 3 Exceedence Procedure** to be followed, as described in the following section and illustrated in (Figure 6.2).

Level 3 Exceedence Procedure

In the event that a Level 3 management trigger has been exceeded, a rapid inference assessment will be undertaken of turbidity-generating activity(s), associated with trunkline installation, which are likely to have contributed to or caused the exceedence. Information used in this assessment could include: the location of the activity compared to the affected reef formation and examination of recent Moderate Resolution Imaging Spectroradiometer (MODIS) imagery illustrating the extent of dredge plumes. Any turbidity-generating activity, associated with trunkline installation, which could reasonably be expected to have caused or contributed to the exceedence and any turbidity-generating activity, associated with trunkline installation, where it cannot be determined will be required to cease. Notification is to be provided to the EPA, DTAP and DotE that the Level 3 management trigger has been exceeded and there has been a cessation of all turbidity-generating activity, associated with trunkline installation that have or could reasonably be expected to, cause or contribute to the exceedence.

Where strong evidence demonstrates that a turbidity-generating activity[12] associated with trunkline installation is not reasonably expected to have caused or contributed to the exceedence, the activity can continue. Since the activity is defined as the 'dredge/disposal/backfill vessel and the location' it is also possible for dredge/disposal/backfill vessels that were required to cease operations, in particular location, to commence activities in other locations, provided there is strong evidence that these activities will not cause or further contribute to an exceedence at the affected site(s). For example if the Level 3 exceedence occurs at a monitored reef formation located inshore, there might be strong evidence that if the vessel was moved to an offshore trenching location, it would not contribute to an exceedence at the affected site.

Turbidity generating activities, associated with trunkline installation, that have been stopped but, based on a comprehensive inference assessment, are not reasonably expected to be causing or contributing to the exceedence may be recommenced. A report setting out the rationale for the assessment that those activities that are not reasonably expected to have contributed to or caused the exceedence must be provided to the OEPA/DotE within two working days of the recommencement.

In the event that a Level 3 management trigger is exceeded, a Coral EPO Assessment will be undertaken at the affected reef formation within approximately two weeks or less (weather permitting) to determine whether coral EPOs are being achieved at the affected reef formation. The monitoring and analysis procedures for the Coral EPO Assessment are detailed in Section 6.4.1.3.

If the Coral EPO Assessment reveals that the EPO is being achieved, the turbidity generating activities associated with trunkline installation that have been stopped can recommence if:

- Modelling of the revised activity predicts turbidity will be less than the trigger intensity at the affected reef formation
- Measured turbidity at the affected reef formation has dropped below the trigger intensity, as demonstrated by telemetered data.

[12] For the purposes of this Plan, turbidity-generating activities, has been defined as a combination of the type of the activity (e.g. CSD, placement of dredge spoil) and the location of activity.

If the revised activity is allowed to recommence and the turbidity generated by this activity at the affected site rises above the intensity of the Level 3 trigger whilst a Level 3 exceedence is still in effect (i.e. while the cumulative number of days above the trigger intensity is still higher than the number of allowable days within a rolling period), the activity would again be required to stop and the Level 3 exceedence procedure would again be followed.

If the Coral EPO Assessment reveals that the EPO is not being achieved at the reef formation where the Level 3 Exceedence occurred, as a result of a turbidity-generating activities associated with trunkline installation, the Recommencement Procedure (Figure 6.3), is required to be followed in accordance with Condition 8-13 of MS 873.

The Level 2 management trigger is based on water quality criteria that, if reached, would indicate that a management response is required to reduce pressure and avoid exceeding the Level 3 management trigger. If a Level 2 trigger is exceeded, management of turbidity-generating activities associated with trunkline installation, is required, where reasonably practicable, to continue to be implemented to reduce pressure on the site(s) where the exceedence occurred until water quality at that site(s) is reduced to below the trigger intensity. Management actions would be assessed as effective if turbidity levels are reduced to below the magnitude of the criteria (i.e. 3.3 or 3.2 times background depending on the criteria).

If Level 2 management triggers are exceeded, monitoring of benthic communities (two surveys) is required at the monitored reef formation(s) where the management trigger was exceeded and at reference reefs to provide verification of whether the water quality criteria are effective in affording the required level of protection to receptors (Section 6.4.2). Two field surveys are planned following a Level 2 management trigger exceedence. One survey will occur within two weeks of the initial exceedence and another will occur within two weeks of the end of the first survey. Consequently, the field survey period following a Level 2 management trigger exceedence will be four weeks in total. During this four week period, should the Level 2 management trigger be exceeded again at the same affected reef formation, it will not trigger an additional two verification monitoring surveys, but will only instigate additional management measures. Verification monitoring can only commence again at that same affected reef formation once the current four week survey period has ended.

Level 1 management triggers provide an early warning that turbidity-generating activities associated with trunkline installation are elevating turbidity at monitoring sites and there is the potential for future impacts to benthic communities should these elevations continue to occur for each monitored reef formation within the ZoI. Level 1 management triggers are set at half the duration of time required to reach a Level 2 management trigger. If Level 1 management triggers are exceeded, this would prompt an investigation of events that led to the trigger being exceeded and identification of any potential management responses that could be implemented in the event that impacts to water quality continue to occur.

As detailed above, in order to formally exceed a management trigger (Level 1, Level 2 or Level 3), an inference assessment must conclude that it is reasonably expected that turbidity-generating activities, associated with trunkline installation, have caused or contributed to the exceedence.

Table 6.2: Management Triggers and Required Responses for Reef Formations within the Zone of Influence

	Trigger Level		
	Level 1	**Level 2**	**Level 3**
Water Quality Criteria	**Chronic criteria** Daily median turbidity >3.3 x background at Reference Sites in similar environment and >2.62 NTU for no more than 10 days out of a 20 day rolling assessment period. **OR** **Moderate criteria** Daily median turbidity >3.2 x background at Reference Sites in similar environment and >5.08 NTU for no more than 4 days out of a 20 day rolling assessment period.	**Chronic criteria** Daily median turbidity >3.3 x background and >2.62 NTU for no more than 20 days out of a 40 day rolling assessment period. **OR** **Moderate criteria** Daily median turbidity >3.2 x background and >5.08 NTU for no more than 8 days out of a 40 day rolling assessment period.	**Chronic criteria** Daily median turbidity >3.3 x background at Reference Sites in similar environment and >2.62 NTU for no more than 40 days out of an 80 day rolling assessment period. **OR** **Moderate criteria** Daily median turbidity >3.2 x background at Reference Sites in similar environment and >5.08 NTU for no more than 16 days out of an 80 day rolling assessment period.
Management Actions	Identify the events that led to the trigger being exceeded and whether they are likely to continue to occur or reoccur. Check model for interpretation. Investigate potential management responses that could be implemented if elevations continue to occur.	Identify the events that led to the trigger being exceeded and whether they are likely to continue to occur or reoccur. Implement management, where reasonably practicable, to reduce levels below the trigger value. Continue monitoring and assessing water quality to ensure the effectiveness of the measures applied. Alter management response if not effective. Monitor benthic communities at targeted sites where exceedence was identified and related reference sites to verify appropriateness of water quality criteria.	Follow the Level 3 Exceedence Procedure (Figure 6.2).

6.4 Monitoring Strategy for Water Quality and Coral

6.4.1 Responsive Monitoring Programme (to achieve EPOs)

Three monitoring programmes, as well as sedimentation monitoring, will be used to assist in the interpretation of data collected under the water quality and benthic community monitoring programmes. These programmes are:

1. **Responsive water quality Monitoring** at the monitored reef formations will be used to collect turbidity data to be assessed against Level 1, 2 and 3 management triggers.
2. **An Assessment of Achievement of Coral EPOs** will be undertaken if a Level 3 management trigger is exceeded.
3. **Verification Monitoring** will be undertaken to verify the effectiveness of water quality criteria in affording protection to benthic communities.

The monitoring programmes are detailed in the following sections.

6.4.1.1 Location of Monitoring Sites

Water quality data will be collected adjacent to approximately ten monitored reef formations in the responsive monitoring programme. ‘Impact’ monitored reef formations and indicative reference reefs are listed in Table 6.3 and their locations are shown in Figure 6.5. A description of the physical attributes for the monitored reef formations (including both impact reefs and indicative reference reefs) is detailed in Table 6.4 and a description of the benthic communities is detailed in Table 6.5.

Table 6.3: Impact Monitored Reef Formations and Indicative Reference Reefs in the Responsive Water Quality Monitoring Programme

Zone/Type	Name	Variables	Monitoring Frequency
Influence	Paroo Shoal	Turbidity, temperature, conductivity, benthic light availability, depth	Data collected ~every 30 minutes
Influence	Ashburton Island		Data collected ~every 30 minutes
Influence	Brewis Reef		Data collected ~every 30 minutes
Reference	Thevenard Island North East		Data collected ~every 30 minutes
Reference	Thevenard Island Southeast		Data collected ~every 30 minutes
Reference	Serrurier Island		Data collected ~every 30 minutes
Reference	West Reef		Data collected ~every 30 minutes
Reference	Airlie Island		Data collected ~every 30 minutes
Reference	Locker Island		Data collected ~every 30 minutes
Reference	Bessieres Island		Data collected ~every 30 minutes

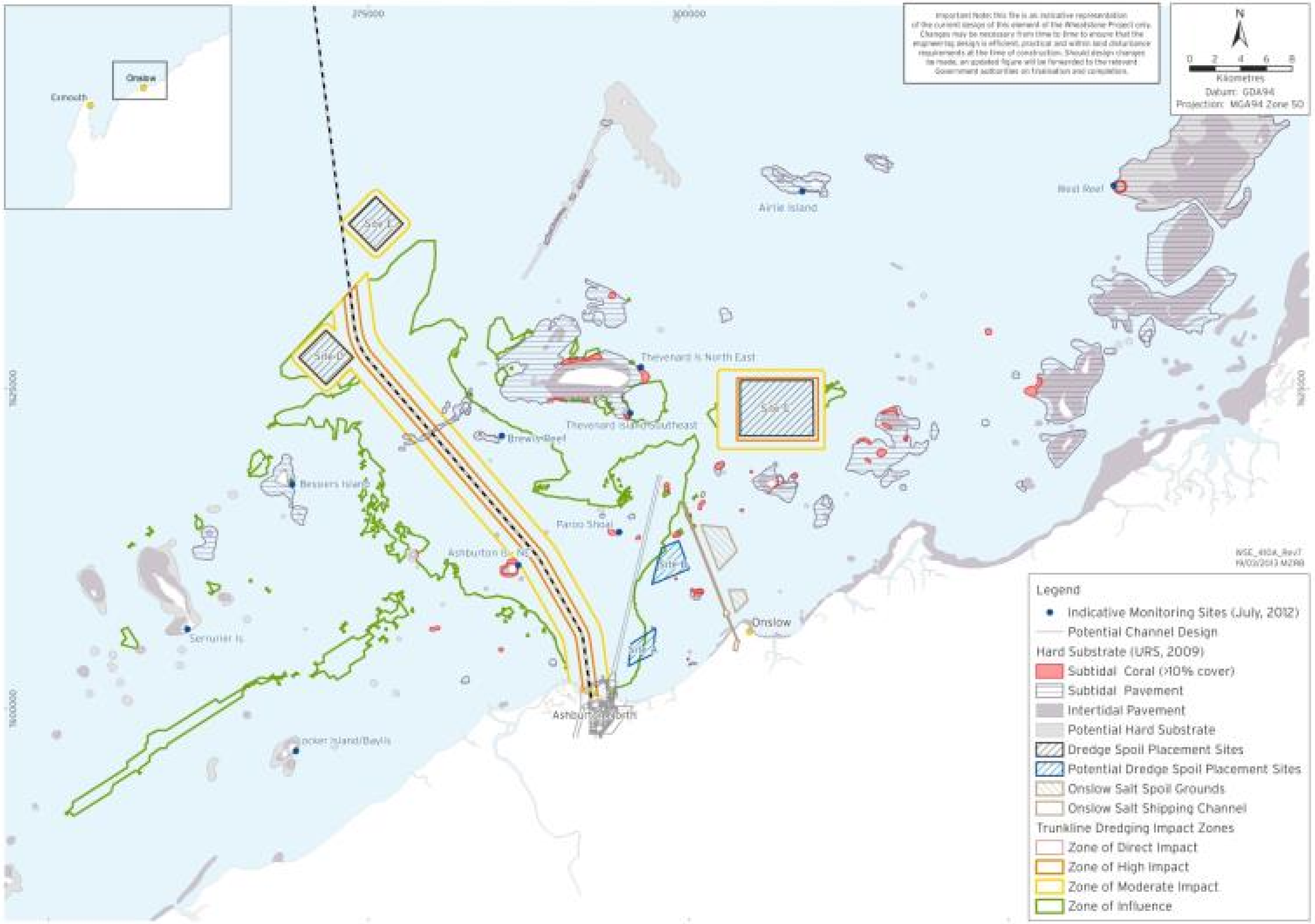


Figure 6.5: Impact Monitored Reef Formations and Indicative Reference Reefs in the Responsive Water Quality Monitoring Programme

Table 6.4: Description of Key Physical Attributes of Impact Monitored Reef Formations and Indicative Reference Reefs

Zone/Type	Name	Average water quality logger depth (m)	Physical Attributes										
			Reef Type	Water Quality Environment (May 2011 to August 2012)									
				Turbidity (NTU)					Light Climate (Total daily PAR- μmol photons/m^2/day)			Sedimentation rate (mg/cm^2/day)	
				Min	Max	Median	80th %ile	95th %ile	Min	Max	Median	Average	Average StDev
Influence	Paroo Shoal	10.2	Patch reef	0.1	133.7	0.7	1.1	3.2	1.2	5773	3082	13.9	0.8
Influence	Brewis Reef	7.0											
Influence	Ashburton Island	9.3	Reef slope	0.1	245.1	0.7	1.1	2.2	0	5873	3210	10.7	0.5
Reference	Thevenard Island North East	10.2	Reef slope	0.1	85.6	0.6	1.0	2.4	1	6513	3150	10.4	0.6
Reference	Thevenard Island Southeast	9.1		0.1	96.3	0.9	1.4	2.6	1.1	6587	3126	14.1	0.6
Reference	West Reef	9.6	Reef flat	0.1	79.9	0.9	2.1	4.7	1.2	7150	2355	24.1	2.9
Reference	Serrurier Island	6.5	Patch reef	0.0	169.4	0.5	0.8	2.3	4.4	14035	6907	21.1	0.7
Reference	Airlie Island	6.3	Patch reef	0.1	95.6	0.7	1.3	3.4	1.2	13022	5517	60.3	13.4
Reference	Locker Island	5.7	Reef slope	0.0	152.2	2.1	3.8	8.1	0	7436	2768	26.3	2.8
Reference	Bessieres Island	7.5	Patch reef	0.0	68.0	0.3	0.4	1.5	1.4	13026	6481	32.9	11.8

Table 6.5: Description of Benthic Communities at Impact Monitored Reef Formations and Indicative Reference Reefs

Zone/Type	Name	Site Depth	Reef Type	Site/species Descriptor[13]	% Benthic Community Cover*
Influence	Paroo Shoal	4-8 m	Patch reef	**Corals** - *Poritidae, Merulindae, Mussidae* and *Pectiniidae* present, dominated by *Faviidae*	2.9
				Filter feeders - Numerous soft coral (Nephtheidae) and numerous sponges	Not available
				Macroalgae - Limited to none macroalgae growth.	0.0
Influence	Brewis	7 m	Not available		
Influence	Ashburton Island	3-7 m	Reef slope	**Coral** - *Faviidae* and *Merulinidae* dominant with the occasional *Dendrophylliidae, Mussidae, Pectiniidae and Poritidae*	5.2
				Filter feeders - Limited to none soft corals and sponges.	Not available
				Macroalgae - Limited to none macroalgae growth.	0.7
Reference	Thevenard Island North East	3-5 m	Reef slope	**Coral** - *Faviidae* dominant with *Poritidae* and *Merulinidae* present[1]	4.5
				Filter feeders - Minimal soft coral and limited to none sponges.	Not available
				Macroalgae - Minimal macroalgae growth.[1]	8.5
Reference	Thevenard Island Southeast	9-10 m	Not available	**Coral –** Very low level of coral cover; mainly Turbinaria.	<1.0
				Filter feeders – Low cover of soft coral.	<5.0
				Macroalgae – Moderate to low (depending on season) level of macroalgae cover .	10.0-30.0
Reference	West Reef	3-5 m	Reef flat	**Coral** - *Faviidae* dominant. *Poritidae present with occasional Mussidae, Pectiniidae* and *Pocilloporidae.*	15.3
				Filter feeders - Limited to none soft corals and sponges.	Not available
				Macroalgae - Limited to none macroalgae growth.	0.0
Reference	Serrurier Island	2-3 m	Patch reef	**Coral** - *Faviidae* and *Poritidae* dominant. Occasional *Acroporidae*, *Agariciidae*, *Dendrophylliidae.*	2.6

[13] Information gathered from baseline studies

Zone/Type	Name	Site Depth	Reef Type	Site/species Descriptor[13]	% Benthic Community Cover*
				Filter feeders - Minimal soft corals and limited to none sponges.	Not available
				Macroalgae - Limited to none macroalgae growth.	0.0
Reference	Locker Island	2-3 m	Reef slope	**Coral** - *Poritidae* and *Faviidae* dominant. *Dendrophylliidae* present with occasional Acroporidae and *Merulinidae*.	3.0
				Filter feeders - Limited to none soft corals and sponges.	Not available
				Macroalgae - Minimal macroalgae growth.	6.9
Reference	Airlie Island	1-2 m	Patch reef	**Coral** - *Faviidae* and *Mussidae* dominated with *Merulinidae* present and the occasional *Poritidae*.	10.0
				Filter feeders - Limited to none soft corals and sponges.	Not available
				Macroalgae - Limited macroalgae growth.	0.2
Reference	Bessieres Island	1-2 m	Patch reef	**Coral** - *Poritidae* dominated. *Faviidae*, *Montipora* and *Mussidae* present with occasional *Merulinidae*.	12.6
				Filter feeders - Numerous soft coral; *Lobophyton* sp. and *Sinularia* sp. Limited to none sponges.	Not available
				Macroalgae - Limited to none macroalgae growth.	0.0

Reference Reefs

Reference reefs will be used for three main purposes in monitoring programmes:

- In water quality trigger assessments, to provide an estimate of 'background' turbidity used in the calculation of trigger criteria (e.g. trigger criteria = 3.2 x geometric mean of associated reference reef daily medians; see Section 6.3.2). The Reference reef daily medians may be adjusted where baseline site comparisons have indicated that the accuracy in predicting impact reef formation background can be improved by applying an adjustment factor. That factor would be based on the relationship between impact and reference reefs, quantified prior to the start of turbidity-generating activities associated with trunkline installation and provided to EPA and DTAP. The adjustment factors may be reviewed during the dredging programme, provided they are still calculated based on baseline data. Any amendments, if required, will be provided to the EPA and DTAP prior to implementation.
- In Coral EPO Assessments, to provide an estimate of the natural level of change in coral communities to determine 'net' change in coral cover at impact reef formations to assess against EPOs (i.e. net change = change at impact reef formations minus average change at associated reference reefs) and to assist in inferring the cause of that change.
- In Verification Monitoring, to interpret any potential change observed in monitored variables at impact reef formations and to assist in inferring the cause of that change.

In most cases, the same reference reefs will be used in each of the above assessments. This would provide reference water quality data and reference data on coral, macroalgae and filter feeders from the same location to be able to infer the cause of changes. However, since water quality trigger assessments are based on calculations of 'background' turbidity, defined as the of reference reef daily medians (or adjusted daily medians; Section 6.4.1.2), it is critical that the water quality characteristics of reference reefs resemble as closely as possible that of impact reef formations against which they are compared. Therefore, in some instances (e.g. in inshore environments) it may be necessary to include specific water quality reference reefs in water quality trigger calculations, but for which no significant benthic communities exist that would provide useful reference data for Coral EPO assessments or Verification Monitoring.

Initial Choice of water quality Reference Reefs

Due to the requirement to understand baseline water quality environments of reference and impact reef formations to be able to match these reefs as best as possible for trigger assessments, the initial list of reference reefs associated with each impact reef formation will be provided, to the EPA and DTAP, for confirmation and transparency, prior to the commencement of turbidity-generating activities associated with trunkline installation. Indicative-only reference reefs are provided in Table 6.3.

The initial list of reference reefs will be chosen to be as comparable as possible (during baseline conditions) to impact reef formations, both in environmental characteristics and trends in water quality conditions (i.e. similar behaviour/changes occur over similar timeframes). The initial choice of reference reefs associated with each impact reef formation will be based on the following criteria:

- For each impact reef formation within the ZoI, there should be at least three Reference reefs and preferably a pool of reference reefs that account, as best as possible for any localised spatial and temporal variation.
- Reference reefs should be located outside the ZoI or towards the outer edge of this zone within the ZoI (see further discussion on reference reefs within the ZoI below).

- Sites should be readily accessible by a survey vessel.
- The turbidity at reference reefs has to be comparable to the turbidity of the impact reef formations it is used for in the trends in water quality conditions (i.e. changes occur over similar timeframes). Statistics such as correlation coefficients and cluster analyses will be used to examine baseline water quality data and determine the comparability of water quality environments of all reference and impact reef formations.
- If reference and impact reefs have similar behaviours in water quality environments (similar timing of fluctuations in turbidity), but differ in the magnitude of turbidity values (i.e. reference reefs are consistently higher or lower in turbidity than the associated impact reef formation), the accuracy in predicting impact reef formation background can be improved by applying an adjustment factor. This factor would be calculated, and provided to EPA and DTAP, based on baseline data. The offset would be based on linear regressions of log-transformed data for each impact/reference reef combination.
- A hierarchical list of possible reference reefs will be produced for each impact reef formation, (based on comparability of water quality environments). From these, the best group of reference reefs (at least three) will be defined and used for trigger assessments. If a malfunction at one reference reef occurs, it will be possible, in most instances, to use the 'next best' reference reef to calculate 'background' turbidity and maintain a minimum of three reference reefs in calculations.
- Where significant seasonal differences exist in correlations between reference and impact reef formations, a different pool of reference reefs may be defined for each season.

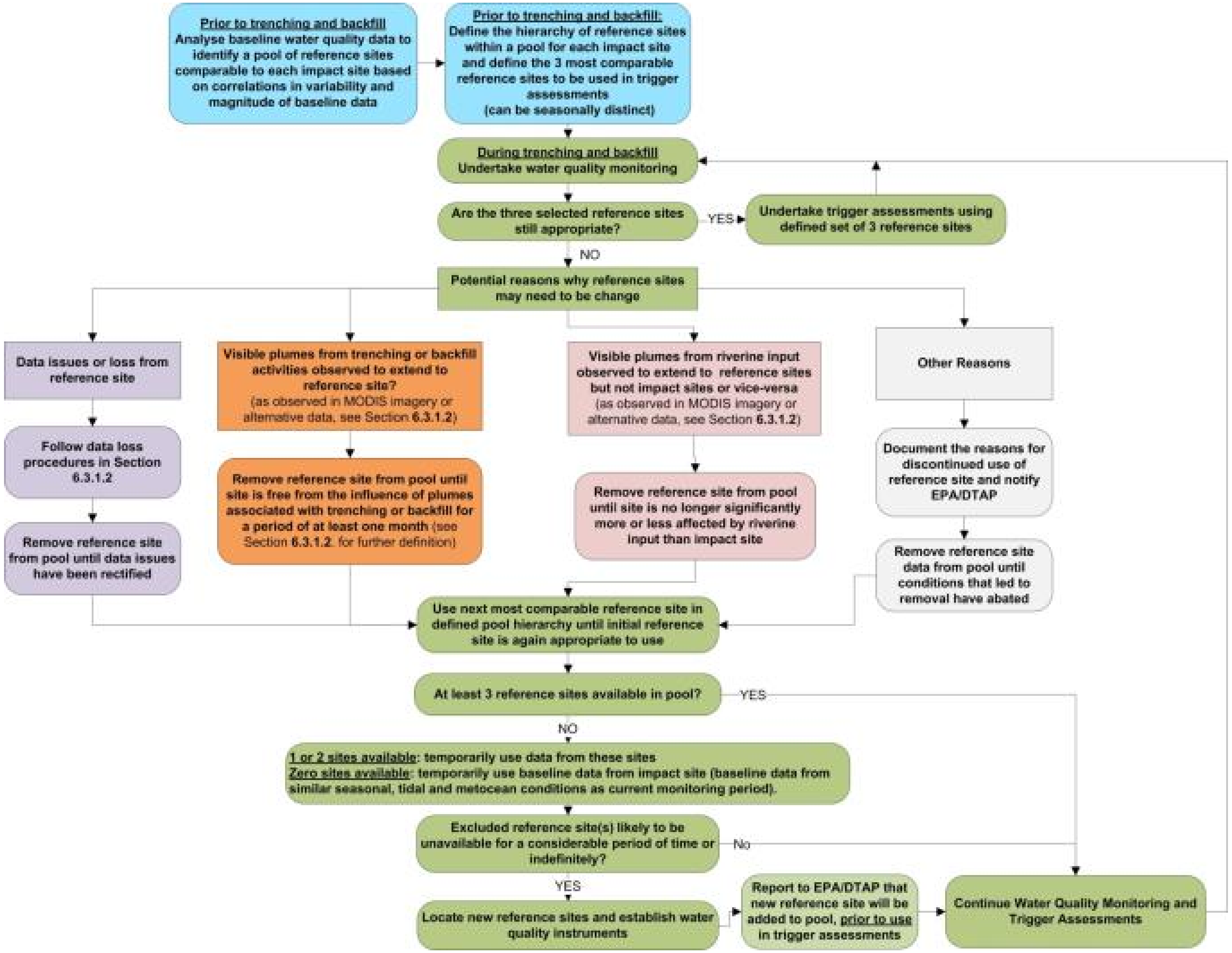


Figure 6.6: Procedures to Select and Modify choice of Reference Sites

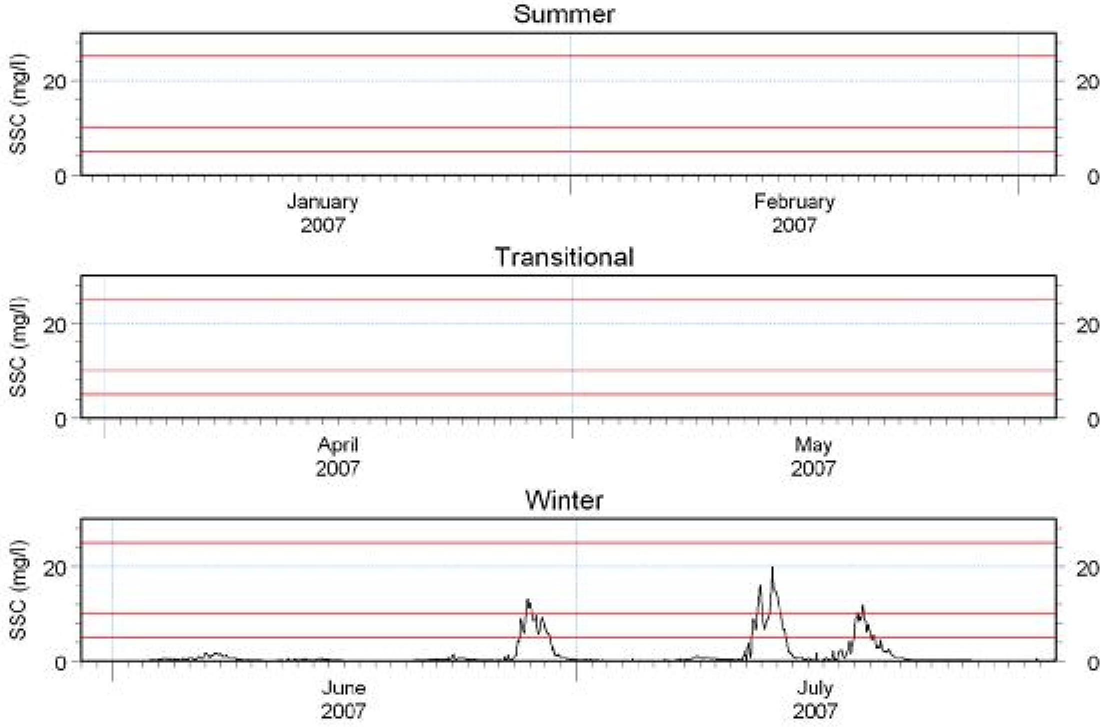
While EPA guidance (EAG7; EPA 2011) recommends the location of reference reefs outside the predicted influence of development activities, it recognises that this is not always possible, nor practical, given the spatial extent of the plume associated with a large dredging campaign. The predicted ZoI for both turbidity-generating activities associated with the construction of the nearshore and offshore marine facilities and trunkline installation activities, extends a considerable distance west and east of the dredge and dredge material placement locations (see EIS/ERMP Section 8.3; MS 873). To the west of the ZoI is the Exmouth Gulf, where depths and exposure to wind and wave action are distinctly different to those within the project area and no comparable reference reefs could be identified. To the east of the ZoI are the Mangrove Islands, within which conditions are generally shallower and more turbid than those within the project area, limiting the comparability of these areas with impact reef formations.

The proposed solution to the limited number of reference reefs that are comparable to impact reef formations is to establish some of the reference reefs in areas within the ZoI but towards the outer boundary of this zone. These reefs will be treated as appropriate reference reefs or controls provided there are no detected elevations in turbidity due turbidity generating activities which are part of the construction of the nearshore and offshore marine facilities or turbidity generating activities associated with trunkline installation at these reefs. This approach is consistent with the guidance of EAG7 (EPA 2011).

Since the main purpose of reference reefs is to provide an estimate of background turbidity, used to calculate water quality-based management trigger criteria on a daily basis (e.g. trigger criteria = 3.2 x geometric mean of associated reference reef daily medians, or adjusted daily medians; Section 6.4.1.2), provided the reference reefs are not being influenced by turbidity-generating activities at the time that reference data are used, nor have been influenced by dredge-related plumes to an extent that resuspension of dredged sediments at the reference reef might be reasonably expected, they are expected to perform as well as reference reefs located outside the ZoI in providing an estimate of background conditions. Some reefs within the ZoI are only expected to be influenced very briefly during turbidity-generating activities, in some cases only within one season (for example, see Figure 6.7). Following the guidance of EAG7 (EPA 2011), conservative criteria have been established to define whether reference reefs are free from impacts of turbidity-generating activities. The following criteria have been established to determine whether reference reefs are suitable controls to indicate background levels of turbidity and coral condition:

- Visible plumes associated with turbidity-generating activities which are part of both trunkline installation and construction of the nearshore and offshore marine facilities (dredging of the MOF, PLF and PLF approach channel) are not observed to extend to reference reefs at the time the data are required for use in trigger calculations based on an examination of MODIS satellite imagery. In the case that satellite imagery is obscured due to cloud cover, recent activities, recent logged water quality data and the most recent history of MODIS satellite imagery will be used in an assessment to determine whether visible plumes are not reasonably expected to extend to reference reefs; and
- Visible plumes associated with turbidity-generating activities which are part of both trunkline installation and construction of the nearshore and offshore marine facilities have not been observed to extend to reference reefs within the last month. This will ensure that any small amounts of dredged sediments that may have been deposited within the vicinity of reference reefs (which is unlikely to be significant at the outer boundary of the ZoI) have had a chance to be removed from the area through wind, wave and tidal action, and that resuspension of dredged sediments is, therefore, not expected to elevate turbidity to detectable levels at reference reefs, nor to affect biota.

Where the above criteria are not met, reference reefs will be assessed as unsuitable for the purposes of calculating background turbidity in water quality trigger calculations. In this instance sub-optimal reefs in the order of hierarchy would be used in the water quality trigger assessment in accordance with the procedure detailed below and illustrated in Figure 6.8.



Note: Red lines correspond to SSC levels of 5mg/L, 10mg/L and 25 mg/L above background. X-axis scale in days

Figure 6.7: Example of a site within the ZoI but close to the outer boundary of this zone (near Locker Island) where predicted excess SSC concentrations due to dredging activity (dredging scenario 5) are only detectable for brief periods during the programme (winter) and hence, it may be possible to use this site as a reference site for part of the programme

Refining water quality Reference Reefs

It is foreseeable that, while Reference reefs will be chosen to match as closely as possible to each impact reef formation, based on available baseline data, during turbidity-generating activities associated with trunkline installation, some Reference reefs may no longer be comparable to impact reef formations or may no longer fit the definition of a ‘control’ in trigger assessments. For example:

- Reference reefs might be influenced by turbidity-generating activities which are part of both trunkline installation and construction of the nearshore and offshore marine facilities and no longer be considered suitable ‘controls’ for a period of time during and after being affected. This is most likely to occur at reference reefs that lie within the Zone of Influence.
- Data recovery issues, such as logger failure, may result in a loss of data from reference reefs for brief periods. This may result in a reference reef not being used for a particular period of testing, after which it will be brought back into use.

The procedure shown in Figure 6.8 will be followed during turbidity-generating activities associated with trunkline installation to allow for reference reefs associated with each impact reef formation to be refined, if required in response to scenarios, such as those described above. This process allows for Reference reefs to be changed objectively and transparently if and when required.

Initial Choice of Reference Reefs used for Coral EPO Assessment and Verification Monitoring

Reference reefs are also required to quantify natural spatial and temporal changes in i) coral cover, to allow net-change to be calculated at impact reefs in order to measure achievement of the coral EPOs; and ii) in coral cover and other variables, such as macroalgae and filter feeders, for the purposes of Verification Monitoring used to assess the appropriateness of water quality criteria. The principles for selecting and refining reference reefs for Coral EPO Assessments and Verification Monitoring are largely consistent with that described for water quality reference reefs. For example, reference reefs need to be environmentally similar to the impact reef formations, but sufficiently far from turbidity-generating activities associated with trunkline installation so as not to be unduly affected, as described in EAG 7 (EPA 2011) and described above.

The initial choice of Coral EPO Assessment and Verification Monitoring reference reefs will be based on the following criteria:

- Where possible, coral reference reefs will be consistent with the water quality reference reefs
- Reference and impact reefs will be chosen to share as similar as possible, baseline coral abundance (percent cover) and genera composition
- For the ZoI there should be at least three reference reefs
- Reference reefs should be located outside the ZoI of all turbidity-generating activities, or at the very least, or towards the outer boundary of the ZoI
- Reference reefs should be readily accessible by a survey vessel.

Refining Reference Reefs used for Coral EPO Assessment and Verification Monitoring

Although reference reefs will be chosen to match as closely as possible to ‘impact’ reef formations based on available baseline data, during the course of time some reference reefs may no longer be suitable and require replacement. For example:

- Reference reefs might be influenced by turbidity-generating activities associated with trunkline installation (e.g. reference sites that lie within the ZoI)
- Anomalous events, such as widespread bleaching or outbreaks of coral predators (e.g. *Drupella* snails or crown of thorns starfish), may affect some reference reefs but not impact reefs.

For these reasons some redundancy is required in the selection of reference reefs. Contingency reference reefs will be identified and used, if required, in the event that an existing reference reef needs to be replaced.

6.4.1.2 Water Quality Monitoring

Objectives

There are two key objectives of the water quality monitoring component of the responsive monitoring programme:

1) To provide data that are assessed against management triggers to inform management of turbidity-generating activities associated with trunkline installation.
2) To provide data to assist in inferring the cause of any potential changes in coral health.

Variables

Water quality variables that will be measured at monitored reef formations via water quality loggers during the responsive monitoring programme include the following:

<u>Turbidity (measured in NTU)</u>

Turbidity provides an indirect measure of the alteration of the light climate received by BPP communities that may be a result of the natural suspension and movement of sediments and/or the suspension and movement of sediments caused by trenching or backfill activities. Due to the link between turbidity and sedimentation rates, turbidity data may also indirectly provide a relative measure of the level of sedimentation settling on the substrate or biota.

<u>Benthic light climate (measured in photosynthetically active radiation – PAR)</u>

The quanta of light received by BPP, measured in PAR, is a direct measure of potential impacts to BPP as a result of altered water quality. However, this measure must be combined with turbidity data to determine whether changes in light climate are a consequence of the suspension and movement of sediments caused by trenching or backfill activities or just due to natural variation.

<u>Water Temperature</u>

Water temperature will not be significantly affected by trenching or backfill activities. However, there have been recorded instances in the Pilbara region of changes in coral health, including bleaching and partial morality, due to natural thermal anomalies (MScience 2008). Therefore, temperature will be recorded at all monitored reef formations to identify natural thermal anomalies to inform the differentiation of potential trenching and backfill impacts on coral health from natural thermal anomaly events.

<u>Salinity</u>

Although salinity is unlikely be significantly altered by turbidity-generating activities associated with trunkline installation, salinity data may be useful for inference assessments. The salinity data can provide supporting evidence on the cause of any detected changes to BPPH that may occur due to the natural variation in salinity (e.g. due to the input of freshwater from the Ashburton River).

In addition, the following information will also be gathered to assist in interpreting trends in data collected during the responsive monitoring programme:

<u>Metocean Conditions</u>

Measurements of metocean conditions (e.g. wave height, current speed, current direction) are being undertaken by metocean buoys at selected locations and resulting data will be used in the interpretation of changes in water quality and coral health. These measurements will identify important relationships between metocean conditions, trenching and backfill activities and location, and any subsequent impacts to water quality and coral health.

<u>Satellite Imagery (Characterisation of the ZoI)</u>

Satellite imagery will be used to satisfy the requirements of Condition 8-11 x. which is "To regularly characterise, spatially-define and report the realised ZoI caused by turbidity-generating activities associated with trunkline installation." MODIS satellite imagery will be used as an indicator to monitor the spatial extent of the ZoI during turbidity-generating activities associated with trunkline installation, from which TSS concentrations in the near-surface waters will be calculated. TSS data derived from MODIS imagery will be correlated from water samples taken for the plume modelling verification, to determine the accuracy of the satellite imagery.

The realised extent of the ZoI during turbidity-generating activities associated with trunkline installation, as derived from MODIS imagery, will then be compared with the predicted extent of the ZoI derived through modelling predictions.

Data Collection

<u>In-situ loggers</u>

Water quality data will be collected at approximately 30 min intervals through the use of *in-situ* water quality data logging instruments. The majority of the sites will be telemetered providing real-time access to data which will be downloaded daily. The *in-situ* water quality data loggers have been deployed adjacent to the monitored reef formations rather than directly on them to prevent damage to the coral during deployment and retrieval.

It is anticipated that during trenching and backfill activities, there is likely to be some loss of data from water quality instruments due to equipment failure or loss. The parameters: light, temperature, depth and salinity are used primarily to assist with the inference assessment for relating water quality with any changes to coral health, and data loss is unlikely to present a significant problem provided it is minimised, where practicable, throughout the programme. However, since turbidity data are critical to the management of turbidity-generating activities associated with trunkline installation and turbidity data are used on a daily basis in management trigger assessments, procedures have been developed to minimise turbidity data loss and to deal with turbidity data loss issues when they occur. These procedures are illustrated in Figure 6.8 and summarised below.

Minimising data loss

The vast majority of water quality loggers (including all reference reefs and impact reef formations assessed to be 'at risk' from turbidity-generating activities associated with trunkline installation) will be telemetered. Therefore, malfunctions or instrument losses/damage can be picked up almost immediately. Once a malfunction or instrument loss/damage is identified, equipment will be repaired or replaced within a maximum of 96 hours (weather permitting) or sooner where possible. However, it should be noted that a maximum of only three water quality loggers can be replaced within 96 hours due to logistical constraints. Therefore, if circumstances arise where more than three loggers have malfunctioned (e.g. following an intense cyclone), replacement of all water quality loggers may take longer than 96 hours.

Dealing with data loss

The first step in the data loss procedure (illustrated in Figure 6.8) is to identify how much data is missing[14]. If the period of lost data is less than 12 hours (i.e. at least 12 hours of data from the daily period of 0.01 am to midnight is still available), the daily median will be based on the remaining data. For locations with greater than 12 hours of data loss within a daily assessment period (0.01 am to midnight), calculating the daily median will depend on one of three site categories:

- ‘At risk’ impact reef formations (defined as being previously exposed to a dredge plume or is one or more days above the daily trigger intensity within a rolling period)
- ‘Unaffected’ impact reef formations (impact reef formations that are not ‘at risk impact reef formations’)
- Reference reefs.

For a monitored reef formation considered to be ‘at risk’, calculating the daily median will be based on the previous available daily median of the same monitored reef. For an ‘unaffected’ monitored reef formation, the daily median will be based on seasonally averaged baseline data from the same site. For a reference reef, this will depend on the availability of other reference reefs. If another reference reef is available the daily median will be based on data from that reef. If a reference reef is unavailable, the daily median will be based on a seasonally averaged baseline data from the impact reef.

[14] Data is only considered to be lost if it cannot be retrieved either via telemetry or manually e.g. it may be that the telemetry unit malfunctions but the data can still be collected manually.

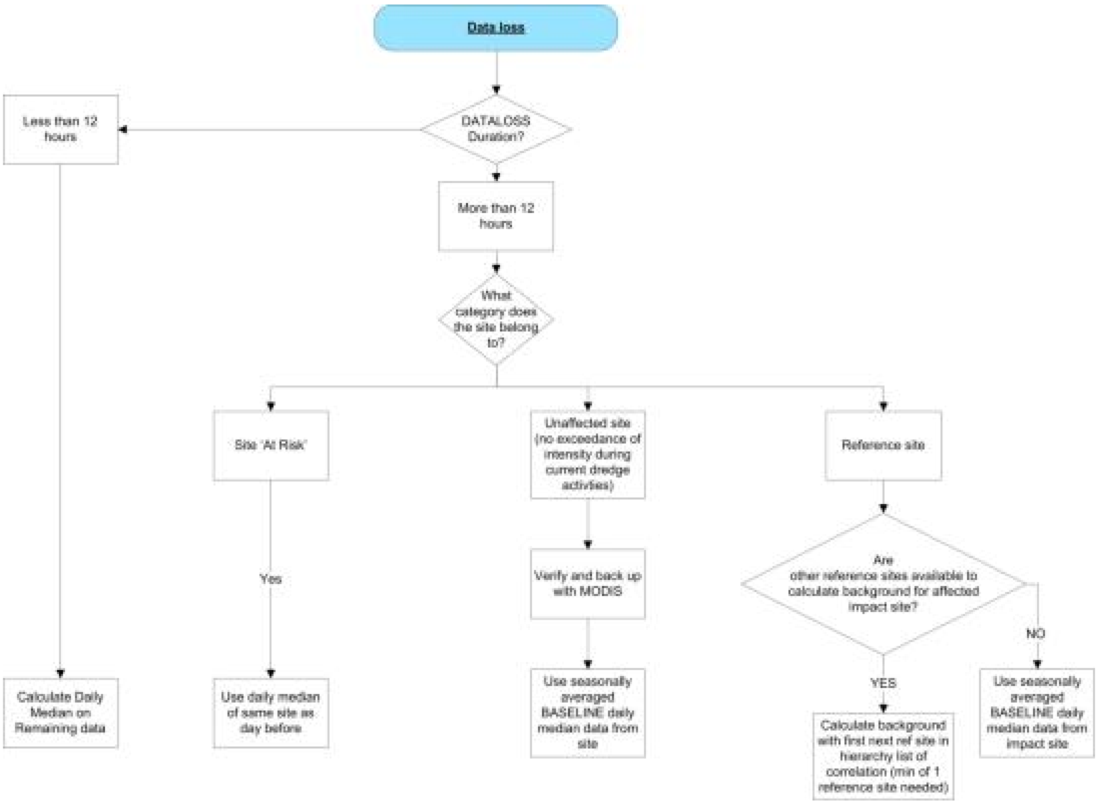


Figure 6.8: Procedure to deal with Water Quality Data Loss

Metocean Buoys

Measurements of metocean conditions are being undertaken by metocean buoys at selected locations (indicative locations are illustrated in Figure 6.9). The metocean buoys are separate to the in-situ water quality loggers at the monitored reef formations.

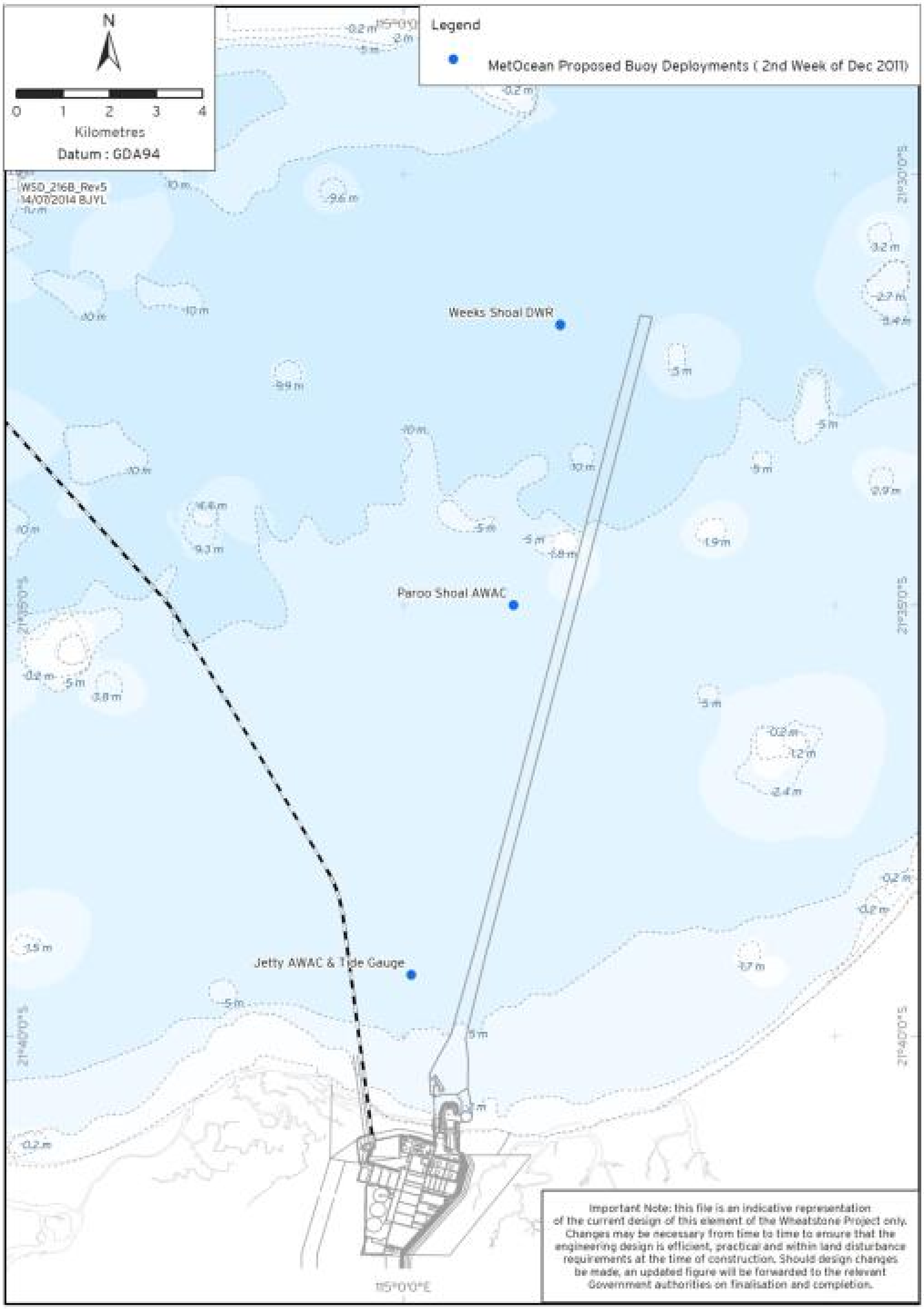


Figure 6.9: Indicative Location of the Metocean Buoys

Data Analysis

All data will be subject to rigorous quality assurance and quality control (QA/QC) procedures. Due to issues with bio-fouling of equipment, a regular maintenance schedule will be implemented and all loggers retrieved, downloaded, cleaned and redeployed or replaced as necessary to maintain the quality of data collected. Prior to the analysis of water quality data to assess whether management triggers have been exceeded, a preliminary check of data integrity will be undertaken and anomalous data removed using an objective function, following guidance outlined in ANZECC and ARMCANZ (2000).

Assessing Water Quality Data against Management Triggers

The following four main steps for assessing water quality criteria will be undertaken during turbidity-generating activities associated with trunkline installation:

- Record the daily median turbidity at each of the monitored reef formations and reference reefs and then calculate the median of all usable 30 minute data (QA/QC'd data) measured within a 24 hour period, from in-situ loggers at each reef. This daily summary of turbidity at each reef is the key variable in all subsequent calculations and assessment against the management triggers.
- Determine daily background levels of turbidity associated with the assessed monitored reef formation, based on the (geometric) average of the measurements of (daily median) turbidity from each of the reference reefs.
- If reference reefs are found to have the same daily patterns in turbidity (i.e. good correlations), but consistently differing magnitude in turbidity (higher or lower) or consistently differing response to changes in metocean conditions than the associated impact reef formations, it may be necessary to use an adjusted daily median for reference reefs. Adjustment factors will be determined prior to commencement of turbidity-generating activities associated with trunkline installation using baseline data these may be reviewed during the dredging program, based on baseline data, and updated if required. These adjustments would be determined using a linear regression of log-transformed baseline data for each reference/impact reef pair and using that linear regression to more accurately predict background turbidity at potential impact reef formations:

  $$\ln y = a.\ln x + b$$

  Where: y= impact reef turbidity, x = reference reef turbidity, a= slope and b= constant.

  For example, if a reference reef and impact reef during baseline show a good correlation in patterns of turbidity, but the reference reef is always 1NTU higher than the impact reef, that reference reef would be adjusted downward by 1 NTU before the geometric mean of all reference reefs in the group is calculated.

- Assess whether measurements of daily median turbidity at monitored impact reef formations are elevated over daily background levels, as calculated on the same day from associated reference reefs. For example daily median turbidity from an 'impact' reef will be compared against the background daily median turbidity calculated on the same day from the associated reference reefs. Water quality criteria (Table 6.2) will be used to determine whether daily elevations are significantly elevated above background levels and are at levels that, if continued over the long term, might lead to management triggers being exceeded.
- Determine the total number of days that elevations in turbidity at the assessed monitored reef formation have been above chronic or moderate water quality criteria for the associated zone (e.g. more than 3.2 x reference reefs and 5.08 NTU, see Table 6.2) within the rolling assessment period defined within each set of criteria (e.g. 20, 40 or 80 days; see Table 6.2). Each day, the latest water quality data from monitoring reef formations (including reference reefs) will be added to the data sets against which criteria are assessed and the oldest day of data from the rolling assessment period will move out of the assessment window. Thus each day the period of data assessed will

move forward by one day, as a rolling window. Early on during the turbidity-generating activities associated with trunkline installation programme, baseline data from before trenching has commenced will need to be included in the window of assessment to begin assessing data against water quality criteria from day one of trenching. In this way, turbidity-generating activities associated with trunkline installation related turbidity could only be above criteria for the allowable number of days within a rolling period before being required to be managed (e.g. 8–16 days), rather than having to wait for the duration of the entire rolling window before assessments could commence.

All four steps, detailed above, will be undertaken daily for monitored reef formations within the ZoI and will occur from the commencement of trenching and will continue during trenching and backfill operations.

As an example, the procedure using water quality criteria would be:

1) For each reef, record the daily median turbidity across the multiple measurements which will have been made with loggers; i.e. the daily median of turbidity measurements made at a site between 0.01 am to midnight. The daily median for each reef then becomes the variable of interest/ used as a measure of turbidity at a reef in all of the subsequent calculations.

2) Determine daily background water quality (associated with each assessed monitored reef formation) which is defined as the geometric average of (daily median, or adjusted daily median) measurements of NTU on a day, across the Reference reefs that correspond to the assessed monitored reef formation. This will be done for each of the days during the baseline and all of the days during turbidity-generating activities associated with trunkline installation leading up until the current day of assessment.

3) Assess whether a significant elevation above background is recorded on a day by day basis, using the moderate and chronic water quality criteria in Table 6.2.

    a) Is the NTU more than 3.3 times the daily background (calculated in 2) and is the NTU at the site at least 2.62? Record a daily elevation for the chronic water quality criteria at that site for each day where this occurred

    b) Is the NTU more than 3.2 times the daily background (calculated in 2) and is the NTU at the site at least 5.08? Record a daily elevation for the moderate water quality criteria at that site for each day where this occurred.

4) Determine whether triggers have been exceeded over the days leading up to present. Triggers based on chronic and moderate water quality criteria are both assessed separately.

    a) For the chronic criteria:

        I. Level 1 – have there been at least 10 daily elevations (‘yes’ in 3.a.) in the preceding 20 days? If yes, a Level 1 trigger has been exceeded

        II. Level 2 – have there been at least 20 daily elevations (‘yes’ in 3.a.) in the preceding 40 days? If yes, a Level 2 trigger has been exceeded

        III. Level 3 – have there been at least 40 daily elevations (‘yes’ in 3.a) in the preceding 80 days? If yes, a Level 3 trigger has been exceeded

    b) For the moderate criteria:

I. Level 1 – have there been at least 4 daily elevations (‘yes’ in 3.b) in the preceding 20 days? If yes, a Level 1 trigger has been exceeded

II. Level 2 – have there been at least 8 daily elevations (‘yes’ in 3.b) in the preceding 40 days? If yes, a Level 2 trigger has been exceeded

III. Level 3 – have there been at least 16 daily elevations (‘yes’ in 3.b) in the preceding 80 days? If yes, a Level 3 trigger has been exceeded.

If water quality is above the criteria for the allowable number of days out of a rolling period, Chevron Australia will undertake an inference assessment to determine whether it could be reasonably expected that turbidity-generating activities associated with trunkline installation caused or contributed to the exceedence. The inference assessment may consider the following:

- MODIS satellite imagery (e.g. Does the imagery show an obvious potential reason for change which could be dredge related, natural or due to other factors)
- Metocean conditions (e.g. what are the prevailing currents and recent meteorological conditions)
- Records of turbidity-generating activities associated with trunkline installation (e.g. Was trenching/backfill activities occurring in the vicinity such that it could have caused the net change)
- Modelling results (e.g. does modelling indicate that the trenching or backfill has contributed to the exceedence)

  Sedimentation data and water quality data to examine the gradient effect away from the source of concern (e.g. did water quality change show a change in intensity of effect with increasing distance from the trenching or backfill activity); and
- Other relevant factors (e.g. riverine inputs).

The management trigger will only be considered to have been exceeded if the results of the inference assessment indicate that turbidity-generating activities associated with trunkline installation have contributed to or caused each daily exceedence of intensity of the trigger.

6.4.1.3 Coral EPO Assessment

This section includes the objective of the coral EPO assessment monitoring, description of the monitoring variables and details how data will be collected. It also provides an overview on the preferred statistical approaches to evaluate the monitoring data to help facilitate interpretation.

Objective

The objective of the Coral EPO Assessment is to provide data that will assist in determining whether the coral EPOs specified in Condition 8-7 (vi)[15] are being achieved.

[15] Due to the definition of ‘no irreversible loss of, or serious damage to’ condition 8-7 (iii) will only be assessed at the post-development surveys.

Timing

The Coral EPO Assessment will occur:

1) In the event that a Level 3 water quality trigger is exceeded as a result of turbidity-generating activities associated with trunkline installation; and

2) At the mid-term of marine works and post development activities[16] (described in the State of the Marine Environment Baseline SoW document; Chevron 2012a).

Variables

Since the coral EPOs described in Condition 8-7 (vi) is stated in terms of a change in live coral cover, the primary variable that will be examined during the Coral EPO Assessment will be change in percent live coral cover. However, during image processing (see Image Processing Section below), a wide range of abiotic categories (such as sediment cover, bare substrate etc.) and biological stressors may also be scored to assist in inferring the cause of any detected change in live coral cover. Each of these parameters will be available for quantitative, semi-quantitative, or qualitative assessment. These data, along with the water quality data and MODIS satellite imagery, will assist with interpreting any potential change in coral cover that might be detected to determine if the change is 'real' or simply an artefact of sampling and low coral cover, and to infer the cause of any detected change.

Sampling approach and image processing

The Coral EPO Assessment will utilise the same data collection and image processing method as the baseline coral monitoring programme (detailed in the following sections).

Sampling design

Multiple reference and impact reefs will be monitored, both before and after the commencement of turbidity-generating activities associated with trunkline installation. An asymmetrical design may be used, which is sub-optimal for inferring causation because the impact effect at the reef could be confounded by a natural change specific to that reef (due to the lack of impact reef replication). For this reason, a structured decision making framework, using a number of approaches, will be required to rigorously assess whether the detected change at an affected reef was due to turbidity-generating activities associated with trunkline installation or simply the result of natural change.

Another important aspect of the sampling design is that one or more sites will be sub-sampled per impact reef formation, depending on its size. This is to reduce site level effects confounding reef level effects and to better understand the spatial scale of observed change. For the purposes of the Coral EPO Assessment, the reef is the biological unit of interest. Sites within reefs will be sub-sampled using replicate transects and then averaged to estimate the level of change within a reef.

Level of replication

During baseline, five transects were sampled per site per reef. Prior to the major decline in coral cover during 2011, this level of replication provided a high level of power for the proposed statistical test. Effect sizes of 10–15% change in baseline live coral cover could be detected with high certainty. Cover of coral in the Project area is now low and spatially variable, making it very difficult to obtain precise measurements of change based on this level of replication. For example, low levels of coral cover (e.g. <2%) is within error terms

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[16] This has been defined under the SoW and will be undertaken under the SoW as detailed in Section 1.6.

routinely associated with the monitoring and statistical analysis techniques (Stoddart et al. 2005). Thus, there is limited benefit in attempting to assess whether coral EPOs are being achieved based solely on the results of statistical tests. Tests of power conducted using coral cover estimates returned from recent surveys of targeted monitored reef formations show that the baseline monitoring methods return a power of less than 0.4 to detect a 30% decline in coral cover for reefs with less than 5% cover (the majority of Wheatstone Sites had less than 5% coral cover as of June 2012), refer to Table 6.6. Based on these results, a considerably greater effects size, possibly in the order of 80–100% change, would be required to achieve a test with a power of 0.8. As approved by the CEO on 27 November 2012, the power will range from 0.05 to 0.8 subject to the additional analysis detailed in the following paragraphs. Nevertheless, during turbidity-generating activities associated with trunkline installation the level of replication used to sample an affected reef following a Level 3 exceedence will be increased, where practicable. The major limitations to greatly increasing the level of replication to achieve greater power is the small size of many of the monitored reef formations present an elevated risk of transects overlapping and not being considered independent sources of data, which is an important assumption of inferential statistical approaches.

Table 6.6: Power Calculations for Two Effect Sizes: 30% and 10% Declines Based on Data collected during June 2012 (following the 2011 natural mass mortality event)

Site	Zone	Region	% coral cover	Power to detect 30% decline	Power to detect 10% decline
Gorgon	NA	Mid Shelf - East	11.1	0.65	0.2
Saladin	NAI	Mid Shelf - West	4.1	0.34	0.13
Ashburton	ZoI	Mid Shelf - West	7.3	0.54	0.15
Direction	NA	Mid Shelf - East	5	0.41	0.14
Roller	NA	Inshore	5.8	0.41	0.14
Weeks	NA	Mid Shelf - East	5.9	0.42	0.12
Ward	NA	Inshore	1.9	0.22	0.09
Hastings	NA	Mid Shelf - West	0.9	0.15	0.09
Paroo	ZoI	Mid Shelf - West	4.7	0.37	0.12

Process for supporting or refuting the dredge impact hypothesis following an exceedence of a Level 3 water quality trigger

A comprehensive and transparent framework for decision-making is required to assess coral cover following a Level 3 water quality exceedence. This process includes two main steps:

1. Step 1: Accumulation and analysis of evidence.
2. Step 2: Submit findings and conclusion to EPA, DotE and DTAP.

Step 1 is summarised in Table 6.7. Up to six evidence types (A to F) may need to be examined and discussed in a formal reporting form (or proforma) to be submitted to the EPA, DTAP and DotE. The proforma will also contain evidence supporting or rejecting the overall conclusion of whether turbidity-generating activities associated with trunkline installation were reasonably expected to have caused or contributed to the observed decline at the affected reef.

Figure 6.10 illustrates, in chronological order, the steps, as listed in Table 6.7, to provide a holistic assessment of the EPO at an affected reef following an exceedence of Level 3 trigger. The first step is a formal statistical test of gross decline in coral cover at the affected reef. If there had been a decline in coral cover this is followed by a similar test, but of net change (i.e. factoring in change in cover that occurred concurrently at reference reefs). The next step is an assessment of the magnitude of change (effect size +-CI) in coral cover between the affected reef and reference reefs, from before turbidity-generating activities associated with trunkline installation to the current survey period (that is, whether the difference in coral cover between the affected reef and the reference reefs had increased or remained consistent since trenching and backfill commenced). Following this is a comparison of trends in mean coral cover through time will be compared among the affected reef and reference reefs. The fifth step is an inference assessment which includes the collation and synthesis of all available circumstantial evidence supporting or refuting the conclusion that either turbidity-generating activity associated with trunkline installation or a natural agent of disturbance resulted in an observed decline in coral cover, if recorded, at the affected reef. Data accumulated via the verification monitoring programme will also be used to support the inference assessment. The final step is the formulation of a conclusion of whether the EPO is being achieved or not achieved as a result of turbidity-generating activities associated with trunkline installation based on a holistic assessment of all analyses and investigations. A report will then be submitted to the EPA, DotE and DTAP containing the conclusion and all supporting evidence.

Table 6.7: Step 1: Accumulation and Analysis of Evidence

	Method to obtain evidence	Description and notes	Interpretation
A	T-test: Before versus after test of change at impact site.	Formal test of a null hypothesis (e.g. no difference between affected reef at time 'x' during dredging compared to baseline). If more than one test is required per assessment period, a correction factor will be applied to limit the risk of an inflated Type I error rate.	If not significant = unsupportive of impact hypothesis.
B	T-test: Test of net change at impact site (i.e. change at impact site versus changes at reference sites).	As above, but this test factors in change measured at the reference reefs.	As above
C	Estimate effect size and its Confidence Interval (CI).	The purpose of this method is to compare the effect size (the difference between affected reef and the reference reefs) before dredging with the effect size after dredging. A CI approach, like this, provides important information for decision-making not gained from a test of a null hypothesis (Evidence Step A and B). A CI approach focuses on the magnitude of change, with some measure of uncertainty. Walshe et al. (2007) also stated that a CI approach has the advantage of communicating the key elements of statistical power without being constrained to a dichotomous decision making framework. For example the width of the CI is influenced by the sample size, variability of the variable being measured and the degree of confidence required. The other element of power analysis (the effect size) can be illustrated graphically.	Larger mean effect size (+-CI) following dredging map provide evidence supportive of the dredge impact hypothesis.
D	Trend analysis	The purpose of this approach is to compare temporal trends in coral cover estimates (mean +-CI) at the affected reef, from before to after the start of dredging. This is also compared with the average trends of the reference reefs.	Evidence supportive of the dredge impact hypothesis would be a decline in cover at the affected reef following dredging, but no decline at the reference reefs.
E	Inference assessment	This approach is used to facilitate inference when the	Refer to Table 6.8

	Method to obtain evidence	Description and notes	Interpretation
		sampling design is sub-optimal (Downes et al. 2002). It uses multiple lines of evidence, based on causal criteria, to assess the impact hypothesis.	
F	Verification monitoring (see Section 6.4.2)	This monitoring is carried out routinely (every three months) and in the event of a Level 2 trigger being exceeded. Data from this monitoring will be used to support the interpretation of results from the Coral EPO Assessment.	Refer to Table 6.11 Increase levels of sediment accumulation on live corals at the monitored reef formation, relative to the reference reefs, would be supportive of the dredge impact hypothesis.

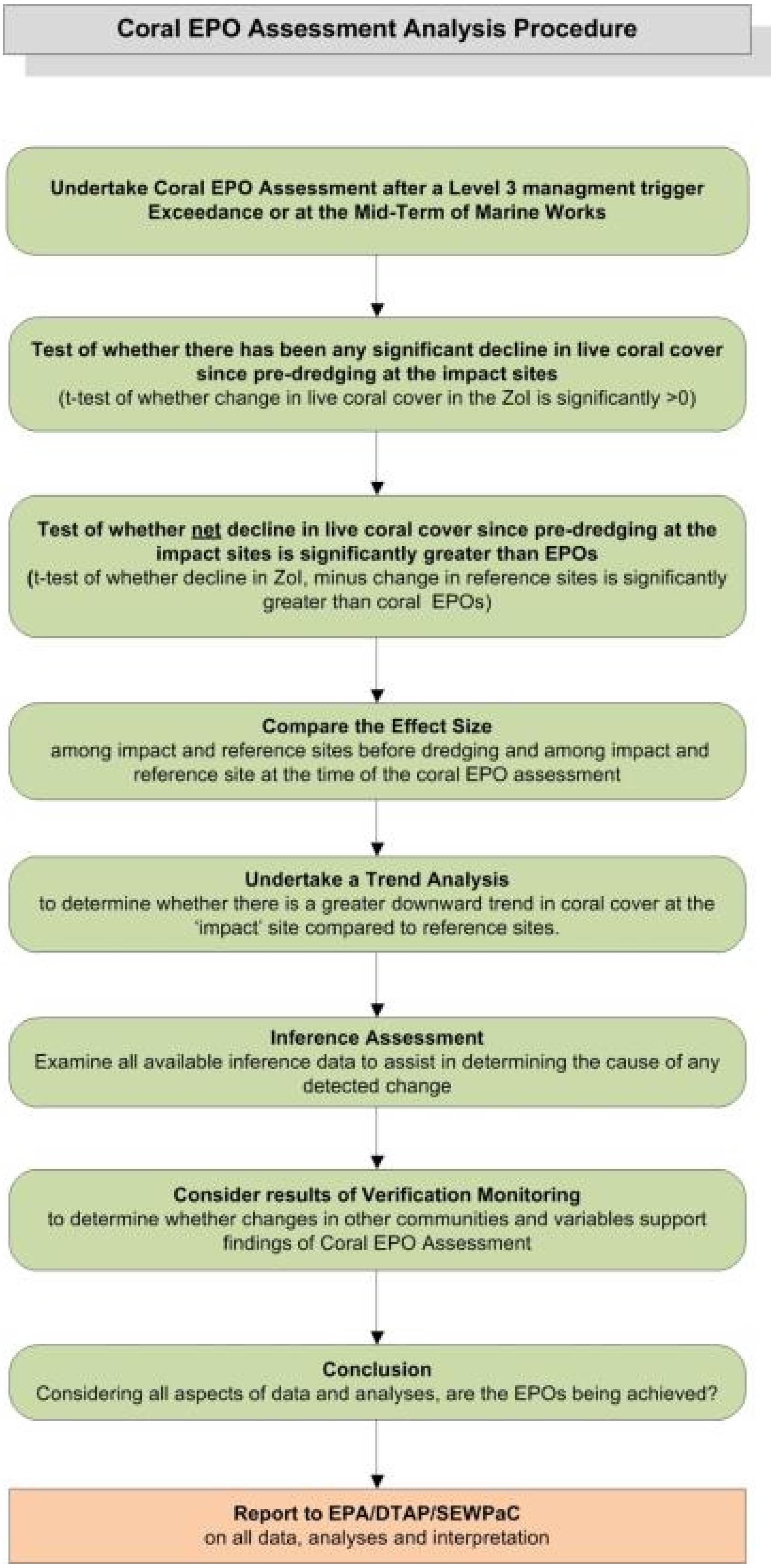

Figure 6.10: Coral EPO Assessment Analysis Procedure

Inferring the cause of the detected change

The sampling design is the primary framework for inference in ecological monitoring (Underwood 1997). An optimal sampling design for impact assessment includes sampling before the start of a disturbance, at replicate impact and reference reefs, and at these same reefs after the start of disturbance. Reference reefs are used to separate trenching and backfill related impacts from those caused by natural disturbance (e.g. thermal stress, predation; freshwater discharge; cyclones). Unfortunately, sampling design in impact assessment is generally sub-optimal because there may be one impact site and limited baseline or few reference reefs that are ecologically comparable to the impact reef. Fortunately, when a sampling design is sub-optimal, other methods can be employed to facilitate inference such as lines of evidence.

With the lines of evidence (Downes et al., 2002; McArdle, 1996; Suter, 1996; Beyers, 1998; Fabricius and De'ath, 2004), inference is developed based on carefully structured arguments. This approach has been used successfully in disciplines where manipulative experimentation is unlikely for ethical reasons; such as assessing the effects of diseases on humans, or when impact sampling designs are sub-optimal (e.g. lack of suitable reference sites). Its formal use in ecological impact assessment is relatively recent (Beyers 1998; Downes *et al*. 2002; Fabricius and De'ath 2004). Hill (1965) categorised different types of causal argument into nine criteria for studies into the effects of diseases on humans. Table 6.8 lists each of Hill's causal criterions and how they relate to ecological impact assessment. With lines of evidence there is a need to seek evidence not only to support the impact prediction, but evidence to rule out plausible alternative predictions, such as that the observed difference was due to natural processes (Beyers 1998; Downes *et al*. 2002).

Table 6.8: Hill's Causal Criteria and Description in the context of Ecological Impact Assessment (sensu Hill 1965 and Downes et al. 2002)

Causal criterion	Description (as per Hill 1965)	Description (as per Downes et al. 2002)
Strength of association	A large proportion of individuals are effected in the exposed area relative to reference areas	A particularly large change in the response variable is observed
Consistency of association	The association has been observed by other investigators at other times and places	The expected effect on the response variable is observed (may be redundant with Strength of association)
Specificity of association	The effect is diagnostic of exposure	The data are observed
Temporality	Exposure must precede the effect in time	The expected change in the response variable occurs after the onset of human activity
Biological gradient	The risk of effect is a function of magnitude of exposure	A dose-response relationship is observed (if a gradient design is used)
Biological plausibility	A plausible mechanism of action links cause and effect	The study at hand meets any requirement for the hypothesised mechanism to apply
Experimental evidence	A valid experiment provides strong evidence of causation	The predicted effects from the experiments are observed to occur in the human impact study
Coherence	Similar stressors cause similar effects	
Analogy	The causal hypothesis does not conflict with existing knowledge of natural history and biology	The predicted effect is observed

A strength of the lines of evidence approach is that it provides a highly structured method of facilitating inference, particularly in situations when an optimum sampling design cannot be implemented (Beyers 1998; Downes et al. 2002). Fabricius and De'ath (2004) also argued that it is transparent and easy for decision makers to understand. A weakness of this method is that the evidence is circumstantial because it is based on correlations (Downes et al. 2002), which does not necessarily imply causation. Proponents acknowledge that each causal argument is weak independently, but argue that when combined may provide strong support for a conclusion (Downes *et al*. 2002). However, rarely will all criterion, listed in Table 6.9, be useful for any one monitoring programme. The criterion *specificity of association* will, for example, not apply unless the assessment relates to an activity that has a unique effect in the environment and the criterion *temporality* will be useful only if monitoring commenced prior to the start of a disturbance.

There are a number of potential causes for impact within the study area and the lines of evidence approach consider each of these and its likelihood of occurrence. Table 6.9 lists the potential causes of impact, their risks and likelihood and how each one will be considered. Each of these potential causes of impact is investigated to determine the likelihood that any observed change in coral health is due to the trenching or backfill activities or natural disturbance. This step in the process enables an approach to be taken which has multiple lines of evidence which complement each other to provide greater certainty of effect. By considering other potential sources of impact it enables greater confidence in the determination of causal effect.

A number of factors are relevant to the likelihood and level of severity of an impact occurring, including existing stress levels, age, size and health status of colonies, associated biota and adaptations to localised conditions. For example, during the inference assessment it is important to consider that in certain localised areas there may be stress causing factors acting on the corals which may not be at a sufficient level to cause mortality but could make the corals more susceptible to a lower level of TSS increases that otherwise may not have had an impact.

The inference assessment also needs to consider the difference in physical characteristics between reference reefs and impact reef formations and how this could affect the scale of effect observed between the corals. For example, the depth of water that the coral are living in could affect the scale of impact, as shallower water is likely to increase the effects of thermal bleaching. All aspects of the causal effect should be considered to determine whether any exceedence is due to trenching or backfill or another factor.

Table 6.9: Potential Impacts to Coral and their Risks and Likelihood

Potential Impact	Likelihood of Occurrence	Consequence of impact and scale of effect	Monitoring
Thermal Bleaching	High	Severe	Temperature recording via water quality loggers Evidence through surveys
Natural Mortality	High	Mild	Evidence through survey and type of impact evident at localised sites
Pollution Incidents (including nutrient enrichment)	Medium	Mild - Severe	Not applicable but engagement will occur with other stakeholders
Localised predation (corals only)	High	Mild - Medium	Monitoring of percent cover of transects in coral reef monitoring sites to identify signs of predation
Cyclones – direct damage	High	Severe	Weather reports together with monitoring of transects
Cyclones – indirect smothering	High	Medium	As above plus water quality loggers
Salinity Change	Low in general area but medium close to Ashburton River	Mild	Salinity recording via water quality loggers
Ship propeller disturbance – increases in TSS	Low generally – but medium in shallower water	Medium	water quality logger information
Other dredging campaigns in the area – capital or maintenance	High for trunkline - possibility for maintenance of existing navigation channel	High	Awareness of other schemes - water quality loggers should record any cumulative plumes

During the inference assessment, data on a number of variables will be considered, to provide a weight of evidence as to whether or not trunkline installation activities were reasonably considered to cause or contribute to the impact. The consideration would include whether the impact is strongly linked to trenching or backfill activities, shows no link, or the assessment is inconclusive.

Table 6.10 shows the causal criteria that would be considered during the assessment of evidence approach to assess whether an impact is due to trenching, backfill or other activities.

Table 6.10: Causal Criteria and Assumptions

Causal Criterion	Criteria and assumptions	Evidence supportive of dredging impact	Evidence unsupportive of dredging impact or evidence is inconclusive
Timing of impact	Exposure must precede the effect in time Greatly elevated turbidity and sedimentation associated with dredging is a potential source of mortality	The abundance of bleached, dead and or smothered coral at the monitoring sites increased after exposure to increased levels of turbidity or sedimentation from the dredging activity (linked to water quality thresholds). Reference sites (if available) showed no similar effects.	The impacts on coral occurred prior to exposure to increased levels of change in water quality or sufficiently long after to reject any lag effects (relate to water quality thresholds). <u>Thermal Stress</u> Coral show a response linked to an increase in temperature shown on the temperature loggers. The impacts will be generally widespread but may be more prevalent in shallower water where temperatures and light intensity are likely to be higher. <u>Freshwater Discharge</u> Impacts occur (generally in nearshore areas only) soon after increased rainfall and storm conditions. <u>Storm Event</u> Physical damage and/or smothering to coral following storm event.
Biological Gradient	The risk of effect is a function of magnitude of exposure (i.e. there is a strong relationship between dose and effect) and distance	The proportion of stress or mortality observed at sites decreases with increasing distance from the dredge or disposal site. Impacts are not observed in the reference sites (if available).	The proportion of individual coral (e.g. colonies) exhibiting signs of stress or mortality did not show any pattern relating to proximity to the dredge site. <u>Thermal Stress</u> Stress and/or mortality occurred at random or widespread sites not linked to distance from the dredge, including at reference sites. <u>Freshwater Discharge</u> Coral show a greater impact close to the source of freshwater input (i.e. close to the Ashburton River mouth). <u>Pollution Event/Disease/Predation/Grazing</u> Highly localised impact within impact site or reference site. Signs of damage to surrounding habitats. Evidence of predators, including feeding scars. <u>Storm Event</u> Generally widespread impact but

Causal Criterion	Criteria and assumptions	Evidence supportive of dredging impact	Evidence unsupportive of dredging impact or evidence is inconclusive
			could show increased localised effect in exposed/shallower areas.
Duration, intensity and frequency of exposure	The length of time that coral is exposed to increased levels of TSS or sedimentation influences the level of response	Sites which have been exposed to longer durations of high exposure (following analysis of water quality data) have suffered higher losses. Water quality thresholds have been exceeded at the site showing impacts but have not exceeded at sites where no impact is observed.	Sites exposed to longer durations of higher exposure show lower losses indicating that another causal factor could be responsible for the impact Water quality thresholds have not been exceeded at the site showing an impact to coral health.
Experimental Evidence		The observed effects were predicted at some level during the impact assessment phase. The impacts correspond with the results of modelling predictions. The sedimentation shown at the site through the monitoring relates to material that could have been moved to the site. This is verified using the hindcast modelling. MODIS imagery shows a clear evidence of a plume in the areas impacted.	The observed effects are not known to occur as a result of dredging during previous schemes. The modelling does not predict increases in TSS at the site experiencing stress and/or mortality. The sedimentation shown at the site through monitoring is coarse material that is unlikely to have been moved to the receptor site from the dredge location. The MODIS imagery does not show plumes reaching the impacted sites during or preceding the impact.
Strength of Association	A ‘particularly large’ change in the response variable is observed	An appreciably large amount of dead and smothered coral within the ‘active plume’ area. The proportion of dead to live coral is higher than would be expected following natural change. No unusual natural events occurring in the preceding period, i.e. cyclones.	No or very low level of dead or smothered coral. Impact severity and distribution could be linked to a periodic or unusual natural or anthropogenic event (i.e. pollution event).
Wider Habitat Change	Changes to corals relating to increases in TSS levels and sedimentation are likely to have similar impacts on	Impacts which could be attributed to dredging (i.e. smothering, light deprivation) can also be observed on habitats and species within the reef system.	There are no impacts on adjacent habitats within the reef system which would indicate dredging related changes.

Causal Criterion	Criteria and assumptions	Evidence supportive of dredging impact	Evidence unsupportive of dredging impact or evidence is inconclusive
	other coral in the surrounding area		

6.4.2 Verification Monitoring Programme

Water quality criteria have been derived using the most recent and relevant information available, based largely on predictive relationships between water quality and coral health developed from the Gorgon Marine Monitoring Programme. To verify that derived water quality criteria afford the appropriate level of protection to benthic communities, a water quality criteria verification monitoring programme (hereafter 'Verification Monitoring Programme') will be utilised to investigate the appropriateness of water quality criteria and to adapt or revise these, if appropriate.

It should be noted that data from the Verification Monitoring Programme <u>will not be used</u> to assess achievement of the EPOs, for the following reasons:

- The benthic communities being investigated are very low in cover (e.g. corals, seagrass) or highly variable (e.g. seagrass, macroalgae) and prone to a high level of natural change. In order to be able to reliably infer the cause of any detected change requires either i) a long-term dataset to examine trends at the impact site compared to that of reference sites (i.e. EPO assessments will be undertaken at the mid-term of marine works and post-development when a long-term dataset is available to assist in interpreting any detected changes) or ii) a definitive pressure on benthic communities that would reasonably be considered to elicit a response (i.e. coral EPOs will also be assessed in the event of a Level 3 water quality trigger exceedence).
- Verification Monitoring focuses on a range of indicators including those designed to detect early signs of biological stress, such as partial coral mortality or sediment accumulation on corals and other sessile organisms. The EPO Assessment Monitoring focuses principally on measuring changes in coral cover, described in Condition 8-7. While indicator variables included in Verification Monitoring cannot be used to assess the EPOs directly, they will be helpful in interpreting change in coral cover during EPO assessments.

This section includes the objectives of the verification monitoring, description of the indicator variables and details how data will be collected. It also provides an overview on the preferred statistical approach to evaluate the monitoring data to help facilitate interpretation. Lastly, it describes what will occur in the event that monitoring indicates water quality criteria are not accurately offering the appropriate level of protection for hard corals, filter feeders, macroalgae and seagrass.

6.4.2.1 Objectives

The primary objectives of the verification monitoring programme are twofold:

- To provide a feedback mechanism to assess whether water quality criteria and management triggers are affording appropriate levels of protection to coral, filter feeders, macroalgae and seagrass; and
- To assist in revision of water quality criteria, if appropriate, by evaluating benthic communities and other available data sources when applicable.

6.4.2.2 Timing

As approved by the CEO of the OEPA, on 27 November 2012, monitoring of biological indicators to inform adaptive management will occur at the following times:

1) Routine Verification Monitoring: Approximately quarterly at all monitored reef formations (Figure 6.5) and at the non-reef sites (See Section 7.2.1 and 7.3.1; Figure 7.2) that are deemed to be ‘at risk’ from trenching and backfill activities, as well as reference reefs; and

2) Responsive Verification Monitoring: Following a positive finding that trenching and backfill activities have caused a Level 2 management trigger to be exceeded, monitoring will be undertaken at the affected monitored reef formation(s) and associated reference reefs (Figure 6.5) and/or at the non-reef sites (See Section 7.2.1 and Section 7.3.1; Figure 7.2). The first survey will occur within approximately two weeks, weather permitting, following the determination of the management trigger being exceeded and the 2nd survey will follow two weeks (weather permitting) after the first survey. A total of two surveys will be conducted following each set of events that led to Level 2 management triggers being exceeded.

6.4.2.3 Verification indicator variables

The verification monitoring programme focuses on the capture of images of benthic quadrats along transects at the monitored reef formations and non-reef sites. Given the low and spatially variable cover of hard coral, seagrasses, and filter feeders, a single variable (e.g. percent cover) on its own may not be sufficient to adequately verify the effectiveness of water quality criteria. However, data on a range of variables, interpreted together, may collectively be useful to inform or validate criteria and determine whether water quality criteria are providing the required protection for benthic communities.

Currently, there is limited consensus on which coral, seagrass, filter feeders and macroalgal indicators are best placed to assess potential impacts from changes in water quality. There are few studies from which to make a robust choice as to the most reliable variables to indicate change in water quality (De’ath and Fabricius 2008), especially in relation to non-corals. To assist with interpretation, Cooper and Fabricius (2007) recommended that indicators have one or more of the following characteristics: the variable should provide some level of response specificity so that the change in the variable could be related to a dose/response relationship; and the change in the variable through time should be low in the absence of a disturbance. Other important considerations are that the indicators are easy to measure and are biologically relevant (Cooper and Fabricius 2007).

A list of coral, seagrass, filter feeders and macroalgae indicator variables to be used initially to verify the water quality criteria during the trenching and backfill programme are provided in Table 6.11. The indicators in Table 6.11 are to be used initially because additional variables may be included at a later stage, while other initially identified may be removed as new knowledge about their reliability is gained via the monitoring programme and the peer-reviewed literature or if they become too variable to describe meaningful changes.

The following two types of indicator variables were adopted:

- Those that will potentially indicate change during or soon after exposure to water quality levels predicted to cause a negative biological response in coral, seagrass, filter feeders and macroalgae; and
- Those that may measure cumulative effects over longer periods of time (Cooper and Fabricius 2007).

Table 6.11, column 2 provides justification for the choice of these indicators, while acknowledging that the utility of some of these variables as reliable predictors of water quality effects to coral, seagrass, filter feeders and macroalgae have not been conclusively demonstrated in the Pilbara. Table 6.11, column 3 briefly describes how change in each variable might be interpreted based on observations of trends through time. Given the uncertainty as to how some of these variables might change naturally through time in response to a range of biotic and abiotic factors, it is unlikely that any single variable can be used to make a decision in relation to the success or otherwise of the water quality criteria. Instead, this section describes how the changes in a range of indicator variables will be described to make a more holistic interpretation of the validity of water quality criteria.

Table 6.11: Coral, Seagrass, Filter Feeders and Macroalgae Indicators that will be used initially to verify Water Quality Criteria

Indicator variables	Justification	Change/trends that would contribute evidence of change attributable to dredging	Source
Corals			
Coral assemblage structure	Coral assemblage structure is known to respond to changes in water quality.	Shift in assemblage structure at impact reef relative to baseline and reference reefs	e.g. Brown *et al*. (2002)
Percent Cover	Percent cover is known to respond to changes in water quality. This variable is potentially useful for assessing change over the long term.	Negative (decreasing) trend in cover, relative to baseline and reference reefs	
Increase in level of partial mortality of randomly chosen colonies	Partial mortality is a known response to changes in water quality. This variable is potentially useful for assessing change over the medium to long term	Positive (increasing) trend in partial mortality, relative to baseline and reference reefs	e.g. Nugues and Roberts (2003) Gorgon data
Mucus production in *Porites*	*Porites* and other corals are known to shed sediment using mucus. Variable potentially useful for assessing change over the short to medium term.	Positive (increasing) trend in the proportion of *Porites* colonies showing evidence of significant mucus production relative to baseline and reference reefs	Gorgon data
Sediment on	Corals can reject	Positive (increasing) trend in the	e.g. Gilmour *et*

Indicator variables	Justification	Change/trends that would contribute evidence of change attributable to dredging	Source
living corals	sedimentation, but sedimentation may accumulate on living corals if coral is overwhelmed. Variable potentially useful for assessing change over the short to medium term.	proportion of colonies showing evidence of sediment accumulation on living tissue relative to baseline and reference reefs	*al*. (2006)
Filter feeders			
Percent Cover	Percent cover is known to respond to changes in water quality.	Negative (decreasing) trend in cover, relative to baseline and reference location.	
Sediment on sponges	Sponges can potentially reject sedimentation, but sedimentation may accumulate on sponges if overwhelmed.	Positive (increasing) trend in the proportion of colonies showing evidence of sediment accumulation on living tissue relative to baseline and reference location.	
Macroalgae			
Percent cover	Percent cover is known to respond to changes in water quality.	Negative (decreasing) trend in cover, relative to baseline and reference location (if available).	
Seagrasses			
Percent Cover	Percent cover is known to respond to changes in water quality.	Negative (decreasing) trend in cover, relative to baseline and reference locations (if available).	
Plant or leaf density	Plant density will potentially respond to changes in water quality.	Negative (decreasing) trend in cover, relative to baseline and reference locations (if available).	

In addition to percent cover and leaf density, additional seagrass variables that will be considered for inclusion in the assessment are C:N:P ratios and above ground biomass. These will be considered in consultation with subject matter experts.

During image processing (see *Image Processing* section below), a wide range of abiotic categories (such as sediment cover, bare substrate etc.) and biological stressors may also be scored. Each of these parameters will be available for quantitative, semi-quantitative, or qualitative assessment. These data, along with the water quality data and MODIS satellite imagery, will assist with interpreting change in coral condition to inform the verification assessment.

In addition to the above parameters, benthic light availability data (measured as PAR every 30 minutes) will be collected at all monitoring sites and used to provide information for inference assessments or as additional lines of evidence. Data will be:

1. Compared with predicted minimum light requirements of seagrasses, macroalgae and filter feeders; and
2. Correlated with temporal changes in the abundance of benthic communities to develop a better understanding of the relationship between light levels and abundances of biota.

6.4.2.4 Data Collection

Reef formations (coral, macroalgae and filter feeders)

The verification monitoring programme will utilise the same survey methods as the baseline benthic community monitoring programme to provide consistent data over a long period of time to investigate temporal trends. The survey method has the following characteristics:

- Data are collected via a ROV
- Five random transects are surveyed per site
- Length of transect is approximately 30 m to 50 m
- Up to 300 images are taken at each site from which approximately 150 images are analysed (based on an objective list of criteria, such as sharpness of the image), i.e. 30 images per transect are retained for analysis
- Size of images collected is approximately 75 cm x 50 cm.

Image Processing

Each image is scored for a variety of habitat categories (such as seagrasses, sponges, soft corals, etc.) and abiotic categories (such as sediment cover), sub-lethal indicators of stress (such as mucus production, bleaching, and the pattern of mortality which includes partial versus total mortality of individual corals and other sessile organisms when applicable).

In relation to hard corals, partial mortality of a sub-sample of coral colonies within frames can be estimated. Differences in the level of partial mortality or partial sediment cover of colonies can be compared between potential impact sites and reference reefs to determine whether any net change has occurred that may provide verification of the appropriateness of water quality criteria. Coral colonies will be chosen from images for partial mortality analyses using definitions modified from Nugues and Roberts (2003). Colonies chosen for analyses will be defined as an autonomous mass of skeleton with living tissue. As such, a colony divided by partial mortality or morphological characteristics into separate patches of living tissue, but located on the same mass of skeleton, will be considered to be one colony. Colonies with more than 50% of their surface area lying outside of frames will not be included in partial mortality analyses.

Partial mortality will be defined as areas of bare and algal-covered skeleton present on the colony surface or areas covered in other organisms (e.g. sponges) or a layer of sediment. It is important to distinguish however, between perceived and realised partial mortality when corals are overlain with sediment. It has been demonstrated in previous studies (e.g. the Gorgon Marine Monitoring Programme) that sediment overlying coral colonies may be subsequently removed through water movement (e.g. wave action), and providing this sediment has not overlain the coral for beyond a critical period of time (e.g. several weeks), the removal of sediment may reveal live tissue underneath, with no subsequent ‘realised’ mortality.

Non-reef sites (seagrass and filter feeder habitats)

Two sampling cells or grids (~500 m x ~500 m) will be located in a seagrass and filter feeder area immediately adjacent to loggers shown in Figure 7.2. Within each cell, benthic habitat data were gathered along five randomly-oriented ~100 m transects. Towed video, based on oblique and downward-facing cameras, will be used to survey transects. Transects, as the smallest unit of measure, will be used to record:

- Distribution of specific habitats along a transect (proportion of habitat type present) quantified from imagery
- Within habitat sections, approximately ten downward still images will be selected randomly for point count scoring (% cover of habitat)
- Random points will be overlain on each still image selected and the substrate type classified beneath each point to estimate percent cover.

In addition, two fixed transects, placed perpendicular to the trunkline, will be surveyed to assess change in sessile benthic communities along a gradient of increasing distance from the centre of the trunkline (Figure 6.11). The two transects extend perpendicular approximately 2 km from the trunkline, thus traversing the DDF, the ZoHI, ZoMI and into the ZoI. Transects are in water depths ranging from approximately 8 m to 13 m and some sections of the transects are in close proximity to existing water quality loggers. One transect has been placed predominantly in filter feeder habitat and the other predominantly in seagrass habitat. However, the marine environment off Onslow can be more accurately characterised as a mosaic of seagrass, filter feeder and/or macroalgae communities of varying proportions, thus transects traverse a range of biota and habitat types and data on all of these types will be collected where they occur. Transects will be sampled using towed camera or similar approach. Cover estimates for biota types will be presented for individual transects or for both transects (averaged) and presented for the DDF, ZoHI, ZoMI and ZoI. Data will be presented in graphs to show the relationship between cover estimates and distance from source of impact.

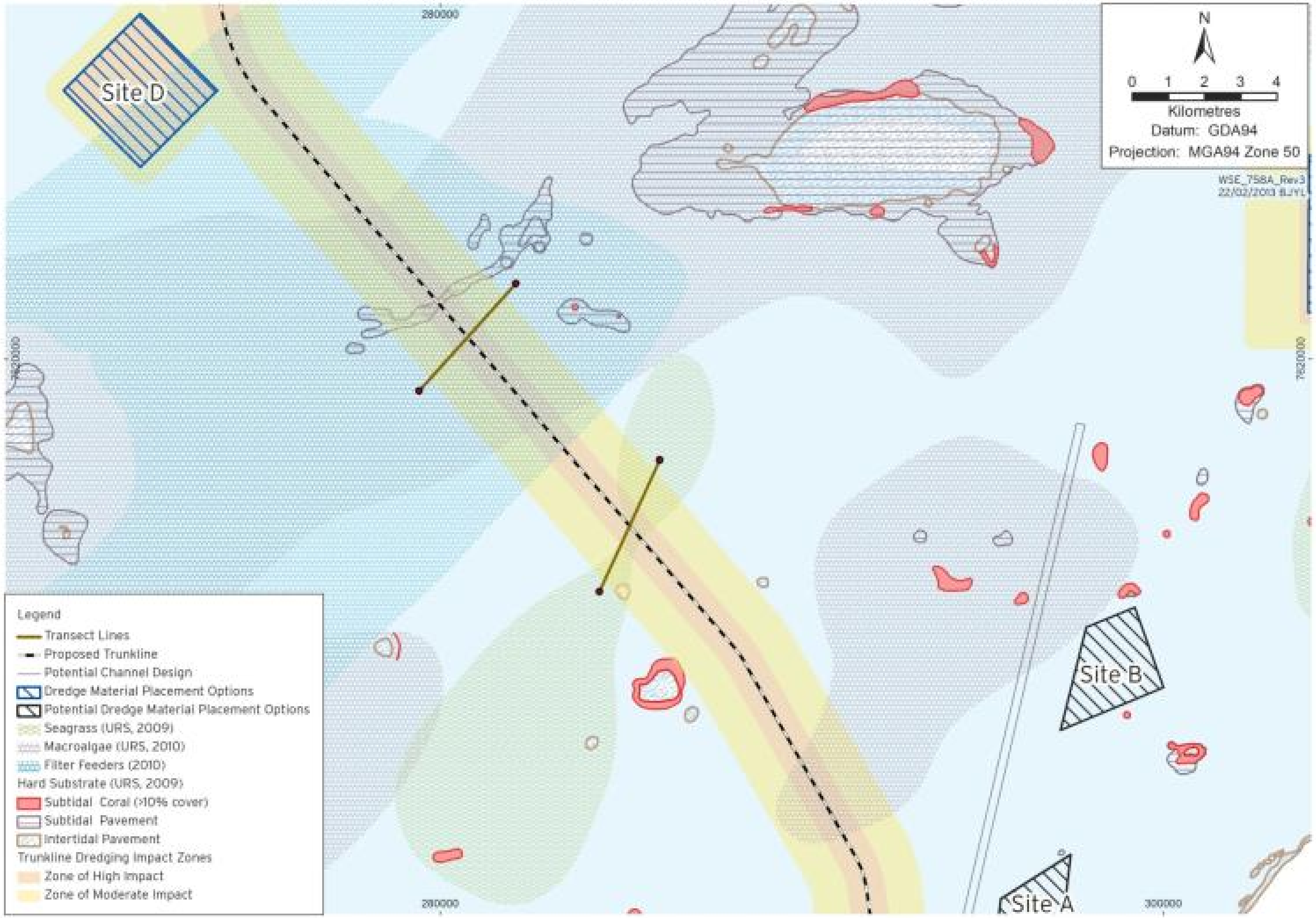

Figure 6.11: Location of transects to be sampled

Inferring the cause of the change

Consistent with monitoring described for coral in Section 6.4.1.3 verification monitoring used to assess whether water quality criteria are affording protection to benthic communities will also use a lines of evidence approach to help infer the cause of any observed changes. Table 6.10 shows the causal criteria that would be considered during the assessment of evidence approach to assess whether an impact is due to trenching, backfill or other activities for all benthic communities. The impact inference criteria shown in Table 6.12 are used to help interpret change in non-coral benthic communities. For brevity, Table 6.9 is not repeated in this section. However, in addition to those criteria shown in Table 6.9, localised grazing of seagrasses and macroalgae should also be considered when interpreting temporal changes in non-coral communities.

Table 6.12: Potential Impacts to Benthic Communities and their Risks and Likelihood

Potential Impact	Likelihood of Occurrence	Consequence of impact and scale of effect	Monitoring
Localised grazing (seagrass and macroalgae)	High	Mild-High	Monitoring of seagrass and macroalgae percent cover to identify signs of predation
Refer to Table 6.9 for the full list of potential impacts to benthic communities			

6.4.2.5 Sedimentation Monitoring

The main objective of monitoring sedimentation rates is to assist in understanding potential impacts of trenching and backfill activities on sedimentation regimes at monitoring reef formations, and to infer potential impacts on benthic communities. It is likely that permanent sedimentation impacts to benthic communities, if any, will only occur in areas within close proximity to trenching and backfill activities where there is deposition of coarse sediments. Finer sediments may deposit on benthic species and habitats at greater distances from the trenching activity. However, much of this finer material is likely to resuspend during water movement associated with tides, wind and wave action, but some may remain in place for periods of time that could cause impacts on benthic species. Sedimentation monitoring is therefore required to provide evidence of whether potential impacts within these areas were caused by trenching, backfill or other factors (i.e. natural resuspension of sediments during storms).

Objectives

The sedimentation monitoring programme has been established to provide gross sedimentation data at the monitored reef formations. This extensive set of data will assist investigations into trends in sediment accumulation on a spatial and temporal scale on the seabed adjacent to the reefs. The specific objectives of the monitoring programme are:

1. To deduce potential dredge-related impact following a management trigger exceedence and identify possible causes (e.g. project attributable) by assessing sedimentation as well as other available data sources when applicable; and
2. To assess whether the water quality criteria are affording appropriate levels of protection to benthic communities, according to the intent of the original EPOs and MOs, and assist in revision of water quality criteria, if necessary, by evaluating sedimentation and other available data sources when applicable.

Variables

Gross sedimentation will be measured at the monitored reef formations (outlined in Section 6.4.1.1) throughout turbidity-generating activities associated with trunkline installation, on a six-weekly basis.

Data Collection

Sediment traps will be deployed at the monitoring sites outlined in Section 6.4.1.1 utilising a frame assembly which consists of at least three sediment traps per site. Collection of the sediment trap assembly samples and re-deployment of the cleared traps will occur approximately every six weeks. Similar to the water quality monitoring assemblies, all sediment trap frame assemblies will be deployed adjacent to the coral reef monitoring sites, rather than directly on the reef, to prevent damage to the coral during deployment and retrieval.

Each sediment trap will be constructed to the design criteria in Storlazzi et al. (2011) or other relevant approaches. The multiple trap assembly allows determination of inorganic weight from sediment within two of the traps and particle size distribution (PSD) from sediment within one of the traps for the duration of deployment. The additional trap also serves as a backup should data from one of the traps be erroneous.

Data Analysis

Sediment samples obtained from the sediment traps will be analysed to provide data on the following two variables:

1. Inorganic weight of the material trapped to determine:
   - The rate of sediment accumulation at each specific location over time,
   - The spatial variability of sediment accumulation among the monitoring sites
   - The change in sediment accumulation both temporally and spatially during trenching and backfill activities as compared to the baseline monitoring period.
2. PSD of each sediment sample will be evaluated to determine the percentage of fines in the sample, especially coarse, medium, and fine sand as compared to silt and clay.

Analysis of the above parameters will be performed at an off-site laboratory. The inorganic weight of the sediment sample will be determined by drying/burning off organic material. The PSD of the sample will be ascertained via sieve analysis and additional measurement techniques, such as laser diffraction, may be incorporated, where warranted and requested, to determine a more intensive fines assessment as needed.

6.4.2.6 Water Quality Criteria Refinement

These refinements serve to develop a better understanding of the relationship between BPPH and water quality, especially turbidity, SSC, and sedimentation. Water quality criteria will be reviewed after the first quarterly verification monitoring surveys or exceedence of a Level 2 management trigger, whichever occurs first. Additionally water quality criteria may be reviewed after the following:

- If a decline in benthic communities, from the most recent baseline, is discovered during a routine quarterly or Level 2 management trigger exceedence monitoring survey, and the initial investigation determines this exceedence is due to trenching and/or backfill-related activities, it may be necessary to assess the need to revise water quality criteria.

- If no decline in coral is determined during a coral EPO assessment following an exceedence of the Level 3 management trigger, it may be appropriate to assess the need to revise water quality criteria.
- If verification monitoring or other assessments indicate that chronic and moderate triggers are not affording the required level of protection for benthic communities from acute elevations in turbidity, the requirement for inclusion of an acute trigger will be reviewed.

7.0 SEAGRASS, MACROALGAE AND FILTER FEEDERS MANAGEMENT AND MONITORING

7.1 Background

As described in Section 6.0 subtidal benthic communities that may potentially be affected by the turbidity-generating activities, associated with trunkline installation, includes habitat supporting hard corals, seagrass, filter feeders and macroalgae. This section describes benthic community monitoring to assess EPOs related to seagrass, filter feeders and macroalgae (note that the benthic community monitoring described in Section 6.4.2 relates specifically to verifying the effectiveness of the water quality criteria).

Trenching, turbidity, impacts to seagrasses and macroalgae are predicted to be temporary (EAG No.3 definition: recoverable within five years; EPA 2009) given the habitat is expected to remain unaltered by the turbidity plume and their life history strategies are conducive to rapid recolonisation or regrowth following disturbance. In addition, the abundance of *Halophila* (the dominant seagrass) and *Sargassum* (the dominant algae) in the region are known to be highly variable in space and time independent of human activities. Filter feeders occur but are predominantly located to the north of the impacted area, from trunkline installation activities, in the ZoI. As such, most filter feeders are predicted to remain unaffected by turbidity-generating activities, associated with trunkline installation.

Table 7.1 outlines the approach to managing water quality to achieve the EPO related to seagrass, filter feeders and macroalgae. The EPOs associated with filter feeders, seagrass and macroalgae will be assessed based on the data collected for the Marine State of Environment: SoW.

Table 7.1: Management and Monitoring Measures to Reduce Impacts to Seagrass, Macroalgae and Filter Feeders

Management Area:	**Management of Subtidal Benthic Communities (Seagrass, Macroalgae and Filter Feeders)**
Performance Objective:	To manage impacts from trunkline installation activities to achieve the EPO 8-7 as follows: *The Proponent shall undertake turbidity-generating activities associated with trunkline installation in State waters consistent with the approved Trunkline Route and Infrastructure Plan and ensure that each of the following EPOs are achieved* *i. no irreversible loss of, or serious damage to macroalgal habitats due to the installation of the trunkline* *ii. no irreversible loss of, or serious damage to, seagrass habitat outside of the Trunkline DDF* *iii. a. no irreversible loss of, or serious damage to filter feeder habitats outside of the Zone of High Impact* *iv. no detectible net negative change from the baseline state of seagrass habitats determined by implementing Condition 7, outside of the Zone of High Impact* *v. no detectible net negative change from the baseline state of filter feeder and macroalgal habitats determined by implementing Condition 7, outside the Zone of High Impact and the Zones of Moderate Impact*
Preventative Management:	There is no preventative management for seagrass however the management measures detailed in Section 6.0 for water quality will also afford protection to

Management Area:	**Management of Subtidal Benthic Communities (Seagrass, Macroalgae and Filter Feeders)**
	seagrass, filter feeders and macroalgae.
Monitoring	*Responsive Water Quality Monitoring* Responsive water quality monitoring and associated management triggers will be implemented to manage any potential impacts that increased turbidity may have on seagrass and filter feeders. Water quality measurements will be logged at approximately 30 minute intervals at a seagrass and filter feeder location throughout the duration of the turbidity-generating activities associated with trunkline installation. Water quality monitoring will be achieved through the use of an *in-situ* water quality data logging instrument. Refer to Section 6.4 for further details of the water quality monitoring programme. The results of the water quality monitoring will be: ♦ Assessed against management triggers, as detailed in Section 6.3.2. ♦ Used to assist in inferring the cause of any observed impacts to benthic communities. *Verification Monitoring* Monitoring will consists of: ♦ Quarterly routine monitoring of benthic communities at the non-reef sites (Figure 7.2) to provide verification of the appropriateness of water quality criteria. ♦ Monitoring of benthic communities which will be triggered by an exceedence of the Level 2 management trigger. Monitoring of benthic communities will be at the non-reef sites (Figure 7.2) at which triggers were exceeded. Note: Data collected under this monitoring programme will not be used to assess achievement of the EPOs or MOs. *Habitat Monitoring* ♦ Pre/during/post surveys assessments of seagrass, macroalgae and filter feeders under the State of the Marine Environment SoW.
Responsive Management	**Potential Management Actions** Management measures will be implemented once a Level 2 management trigger is exceeded (see Section 7.2.1), dependent upon the applicability of the measure and the potential for severity of environmental impact. Notably, no change in trenching or disposal operations may be required to reduce potential environmental impacts attributed to the exceedence of the management trigger if, for instance, metocean conditions change and water quality returns to a level which does not lend itself to concern, especially if below the trigger intensity. The chosen measure(s) will take into account current and forecast metocean conditions, proximity of sensitive receptors, flexibility in the dredge execution plan and the adaptive management strategy. While the optimal measures will be employed given the specific situation, additional measures will still be available in case the initial measures are found to be ineffective. Management measures that may be considered include: ♦ Optimising the monitoring programme including the monitoring frequency, parameters, and area to more closely scrutinise the cause and possibility of recurrence of the exceedence ♦ Refining trenching and/or placement and/or sand backfill operations based on sediment plume model results, current and forecasted metocean conditions and/or results from the water quality monitoring. Implementing

Management Area:	Management of Subtidal Benthic Communities (Seagrass, Macroalgae and Filter Feeders)
	the refined trenching and/or backfill operations until the exceedence resolves. These refined operations may include modifying: ▪ Scale of operations and resulting potential area of influence ▪ Location of trenching, type of dredging technique, overflow, and/or dredge spoil placement activities ▪ Dredging practice including overflow operations and production rate and/or volume ▪ Disposal technique including discharge rate and/or volume ▪ Redefining transit routes ▪ Reduce exceedence and/or material placement activities.

7.2 Management Strategy for Seagrass, Macroalgae and Filter Feeders

EPOs have been set for seagrass, macroalgae and filter feeders, to reduce impacts from turbidity-generating activities associated with the trunkline installation (Condition 8-7). The impact zones and associated EPOs relating to the management of BPPH are summarised below.

The ZoHI, which extends 525 m either side of the centre-line of the trunkline, contains filter feeder, seagrass and macroalgae habitat (as per Figure 5.13). In the ZoHI, Condition 8-7 does not specify a level of protection for filter feeder habitat (thus 100% loss is permissible), but no irreversible change is permitted for seagrass and macroalgae. While trenching impacts to seagrass and macroalgae within the ZoHI are expected to recover within 5 years, filter feeders are not predicted to recover within that timeframe due to the large size (presumed age) of some of the individual colonies observed.

Condition 8-7 (i) require that no irreversible losses of the macroalgae occur within the DDF (25 m either side of the centre-line), ZoHI and the ZoMI (1525 m either side of the centre-line). Within these zones, impacts to macroalgae from dredging are predicted to recover within five years.

Condition 8-7iiia requires no irreversible losses in the ZoMI for filter feeder and 8-7iv requires no detectable net change from baseline state for seagrass in the ZoMI. If there are trenching and backfill impacts to filter feeder in the ZoMI it is predicted that recovery will be within five years. No impacts are predicted for seagrass habitat in this zone.

Condition 8-7 (iv) and (v) for the ZoI requires no net detectable impacts to filter feeder, seagrass, or macroalgae. Within the ZoI, no detectable impacts are predicted as a result of dredging to seagrass, filter feeders, and macroalgae.

The management triggers (based on water quality criteria) outlined in Section 6.3.2 are predicted to afford protection to seagrass, macroalgae and filter feeders. Justification for this is summarised below.

The most common genus of seagrass in subtidal areas off Onslow is *Halophila* (mostly *H. minor* and *H. spinulosa*). However, cover of seagrass is low, with average cover only 1.3% across all transects sampled (RPS 2012). Seagrass within the Project area were most abundant in depths less than 10m (RPS 2012). The transect zones with the highest percent cover of seagrass were S4 (depth range 8–10 m) and S10 (depth 5–6 m). In areas at water depths ranging from 8–10 m, seagrasses are believed to peak in abundance in summer and senesce in winter (RPS 2012). This pattern differs from inshore areas where seagrass abundance is greatest in winter. In summer, seagrasses in inshore areas die-off naturally and is thought to be attributed to elevated turbidity levels caused by resuspension and river discharge.

As stated earlier, the water quality criteria prepared for the preservation of coral during the Wheatstone dredge programme (Section 6.3.2) should afford protection to seagrasses. This prediction was based on a comparison between the predicted light levels that the EPOs would maintain at the seafloor and published minimum light requirements for *Halophila* (Duarte 1991; Schwartz et al. 2000). Based on Duarte (1991) and Schwartz et al. (2000) the light requirements for *Halophila* is estimated to range from 5 to 16% of surface irradiance over a range of temporal scales which equates to minimum light requirement of approximately 1.6 to 4.5 E/m^2/d. Some researchers have suggested that *Halophila* can tolerate even less light levels. Collier and Waycott (2009) reported minimum light requirement (expressed as % of surface irradiance) for *Halophila* ranging from 1–6%. Fourqurean et al. (2003) reported that *H. decipiens* in Florida Bay had a minimum light requirement ranging from <1–5%.

To relate minimum light requirements to seagrass resources in the Wheatstone area, the average light levels that would be afforded by the Gorgon derived water quality triggers for two depths and for two seasons were calculated (Table 7.2). These two depths (6 m and 9 m) were chosen because they encompass the depth range of a large proportion of mapped seagrasses in the Wheatstone area. The average light levels associated with the water quality triggers proposed for Wheatstone were predicted using light level data recorded by loggers at two Gorgon sites (6 m and 9 m depth) that experienced elevated turbidity during dredging at levels used to develop the water quality triggers proposed for Wheatstone.

Table 7.2: Predicted Average Light Levels to be afforded by the Water Quality Criteria for Two Depths and Two Seasons

Depth (m)	Summer Mean (min to max)	Winter Mean (min to max)
6	4.8 E/m^2/d (0.04 to 13.11)	2.8 E/m^2/d (0.09 to 9.03)
9	2.7 E/m^2/d (0.13 to 6.73)	0.74 E/m^2/d (0.001 to 3.76)

Compared with the light requirements for *Halophila* estimated from Duarte (1991) and Schwartz *et al*. (2000), the water quality criteria are predicted to afford seagrass protection in summer, since average light levels will be maintained above 1.6 E/m^2/d at both shallow (6m) and deeper (9m) seagrass habitats. However, during winter, when surface irradiance is naturally lower, triggers are predicted to maintain average light levels above the minimum light requirements at shallow seagrass habitats. In the deeper seagrass habitats during winter, the range of available light will encompasses the minimum light requirement for *Halophila* as predicted by Duarte (1991) and Schwartz *et al*. (2000).Maintaining adequate light levels for deeper seagrasses during winter may be less critical because of a potential tendency for natural senescence of *Halophila* commencing late summer in response to a natural decline in light levels to below minimum requirements, as observed in Queensland (Chartland et al. 2008) and potentially in northern Western Australia (Straits Salt 2004; DEC 2009). In the Project area, RPS (2012) reported seagrass to be very low abundance in September compared with December, and thus, it is also likely that *Halophila* may undergo a natural period of senescence during winter. However, it is acknowledged that there is currently an incomplete understanding of the temporal dynamics of seagrasses within the

Project area and this issue will be reviewed when further data is available. In addition, light monitoring and verification monitoring within seagrass habitat (Section 6.4.2) will assist in determining the effectiveness of the triggers in affording protection to seagrasses.

The minimum light requirement for macroalgal functional groups ranges from 0.13 to 1.95 $E/m^2/d$ (Browse 2010). In general, the minimum light requirements for macroalgae are lower than those for seagrass, but are likely to be highly variable with season, species and morphology. However, the water quality criteria within the ZoI are designed to retain light above 2.7 $E/m^2/d$, which is above the minimum light requirement for macroalgae. These light levels correspond to a depth of 8.9 m (the depth of the Gorgon site from which the criteria were derived). Macroalgal beds within the Project area are relatively shallow and therefore, light levels will be far greater at these depths if water quality is managed to the water quality criteria. Therefore, the water quality criteria should afford adequate protection for macroalgal communities.

Little is known of the response of filter feeders to dredging impacts. Until more data becomes available, the tolerance limit of filter feeders has been assumed to be similar to that of corals, upon which the water quality criteria are based. Providing this assumption is justified, the proposed water quality criteria derived for Wheatstone should also provide protection for filter feeders from turbidity impacts, since the turbidity water quality criteria will perform a dual role of managing impacts associated with light reduction and sedimentation (see Section 6.4.2). However, verification monitoring will assist in determining the effectiveness of management triggers in affording protection to filter feeders, and triggers may be refined based on the results of this monitoring if deemed appropriate.

7.2.1 Responsive Management

Responsive management of the trenching and backfill activities[17] for seagrass and filter feeder habitat will occur through the use of the management triggers as described in Section 6.3.2. The relevant management triggers and management responses for seagrass and filter feeders are detailed in Table 7.3 and illustrated in Figure 7.1.

[17] Responsive management will not be implemented during maintenance/clean up and minor dredging works, see Section 6.2.1.

Table 7.3: Management Triggers and Required Responses for Seagrass and Filter Feeder Locations within the Zone of Influence

	Trigger Level	
	Level 1	**Level 2**
Water Quality Criteria	**Chronic criteria** Daily median turbidity >3.3 x background at Reference Sites in similar environment and >2.62 NTU for no more than 10 days out of a 20 day rolling assessment period. **Moderate criteria** Daily median turbidity >3.2 x background at Reference Sites in similar environment and >5.08 NTU for no more than 4 days out of a 20 day rolling assessment period.	**Chronic criteria** Daily median turbidity >3.3 x background and >2.62 NTU for no more than 20 days out of a 40 day rolling assessment period. **Moderate criteria** Daily median turbidity >3.2 x background and >5.08 NTU for no more than 8 days out of a 40 day rolling assessment period.
Management Actions	Identify the events that led to the trigger being exceeded and whether they are likely to continue to occur or reoccur. Check model for interpretation. Investigate potential management responses that could be implemented if elevations continue to occur.	Identify the events that led to the trigger being exceeded and whether they are likely to continue to occur or reoccur. Implement management, where reasonably practicable, to reduce levels below the trigger value. Continue monitoring and assessing water quality to ensure the effectiveness of the measures applied. Alter management response if not effective.

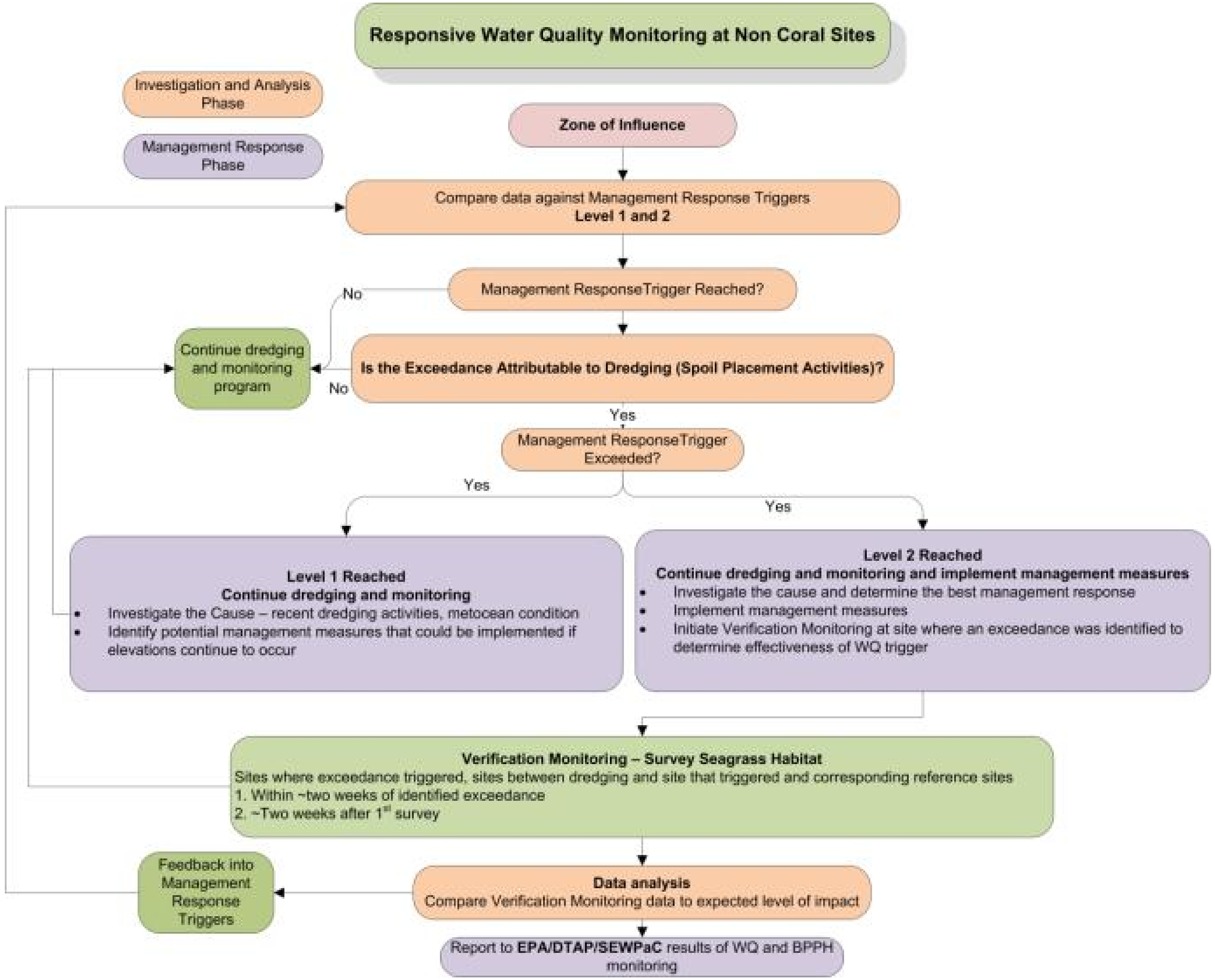

Figure 7.1: Seagrass Responsive Management and Monitoring Procedure

7.3 Monitoring Strategy for Seagrass, Macroalgae and Filter Feeders

7.3.1 Responsive Monitoring

A responsive monitoring programme will be undertaken to allow adaptive management (as detailed in Section 7.2.1) of the trenching activities[18].

In addition to the water quality loggers at the monitored reef formations (Section 6.4.1), water quality data will be collected from two monitoring sites, one in mapped seagrass habitat and the other in mapped filter feeder habitat (see Figure 7.2). The locations illustrated in Figure 7.2 are only indicative at this stage; the final placement of the water quality loggers will be based on the final water quality and BPPH baseline surveys.

The variables, data collection and data analysis methods will be the same as described in Section 6.4.1.

[18] Responsive monitoring will not be implemented during maintenance/clean up and minor dredging works, see Section 6.2.1.

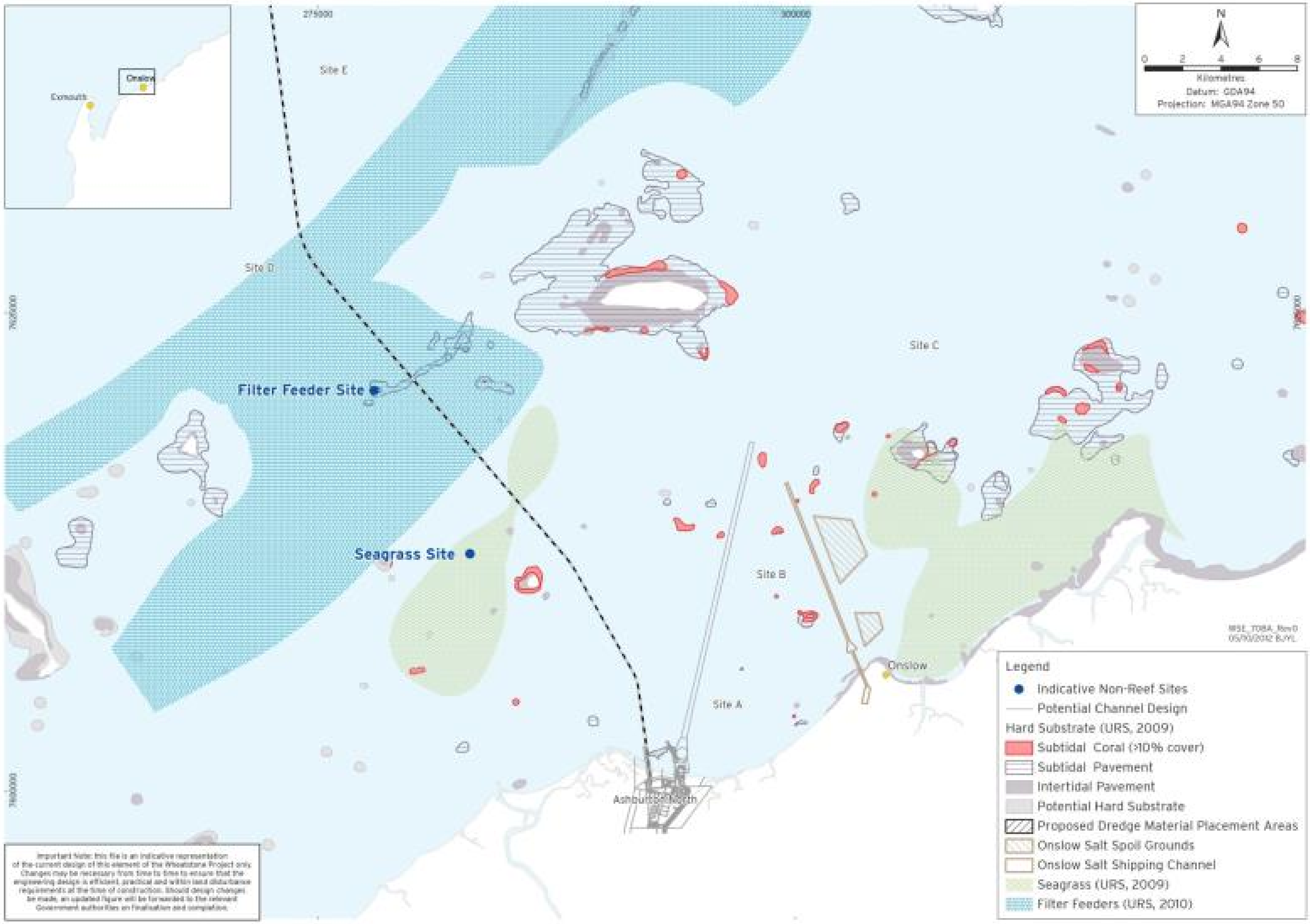

Figure 7.2: Indicative Monitored Non-Reef Sites in the Responsive Water Quality Monitoring Programme

7.3.2 Habitat Monitoring

This section is intended to be a duplication of the seagrass, macroalgae and filter feeder monitoring as detailed in the SoW for the State of the Marine Environment Report and may be amended from time to time if the SoW for the State of the Marine Environment Report is amended, the same amendments will be taken to be made as part of the TIEMMP and an updated copy will be prepared and provided to OEPA and DotE as soon as practicable. If the SoW for the State of the Marine Environment Report amendments also requires a review of the TIEMMP the review will be in accordance with Section 12.0. The data collected as part of the State of the Marine Environment Reports will be used to assess achievement of Conditions 8-7 (i), (ii), (iiia), (iv) and (v). In the event of any inconsistencies or differences between the SoW for the State of the Marine Environment and this document, the SoW for the State of the Marine Environment takes precedence to the extent of any difference or inconsistency.

The potential for detection of permanent loss of benthic communities that might be attributed to the effects of trenching or backfill activities will be assessed through a monitoring programme. This monitoring programme is designed to detect changes in the abundance of benthic biota and changes in the underlying habitat using a before, during and after impact design and with reference sites if available. More specifically, biota will be surveyed mid-way through the marine works and post-development to establish recovery of any affected biota. During each monitoring period, sampling will also be undertaken at increasing distances from the source of impact (gradient sampling approach) to help establish the spatial scale of impact and allow a cause-effect relationship to be investigated. A standard BACI (Before/After/Control/Impact) sampling design is not proposed because there are limited seagrass, macroalgae and filter feeder communities which are not expected to be influenced by dredging activities that could be used as ‘controls’ (references). Baseline data are currently being collected to describe how the abundance and distribution of these BPP change naturally through time. Habitat monitoring, using PSD as an indicator, will also be undertaken to assess if impacted biota will be able to recover following cessation of dredging.

7.3.2.1 Location and Establishment of Survey Sites

During the marine works, there will be two dredge programmes with the potential to cause indirect impacts to seagrass, macroalgae and filter feeders: the navigation channel (including the turning basin, MOF and tanker berths) and the trunkline dredge programmes. Elevated turbidity levels originating from these two programmes potentially threaten seagrasses and other benthic communities in adjacent areas. Modelling used to predict the trajectory and fate of the plume during dredging for the nearshore and offshore marine facilities suggest that the plume could extend up to approximately 80 km west and 40 km east of the channel (Section 8.3 Draft EIS/ERMP).

The locations for the seagrass, macroalgae and filter feeder surveys for the 2011 survey period are shown in Figure 7.3. Figure 7.4 illustrates the sampling locations undertaken in 2012 and will form the basis for the mid-term and post development surveys. An explanation for the survey designs in both years is given in Section 7.3.2.4.

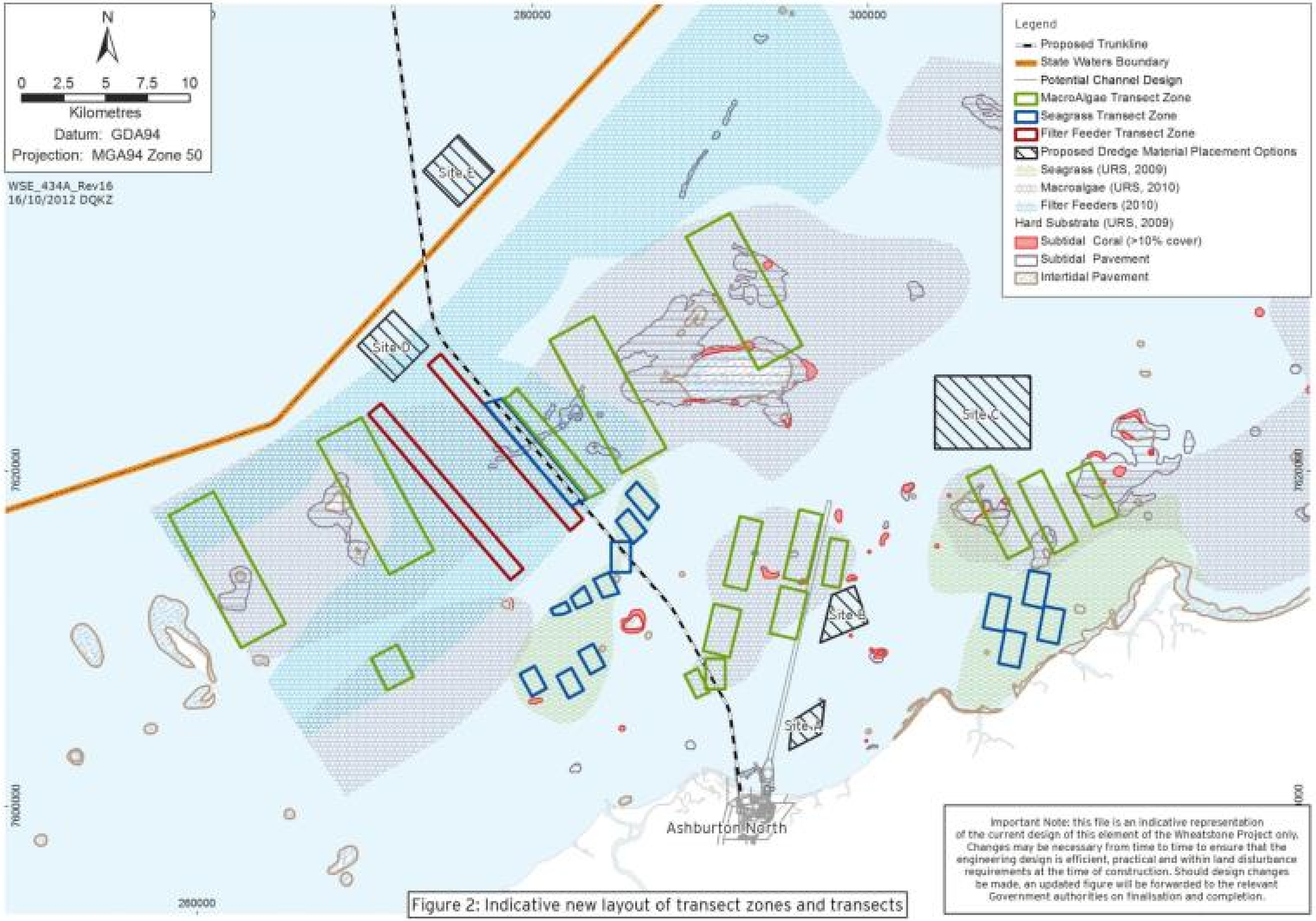

Figure 7.3: 2011 Survey Locations of the Seagrass, Macroalgae and Filter Feeder Transects

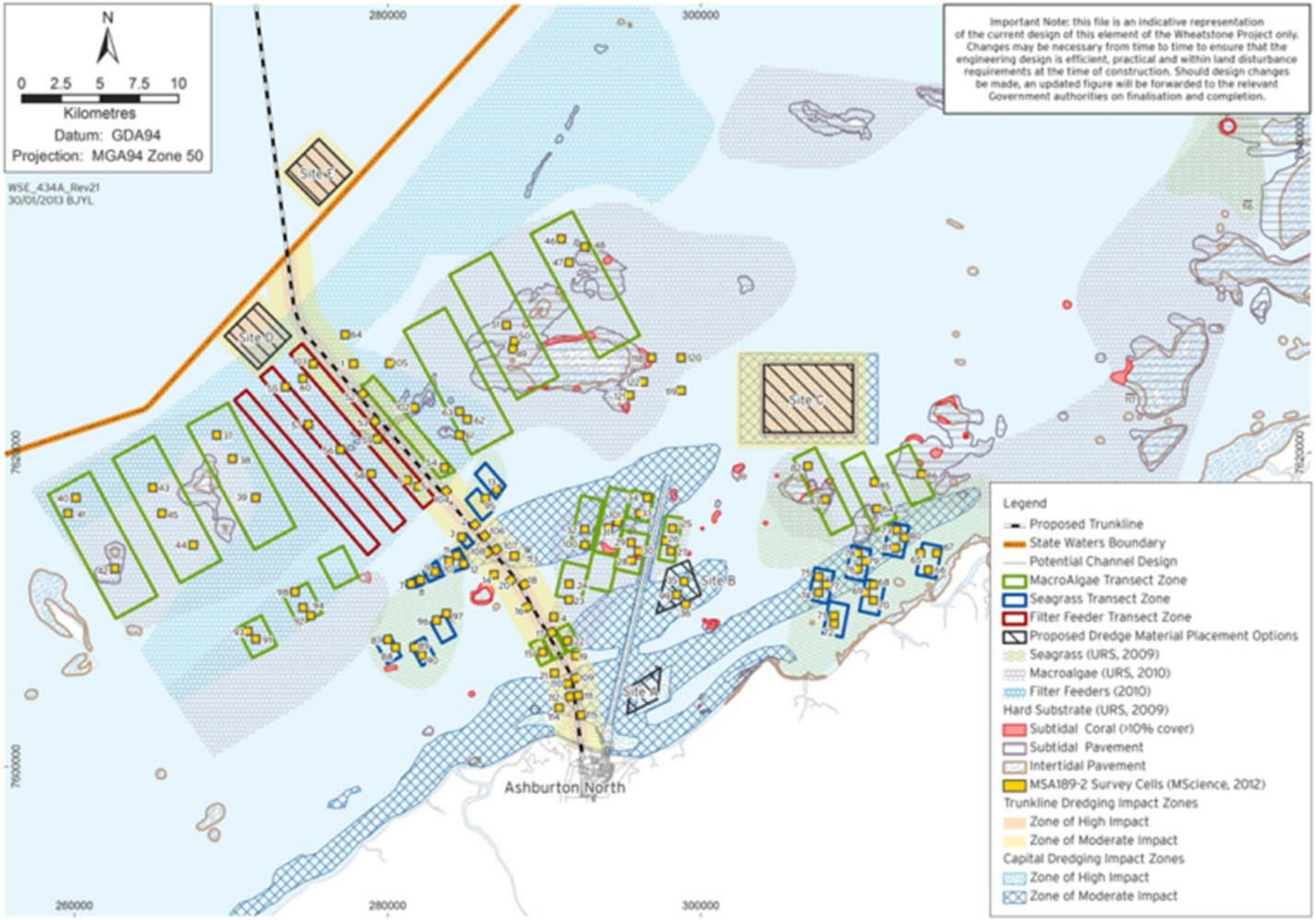

Figure 7.4: 2012 Survey Locations of the Seagrass, Macroalgae and Filter Feeder Transects

7.3.2.2 Variables

In order to monitor any changes over time, and differentiate between natural and dredging impacts, seagrass, macroalgae and filter feeders will be sampled with the following information recorded:

- Percentage cover
- Above ground biomass
- Below ground biomass
- Seed type.

These variables have been selected to identify changes in seagrass, macroalgae and filter feeders. These habitats vary naturally and therefore the baseline should provide an understanding of the expected natural variability, both spatial and temporal. This is required as the BPP may be influenced by the dredge operations.

7.3.2.3 Sampling Design

A gradient approach based on distance from the channel and trunkline dredging footprints is proposed (at this stage) to allow an evaluation of the potential changes to seagrasses, macroalgae and filter feeders at increasing distances from the source(s) of disturbance. This sampling approach may be necessary, particularly for seagrasses, given the lack of appropriate reference sites due to the modelling prediction that the turbidity plume could, at some stage during dredging, extend 80 km west and 40 km east of the dredge footprint. A traditional BACI sampling approach (Underwood 1994) relies on the fact that reference (control) are close enough to the disturbance so that the reference site is comparable to the natural variability of the disturbed environment and yet far enough away that the reference site is not affected by the disturbance (Ellis and Schneider 1997). Consequently, if ‘true’ control sites are required these need to be located >80 km west and >40 km east of the dredge foot print. Such distant sites are unlikely to share similar hydrodynamic conditions and community types to the putative impact sites, thus compromising their utility as reference sites.

However, it may be possible for suitable reference sites to be established immediately outside, or just within, the outer boundary of the ZoI. Recent guidance from the EPA (EPA, 2011) has assessed that it may be possible to use reference sites from within the ZoI as long as these sites are not influenced or only infrequently influenced. If the communities at the reference sites are found to share similar characteristics to those communities predicted to be impacted (e.g. similar taxa composition and structure), they might serve as suitable reference sites, thus allowing a BACI design to be used for these BPP. This will be reviewed during the initial baseline surveys.

Gradient sampling approaches have been adopted previously by researchers (e.g. Ellis and Schneider 1997) where disturbances are reliably predicted to attenuate with distance from the point source of disturbance (e.g. drilling operations and sewage outfalls) and in situations where the aim is to measure precisely the spatial scale of impact. With the proposed gradient approach, inference is not based on a comparison between control and impact sites; rather it is based on the level of impact with increasing distance from the source of impact (Ellis and Schneider 1997) which, in this case, is the dredge footprint. The impact hypothesis would be supported if the level of impact to benthic primary producers decreased, on average, with increasing distance from the disturbance area. Ellis and Schneider (1997) tested the gradient approach against a randomised approach for detecting certain impacts in the marine environment and found that the gradient approach was more powerful at detecting changes in benthic abundance than the control impact design. An obvious weakness of a gradient approach is that inference is based on correlations, which do not necessarily infer causation. Abundances of many marine organisms are naturally correlated with environmental gradients which may make it difficult to separate out the effects of human disturbance from natural agents of disturbance. However, inferential uncertainty in these instances can be reduced by adopting approaches such as levels-of-evidence (Fabricius and De'ath 2004).

7.3.2.4 Sampling approach

Three benthic communities will be investigated under this scope: seagrass; macroalgae and filter feeders. It should be noted that seagrass in the area is sparse and patchy and the dominant genus recorded, *Halophila*, is ephemeral and as such their abundance varies greatly over short-term temporal scales, making such biota types difficult to monitor. This SOW includes above and below ground monitoring for seagrasses which may, to some extent, counter this issue.

Macroalgae is also ephemeral and difficult to monitor due to the seasonal changes in cover and biomass. Filter feeders are relatively unknown and are problematic to monitor due to the lack of scientific knowledge on which variables can be reliably used as key indicators of the condition of filter feeder habitats. Given the lack of knowledge about the abundance and distribution of seagrass, filter feeder and macroalgae in the survey area, it was necessary to undertake a survey in 2011 to achieve two goals:

1. Obtain baseline (2011 combined with 2012 would provide baseline over two years).
2. Provide data to optimise the 2012 baseline survey design so that it will allow a rigorous assessment of the EPOs.

For these reasons, the sampling approached used in 2012 was slightly different from that used in 2011, and thus, both are described separately below. Importantly, the 2012 methods will form the primary basis for the mid-term and post development surveys.

7.3.2.1 2011 Surveys

The following description relates to the surveys in September and December 2011.

Transect zones

Transect zones were defined based on the described gradient approach for each biota type as shown in Figure 7.3. The transect zones covered seagrass, filter feeder and macroalgae habitat.

Transects and sampling method

Five transects, approximately 500m in length, were established within each of the transect zones. Transects were fixed and recorded to return to the same locations to undertake repeat monitoring of each transect (the method used will depend on the level of accuracy required which will be appraised following the initial baseline survey).

The indicative transect zones were surveyed using a remotely operated towed video system consisting of a forward facing high definition video/stills camera with two light emitting diode (LED) arrays attached to an adjustable frame. The frame was deployed off the stern of the vessel using an A-frame and towed at a speed of approximately 1–1.5 knots and maintained at a target depth approximately 1 m above the seabed. Live towed video feed to the surface was used to undertake geo-referenced qualitative classification of benthic habitats types and substrates. This provided a qualitative record of the change in habitat and biota types over a longer distance to give broad scale coverage.

Over 22,000 still images were captured along the towed video transects during the survey. Images were of a standard size of approximately 3840 x 2160 pixels. A quality control process was used to ensure that only still images of suitable quality were used for analysis. After the quality control process was complete, a subset of 50 randomly selected images for each transect was used to estimate the percent cover of benthic habitats CPCe 3.5 or similar. All images were analysed where less than 50 images were available.

Grab samples

Seagrass biomass within the seagrass transect zones was assessed using 34 sediment grabs. Sediment subsamples were taken from the grab sample (~300 mL each) for seed stock analysis. Each sediment sample was placed into a large graduated cylinder to calculate the total volume. Sediments were then wet sieved with a 125 µm sieve, as seeds of species in the region are >200 µm. All seagrass material was removed from the sample, identified to species and weighed onshore using a balance to obtain total biomass after being blot dried with tissue paper. Biomass samples were then frozen and transported to Perth where they were separated into above and below ground biomass and weighed.

7.3.2.2 2012 surveys

The 2012 September and December surveys was an extension of surveys conducted in September and December 2011. Whilst it was important to retain a similar design to the 2011 survey to allow for a comparison, there were some amendments made in the 2012 design. The current design better targets habitats for survey, albeit in the same areas as the 2011 survey. Further, it incorporated a randomised design component to make it more conducive to assess achievement with the EPOs during the mid and post dredging surveys.

Transect Zone (hereafter Blocks)

Blocks for the 2012 survey were largely consistent with the 2011 survey. The terminology was changed to minimise confusion with the term ‘transects’ and ‘impact zones’ used in the Draft EIS/ERMP. Blocks in the 2011 survey were labelled according to the habitat target at each zone, based on the habitat mapping presented in the Draft EIS/ERMP (Chevron 2010).

Cells

Rather than use fixed transects within a block, each block was divided into 500 x 500 m grids (Figure 7.5). The Cells forming the grid then became potential sampling sites. One to three cells were selected from each block to be included in the survey, using a combination of randomised and targeted selection criteria. Firstly, a geospatial modelling environment was used to randomly select 40% of cells. From this selection, the cells to be sampled were finalised by querying habitat data to ensure that majority of cells had macroalgae, filter feeders and/or seagrass habitat present, based on past surveys.

The number of sample cells was then balanced over Zones of Impact and depth. Consequently, additional cells were established outside of the blocks. All zones were designed to have 12 cells except the trunkline Zone of Moderate Impact, the Trunkline Zone of High Impact and the area where channel and Trunkline Zone of Moderate Impact overlap (Table 7.4). These areas were too small so had a minimum of ten (10) cells. There are also cells in potential reference areas to meet the requirements of a BACI design. There was a bias to deeper transect areas as the large vessel used for surveys was unable to safely access areas shallower than -3 m. The design included 122 cells sampled during the baseline period, with the breakdown of the cells in the specific zones shown in Table 7.4. The investigative cells (5 cells) will not be surveyed during the mid-term or post development surveys. The final number and location of cells surveyed during the mid-term and post development surveys may vary as a result of further knowledge gained from baseline studies.

Table 7.4: Number of Cells in each Zone of Influence/Impact, Depth Range and Habitat Class

Location / Zone	Number of cells
Channel	
Cells in Zone of Moderate Impact	12
Cells in Zone of Influence	12
Trunkline	
Cells in Zone of High Impact	10
Cells of Zone of Moderate Impact	10
Cells in Zone of Influence	12
Channel and Trunkline	
Cells in both Zone of Influence	12
Cells in Channel Zone of Moderate Impact and Trunkline Zone of Influence	12
Cells in Channel and Trunkline Zone of Moderate Impacts	10
Reference	
Cells in seagrass habitat (but inside Channel Zone of Influence)	10
Cells in macroalgae and filter feeder habitat	15
Cells Potential seagrass (outside channel Zone of Influence)	2
Investigative cells*	5
Total	**122****

*These cells will not be surveyed during the mid-term or post development surveys

**The final number and location of cells surveyed during the mid-term and post development surveys may vary as a result of further knowledge from baseline studies.

Transects and sampling method

Within each Cell, benthic habitat data was recorded along five randomly placed (start and orientation randomised) 100 m transects (Figure 7.5). Randomising the transect orientation minimised the potential for transects to be aligned with, or across, any linear trends in the underlying habitat. Data was gathered along transects using a towed camera system, comprising a forward-facing video and a downward-looking still camera mounted on a frame. The frame was towed behind the boat, approximately 50 cm above the seafloor, while the boat was driven along the transect lines. The still camera was fixed on the underside of the sled, facing downward and recorded images approximately every 3 seconds. At the tow speeds of approximately 1.5–2 knots, a three second interval corresponds to approximately 2–3 m spacing between images.

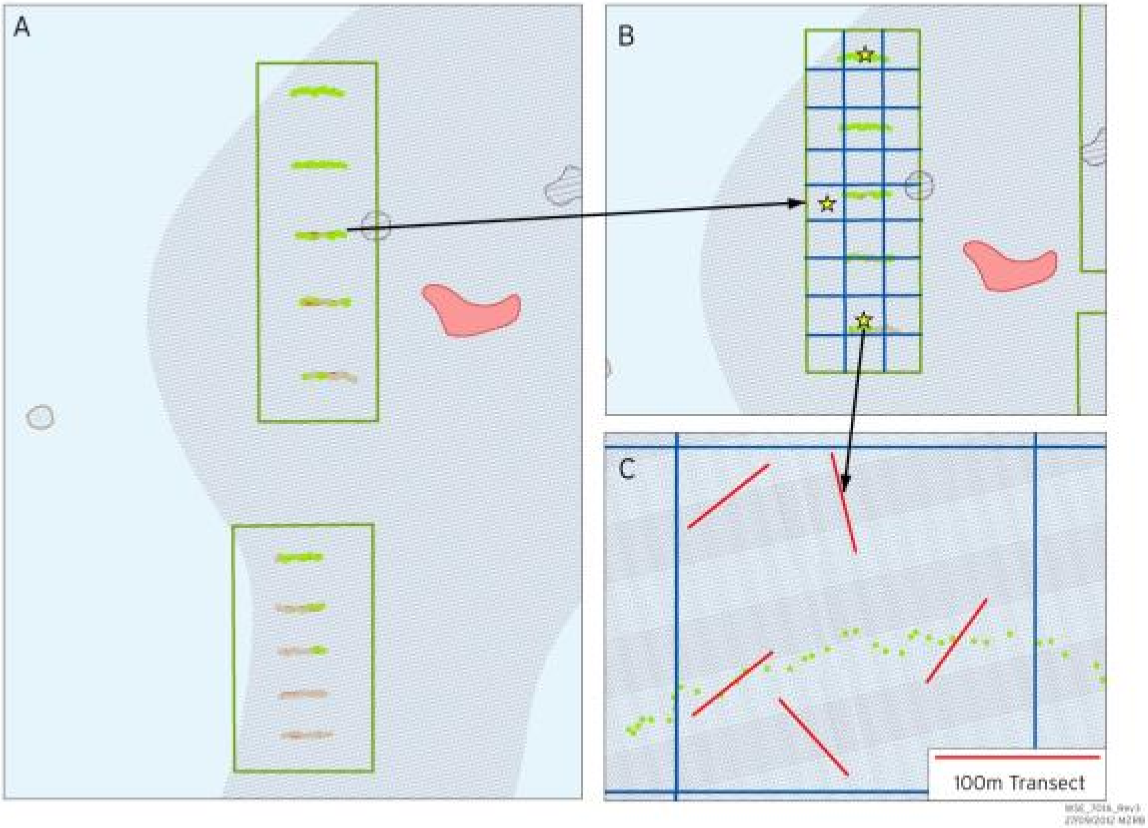

Figure 7.5: Sampling Grid Pattern

Grab samples

Sediment grab sampling for seeds were obtained from a range of locations (includes QA samples). Sampling was undertaken using covers on the grab and careful handling to minimise the loss of fines during sampling. On return from the survey, samples for seagrass seed samples were sent for analysis.

Seeds were quantified based on the method developed by Hammerstrom and Kenworthy (2003). Firstly, sediment was fractionated based on grain size. The sizes of *H. decipiens* seeds are 0.4–0.6 mm (Hammerstrom and Kenworthy 2003). Consequently, sediment samples were wet sieved in order to separate the sediment fraction ranging between 0.25-1 mm, ensuring all seeds were present in sediment analysed. Seeds were then removed from this fractionated sediment using a density separation technique. Briefly, five replicate sub-samples (2 cm^3) of the sieved sediment from each sample were placed in centrifuge tubes. Where there was not enough sediment collected from some sites for five replicate sub-samples, the entire sediment sample was used and volume of sediment recorded. This was then standardised to the 2 cm^3 samples. For each sub-sample, 10 ml of chilled Ludox (colloidal silica 40%) was added to each tube as the extract solution. Tubes were capped, shaken vigorously for 20 seconds and then centrifuged at 2500 revolutions per minute (rpm) for three minutes. Most inorganic sediment particles sink to the bottom, whilst organic matter (including seeds) floats at the top of the tube. The floating organic matter was then removed from the tube using a pipette, and transferred to a Petri dish, allowing the number of seeds to be counted under a dissecting microscope. The same or very similar approaches will be used for seed analysis during the mid-term and post development surveys to ensure consistency of results.

7.3.2.3 Timing and Frequency of Surveys

Sampling will be undertaken prior to commencement of dredging (baseline), mid-term of dredging and post development of dredging for all three biota types, but at different frequencies. Tropical seagrasses and macroalgae are known to vary in abundance seasonally (e.g. between dry and wet seasons in tropical Australia), but such patterns are not always predictable. The most likely period to detect these biota types is summer (December/January). Seagrasses and macroalgae are predicted to exhibit the greatest levels of natural variability warranting the greatest level of survey replication. Filter feeders are considered more stable in terms of their abundance and distribution and could therefore be sampled less frequently whilst still picking up any change in abundance due to natural disturbance events. Percentage cover will be sampled in all surveys. Biomass and PSD will be sampled on a less frequent basis.

7.3.2.4 Treatment of Survey Data

The approach to detect impacts involves the use of an appropriate statistical test (e.g. t-test, ANOVA or similar approach). The method for analysis will be dependent on the location of suitable reference sites for assessment of net changes. If reference sites are unavailable then a test for gross change will be carried out, using a t-test, or similar. Regression analysis can be applied to assess linear relationships, testing whether there is a change with increasing distance from the source of impact. If reference sites are available then net change can be established and an ANOVA approach can be used.

The detection of any changes with increasing distance from the source of impact will be used in an inference assessment, should any detectable change occur, which will also take into account any other potential sources of impact.

8.0 CORAL SPAWNING MANAGEMENT AND MONITORING

8.1 Background

Corals spawn through the release of gametes into the water column. Elevations in turbidity, such as those associated with dredge plumes, have the potential to reduce fertilisation success of coral gametes and the survival of coral larvae (Gilmour 1999). As such, to manage the potential impacts of elevated turbidity on coral reproduction and therefore coral recruitment, Condition 8-18 (MS 873) requires that the proponent:

> *'shall not conduct turbidity-generating activities associated with trunkline installation during the period 3 days prior to the predicted commencement of mass coral spawning, or as soon as mass coral spawning is detected if prior to the predicted time, and those turbidity-generating activities are to remain suspended for 7 days from the commencement of mass coral spawning unless it supplies peer-reviewed scientific evidence that if those turbidity-generating activities were to continue during coral mass spawning events, any effect, if it were to occur, would not significantly impact the functional ecology of local and regional reefs, and the CEO provides a written exemption of those turbidity-generating activities from the requirement to cease over the period specified or alter the period that turbidity generating activities must cease'.*

And Condition 11 (d) and (e) of EPBC 2008/4469 requires:

> *(d) A commitment to cease dredging activities at least 3 days prior to the predicted commencement of mass coral-spawning, or as soon as mass coral spawning is detected, if prior to the predicted time, and to only recommence dredging activities after at least 7 days have passed since the commencement of mass coral spawning unless 11 (e) applies.*
>
> *(e) The Minister may approve in writing, a reduction in the period over which dredging must cease (refer condition 11 d), if the person taking the action provides peer-reviewed scientific evidence that demonstrates that if dredging activities were to continue during mass coral spawning events, any effect, if it were to occur, would not significantly impact the functional ecology of local and regional reefs.*

Mass spawning events or synchronous spawning is when individual colonies of many different species release gametes simultaneously (Babcock *et al*. 1984). These events can vary in terms of how many species spawn at once (the extent of spawning) and also the proportion of individuals within populations of those species that spawn synchronously (the magnitude of spawning).

For the purposes of this Plan, an autumn mass spawning event is predicted to occur if at least 50% of females within the colonies sampled have mature eggs (or at least 40% in the event that a split spawning event is likely to occur; see Section 8.2) where sampling targets species or genus-groups known to spawn in a given season. For hermaphroditic species this would mean that at least 50% of the colonies sampled were observed to have pigmented eggs. For gonochoristic species or genus-groups, the percentage of individuals showing pigmented eggs will need to be adjusted by the estimated sex ratio. For example, if 30% of gonochoristic species or genus groups were recorded as having pigmented eggs, and the sex ratio is assumed to be 50:50, then the percentage of females with mature eggs for gonochoristic species or genus groups within the sample would be adjusted to 60%. If histological assessments are undertaken, these can be used to determine the actual sex ratio by examining the number of males and females in the sample. In this case, the percentage of females with mature eggs would be adjusted by the actual sex ratio of the sample. However, for colonies where no eggs and no sperm were observed in histological assessments, a 50:50 sex ratio will be assumed for those colonies.

The above definitions are likely to capture the major spawning event for the year, assuming that most species spawn once per year, and increases confidence in determining the correct timing of a mass spawning event compared to a definition based on a lower proportion of species or colonies spawning (Styan and Rosser 2012).

A spring, dominant *Porites*, spawning event is predicted to occur if an assessment of *Porites* spp. corals indicates that >40% of samples contain mature gametes (stage IV or late stage III). A summary of the management and monitoring measures associated with coral spawning is provided in Table 8.1.

Table 8.1: Summary of Management and Monitoring Measures to Manage Impacts to Coral Spawning

Management Area:	**Coral Spawning**
Performance Objective:	To achieve Condition 8-18 (MS 873) and Condition 11 (d) EPBC 2010/4469. *To not significantly impact the functional ecology of local and regional reefs by limiting interactions between dredging-related turbidity and a mass spawning event*
Management:	♦ Cessation of dredging operations during coral mass spawning events unless the CEO provides a written exemption under MS 873 Condition 8-18 and the Commonwealth Minister provides written approval under EPBC 2008/4469 Condition 11(e) ▪ If cessation of turbidity-generating activities, associated with trunkline installation, is assessed as unnecessary management of turbidity-generating activities to ensure no significant effects on functional ecology of local and regional reefs will be undertaken by changing the activity location
Monitoring:	♦ Coral Spawning Prediction Monitoring (Section 8.3)

8.2 Management Strategy for Coral Spawning

The first step in the management of turbidity-generating activities, associated with trunkline installation, to minimise interaction with mass coral spawning is to identify potential mass coral spawning events that may occur throughout the proposed dredge programme. The identification of potential mass coral spawning events is based on an examination of historical records and an understanding of the environmental factors that produce the most conducive conditions for successful spawning of corals. Typically, corals in the Pilbara region have been observed to spawn 6 to 10 days after the full moon during autumn each year (Simpson 1985; Simpson *et al*. 1991; Rosser and Gilmour 2008; Gilmour *et al*. 2009). However, separate multi-specific spawning events have also been reported in the region during spring to early summer (Rosser and Gilmour 2008).

Recent studies have been undertaken to investigate the seasonality of coral reproduction in the Dampier Archipelago (Baird *et al*, 2011). This research has confirmed that, as stated above, coral spawning predominantly occurs in the autumn with a smaller proportion of species (~7%) active in spring and summer. Species noted to spawn in spring included three *Acropora* species, *Favites flexuosa*, a range of *Porites* spp. and possibly *Turbinaria mesenterina*. Studies have indicated that typically there is only one gametogenic cycle per colony in each year (Rosser & Gilmour, 2008; Baird *et al*, 2011). This suggests that typically the majority of corals will either spawn in autumn (with the exception of a few species) or not at all for that year. Spring spawning events were found to be much smaller than those previously documented in northern WA where up to 16 *Acropora* species spawn in spring. Studies have indicated that typically there is only one gametogenic cycle per colony in each year (Rosser & Gilmour, 2008; Baird *et al*, 2011). This suggests that typically the majority of corals will either spawn in autumn (with the exception of a few species) or not at all for that year. There is currently a limited understanding of spring spawning on reefs within the Project area, although *Porites* spp., which are known to spawn in spring in the Pilbara region (Baird *et al*. 2011), are common on some reefs within the Project area. The sampling of corals for spawning predictions will target species or genus-groups known to predominantly spawn within the season sampled: autumn or spring, to increase the likelihood of detecting a spawning event. Within these groups known to spawn in a given season, a wide range of species will be sampled haphazardly, rather than targeting a few individual species, according to recommendations of Styan and Rosser (2012). This haphazard sampling ensures that an assessment of spawning is not dominated by a single species, which may or may not be representative of the community as a whole.

Table 8.3 lists potential coral spawning windows in the region during trunkline installation activities works, based on a knowledge of spawning periods for corals at similar locations, including Dampier (Simpson 1985), Barrow Island (Rosser and Baird 2009), and Scott Reef (Gilmour *et al*. 2009). The actual likelihood of a mass spawning event occurring within these potential windows will not be known until pre-spawning surveys are undertaken to examine the stage of maturity of gametes in coral samples (see Section 8.3 for details of monitoring).

Once a mass coral spawning event is predicted to occur in an upcoming spawning window (Table 8.3) it will be assumed that corals will spawn during that window and no further coral spawning assessments are required for that season. If a mass spawning event is not predicted to occur during the upcoming window, further monitoring is required prior to upcoming spawning windows during that season.

However, in stating the above, if there is indication that a split mass spawning event is likely, in autumn, and the sampling prior to the spawning window indicates that > 40% to < 70% of colonies sampled during autumn contain mature gametes, the potential for a mass split coral spawning event in March and April will be predicted to occur, requiring management of dredging around the March spawning window (pending exemption). In this event, an assessment would again be required prior to the subsequent April spawning window and if >40% of colonies sampled contain mature gametes this would reaffirm the potential of a mass split coral spawning event between March and April, requiring management of dredging during April in addition to March (pending exemption). This approach would increase the likelihood that two smaller ‘mass’ spawning events would be captured.

However, if >70% of colonies sampled contain mature gametes it will be assumed that a single mass coral spawning event is likely to occur in the upcoming window, requiring management of dredging during that window (pending exemption), and no further assessments will be required for subsequent windows during that spawning season, to avoid unnecessary damage to corals.

During the spring spawning season if sampling of *Porites* corals indicates that >40% of samples contain mature gametes (stage IV or late stage III), a dominant *Porites* spawning event will be predicted to occur in the next spawning window, requiring management of dredging (pending exemption). Once a dominant *Porites* spawning event has been predicted to occur in the next spawning window, it will be assumed that *Porites* will not exhibit another significant spawning event, and no further assessments will be required for subsequent windows during that spawning season, to avoid unnecessary damage to corals[19].

Any identified mass coral spawning period will result in the suspension of turbidity-generating activities, associated with trunkline installation, during the three days prior to the predicted commencement of mass coral spawning and activities will remain suspended for seven days (since the commencement of spawning is difficult to define, it will be considered here to be seven days from the first day of the spawning window), unless the CEO provides a written exemption under MS 873 Condition 8-18 and the Commonwealth Minister provides written approval under EPBC 2008/4469 Condition 11(e). However, Chevron Australia can seek an exemption from the requirement to cease turbidity-generating activities, associated with trunkline installation for 10 days based on peer-reviewed scientific evidence that if those turbidity-generating activities were to continue during mass spawning events, any effect, if it were to occur, would not significantly impact the functional ecology of local and regional reefs.

8.2.1 Approved Exemptions

Following provisions made within MS 873 Condition 8-18 and EPBC 2008/4469 Condition 11(e), Chevron Australia submitted requests for approval from DotE and the OEPA for specific dredging activities to continue during mass coral spawning periods based on peer-reviewed scientific evidence that any effect, if it were to occur, would not significantly impact the functional ecology of local and regional reefs.

Autumn 2013

The CEO of the OEPA granted an exemption, on 1 March 2013, from the requirements of Condition 8-18 of MS 873, for turbidity-generating activities associated with trunkline installation between KP0-KP3 and KP31-37, with dredge material placed at DSPS D and/or E, to continue during the April and May predicted potential coral mass spawning periods (Table 8.3).

Spring 2013

The CEO of the OEPA granted an exemption, on 11 November 2013, from the requirements of Condition 8-18 of MS 873 and the Minister granted an exemption, on 23 October 2013, from the requirements of Condition 11d, in accordance condition 11e, for turbidity generating activities to be undertaken at the following locations:

- Microtunnel Exit Pit Excavation between KP 0 and KP 1, with dredge material placement at DSPS D during October; and
- Microtunnel Exit Pit Excavation, using Damen type Suction Excavation Tool, between KP0 and KP1, with dredge material transferred to the temporary access channel.

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[19] A decision will be made by Chevron to determine if assessments will continue for additional potential spawning windows should a dominant spawning event be triggered. In this decision, the benefit of improving our understanding of spawning in *Porites* will be weighed against avoiding unnecessary damage to *Porites* colonies through sampling.

Autumn 2014

In December 2013 Chevron Australia submitted a request to the OEPA and DotE for a blanket exemption for turbidity-generating activities to occur in six individual proposed Dredge and Disposal Exemption Zones. The turbidity-generating activities associated with trunkline installation within the Dredge and Disposal Exemption Zones requested are summarised in Table 8.2.

The CEO of the OEPA granted an exemption, on 17 February, from the requirements of Condition 8-18 of MS 873, for the activities and locations detailed in Table 8.2 to occur during mass coral spawning events for the remainder of the dredging program.

The Minister granted an exemption, on 26 February 2013, from the requirements of Condition 11d, in accordance with Condition 11e, for the dredging methods, activities and locations detailed in Table 8.2 to occur during the Autumn and Spring mass coral spawning events in 2014.

Table 8.2: Turbidity-generating activities associated with trunkline installation to continue within Dredge and Disposal Exemption Zones

Wheatstone Project	Dredge Exemption Zones	Equipment	Disposal Exemption Zones
Trunkline Corridor	Nearshore Exemption Zone (KP0-KP3)	TSHD, BHD, SSDV (include rock-dumping & backfill)	Site D or E
	Offshore Trunkline Exemption Zone (KP31-KP37)	TSHD, SSDV or FPV	Site D or E

Spring 2014

The CEO of OEPA granted an exemption, on 05 September 2014, from the requirements of Condition 8-18 of MS 873, and the Minister granted an exemption, on 22 September 2014, from the requirements of Condition 11d, in accordance with Condition 11e of EPBC 2008/4469. The exemptions provided the following relevant to spring spawning in 2014:

- No mass coral spawning prediction assessments are required to be undertaken
- Dredging may continue across the site during the October, November and December 2014 mass coral spawning events, with dredge disposal at DSPS D.

Table 8.3: Predicted Potential Coral Spawning Windows associated with the timing of Turbidity-generating Activities associated with Trunkline Installation

Dredging works estimated to occur from 2013 to mid-2015	
Full Moon	**Potential Spawning Period**
2013	
April 26th	May 2nd to 6th
September 19th	September 25th to 29th
October 19th	October 25th to 29th
November 17th	November 23rd to 27th
2014	
March 17th	March 23rd to 27th
April 15th	April 21st to 25th
November 7th	November 9th to 12th
December 6th	December 8th to 11th
2015	
March 6th	March 12th to 16th
April 4th	April 10th to 14th
May 4th	May 10th to 14th

8.3 Monitoring Approach

Since the overall objective of Mass Coral Spawning Prediction Assessments are to predict, with a high level of confidence, whether a mass spawning event is likely to occur during upcoming potential spawning windows, a pre-spawning survey is required prior to each potential mass coral spawning window. However, in the case where monitoring predicts corals will undergo a mass spawning event in the upcoming spawning window, it will be assumed that corals are unlikely to exhibit a mass spawning event again within that season (i.e. autumn or spring) and no further spawning prediction monitoring will be undertaken within that season to minimise further impacts to corals through sampling.

8.3.1 Data Collection

8.3.1.1 Sampling Sites

At least three coral spawning assessment sites (depending on the potential area of vulnerability from sediment plumes at the predicted times of spawning and range of dominant and sub-dominant genera at those sites) will be selected within either the ZoI or reference areas. It is expected that if a mass spawning event takes place, it will occur at a regional level and sampling of a subset of sites will sufficiently enable prediction of a mass spawning event. Additionally given that coral spawning monitoring requires the collection of coral samples, using a subset of sites for predictive monitoring will reduce the extent of impacts to coral communities.

Since coral cover is very low in the project area and still on a downward trajectory, it is not possible to identify which monitoring sites will be chosen for a given spawning assessment at this stage, and indeed, sites may need to be changed during trunkline installation activities if low coral cover precludes sampling. Sites will be chosen prior to spawning assessments based on the coral communities present and their representation of coral communities that occur throughout the region. Sites will also be chosen based on whether they contain sufficient representative colonies of species that are likely to spawn in a given predicted spawning window.

8.3.1.2 Collection of samples

Species will be sampled haphazardly (following recommendations of Styan and Rosser 2012) from within genus-groups known to spawn in the given season within which sampling is to occur. One nubbin per colony (pieces of coral approx. 1–4 cm in length) will be taken from 60 to 100 colonies throughout the selected sample sites. Where possible, large colonies will be chosen to ensure the colony has reached sexual maturity. Coral corers or chisels will be used to collect samples from massive and plating corals, whereas branching coral samples will be removed by hand.

Coral colonies sampled will, where possible, be situated away from areas where routine monitoring is undertaken (e.g. away from reef areas used for water quality Monitoring, Coral EPO Assessments) to avoid interference and confoundment of datasets collected for other purposes.

Coral samples will be obtained up to a maximum of 2 weeks prior to the predicted mass spawning window to more accurately capture the reproductive status of late-maturing species (e.g. *Porites* spp. which have been reported to mature just prior to spawning).

8.3.2 Data Analysis and Mass Spawning Prediction

Collected samples will be examined under a dissecting microscope in the field to assess reproductive status, as per Table 8.4. For most species, microscopic assessments can be used to assess the presence of mature eggs. However, for certain species, samples may be required to be histologically staged where the results from field dissecting microscope examination are inconclusive (for example, results that are within 10% of the cut-off spawning value, or where species are sampled that have very small eggs which cannot be adequately assessed using a dissecting microscope (e.g. *Porites*)). Additionally, where results are marginal, gonochoristic species may require histological analysis in order to more accurately determine the sex ratio of the collected sample.

Results will be pooled among sites and the percentage of females containing mature eggs (or adjusted percentage of females containing mature eggs for gonochoristic species; see Section 8.1) will be determined for the whole sample. This percentage will be compared to the definition described in Section 8.1 to determine whether management of turbidity-generating activities, associated with trunkline installation, is required during the upcoming spawning window.

Table 8.4: Coral Reproductive Status Scoring Criteria

Egg Development Status Microscope	Egg Development Status Histology	Interpretation
Eggs present, pigmented (e.g. pink, purple, green) and irregular in shape	Stage IV, late Stage III	Spawning likely to occur in the upcoming spawning window
Eggs present, un-pigmented (white or opaque) and regular in shape	Stage III, late Stage II	Spawning unlikely to occur in upcoming spawning window but is likely to occur in the following spawning window
No eggs present	No gametes, Stage I or Stage II	Spawning will not occur in upcoming spawning window

In the case where monitoring predicts that corals will undergo a mass spawning event in the next spawning window, it will be assumed that spawning will commence at the beginning of the predicted spawning window and no monitoring will be undertaken during the spawning window (this reduces impacts to coral communities through over sampling).

8.3.3 Refinement of Coral Spawning Assessment Procedures

Since coral spawning assessments are within an emerging field, there are likely to be advances in methods and new information on timing of spawning at hand during the course of the Wheatstone trenching and backfill programme. Additionally, data collected during the Wheatstone coral spawning assessments may help to improve knowledge of the timing of spawning in certain genera. New information will be considered and may be used to refine coral spawning assessment procedures where the information improves confidence in the prediction of mass spawning events and management of trenching and backfill activities around these events. In particular, considering the known variability in the timing of spawning of *Porites* in the Pilbara region, information gathered on the reproductive activity (including, but not limited, to the timing of spawning and the proportion of colonies spawning each month during split spawning events) in this genus during Wheatstone trenching and backfill will feed into the refinement of coral spawning assessment procedures and management of trenching and backfill where confidence is improved. Following the collection of each year of field data the OEPA will be consulted in a review of those results and the applicability of existing management in the identification and management of ecologically significant spawning events in this genus.

9.0 MARINE FAUNA MANAGEMENT AND MONITORING

9.1 Background

Potential impacts on marine fauna as a result of the trenching activities include disturbance, entrainment, vessel strike and potential impacts on habitat. These are discussed in detail in the CSMFIMP. Management actions for CSMF from potential impacts from the physical presence of the DSPSs, due to dredge spoil placement activities associated with trunkline installation, are dealt with in this Plan. Management actions for potential impacts to CSMF from trenching activities, including entrainment and disturbance are also dealt with in this plan. Other potential impacts from the construction and operations of the Project are dealt with in the CSMFIMP (Chevron 2012c).

Table 9.1 provides a set of the management measures to be applied to minimise impacts on marine fauna during trenching and placement activities associated with trunkline installation activities in State and Commonwealth waters. Management and reduction of potential impacts to habitats likely to be used by marine mammals and turtles is covered under the sections on hard coral and seagrass, macroalgae and filter feeders.

Table 9.1: Management: Whales, Dolphins, Dugongs and Marine Turtles

Management Area:	**Marine Fauna (Whales, Dolphins, Dugongs and Marine Turtles)**
Performance Objective:	*To manage trunkline installation activities during the construction phase of the Project to reduce, as far as reasonably practicable, Project-attributable impacts on marine fauna.*
Management Triggers (Environmental Performance Standard):	♦ No project-attributable deaths of marine fauna due to trunkline installation activities
Management:	The following measures will be employed to monitor any sightings or interactions with marine fauna: ♦ Prior to commencement of dredging and dredge spoil placement, selected crew will receive training in marine fauna observations, including procedures in the event of injury or death ♦ Condition 10-1 of MS 873 requires at least one dedicated Marine Fauna Observer (MFO), to be on active duty on vessels actively engaged in dredging[20] during all daylight hours when dredging is conducted ♦ Condition 10-3 requires at least one member of the vessel crew (on vessels other than those with an MFO on active duty), trained in marine fauna observation and mitigation measures, to be on active duty during daylight hours during vessel movement. The trained crew member may have other vessel duties <u>Striking impact on Whales, Dolphins and Dugongs</u> ♦ Whale and dugong observations and response procedures including application of ~300 m observation zone and ~100 m

[20] For the purposes of this plan ‘actively engaged in dredging’ only refers to CSDs and TSHDs this is due the low risk to marine fauna posed by the stationary BHD or grab dredge. Note though that a BHD/ grab dredge will have a trained crew member to monitor and ensure management is implemented as required, including recording observed marine fauna.

Management Area:	Marine Fauna (Whales, Dolphins, Dugongs and Marine Turtles)
	exclusion zone will be implemented during dredging and dredge spoil placement works as outlined in Figure 9.1. If calves are present the exclusion zone will be extended to ~300 m ♦ Dolphin observations and response procedures including application of ~150 m observation zone will be implemented during dredging and dredge spoil placement works (Figure 9.1) ♦ The presence of whales, dolphins, or dugongs in or near exclusion zones established for key dredging activities will be recorded ♦ All sightings of whales, dolphins or dugongs that result in any management measures being implemented will be recorded ♦ A trained crew member will maintain a watch, during daylight hours, for whales, dolphins and dugongs while any dredge is on route to and from the dredge area to DSPSs. If sighted, direction/speed will be adjusted to avoid impact (within the safety constraints of the vessel) ♦ A MFO will maintain a watch, during daylight hours, for whales, dolphins and dugongs during dredge operations ♦ Dredge vessels associated with trunkline prelay dredging will transit along the corridors when working at the shorecrossing location out to KP3 and will utilise more direct routes that avoid sensitive receptors when working beyond this point (Figure 9.2) these may be reviewed if required ♦ Vessels engaged in construction of the Project (excluding any vessels engaged in emergency response) will adhere to speed limits presented in the Conservation Significant Marine Fauna Interaction Management Plan (CSMFIMP) or any speed limit designated by the Department of Transport or relevant Port Authority; whichever is lesser (MS 873 Condition 10-4) <u>Entrainment impacts on Marine Turtles (TSHD)</u> ♦ When operating with less than 4 m under-keel clearance, the dredge will initially move slowly through the area before commencing dredging so that the noise and vibration alerts marine turtles in the vicinity and encourages them to leave. This will only be applied on dredging in new areas and not once the work area has been established and if tickler chains are not installed ♦ Dredge pumps will be stopped as soon as practically possible after completion of dredging and where practical the draghead will remain as close as practicable to the seabed until the dredge pump is stopped ♦ When initiating dredging, suction through dragheads will be initiated just long enough to prime the pumps, prior to drag heads engaging the seabed ♦ Tickler chains and/or deflector devices on the draghead of the THSD will be used as a management mitigation approach to reduce potential turtle entrainment ♦ Overflow screens will be used on TSHDs to visually assess (after each hopper load) for turtles and turtle remains associated with entrainment during dredging after each load.
Monitoring:	♦ The following monitoring programmes will provide an indication of potential impacts to marine fauna habitat: ▪ Water quality monitoring (Section 6.3.2)

Management Area:	Marine Fauna (Whales, Dolphins, Dugongs and Marine Turtles)
	▪ Benthic community verification monitoring (Section 6.4.2) ▪ Seagrass, macroalgae and filter feeder monitoring for impact on habitat (Section 7.3.2) ♦ MFO or trained crew members (as applicable) observations of whale, dolphin, dugong and marine turtle throughout trenching ♦ Monitoring of draghead and overflow screens to identify turtle remains ♦ Results from the Dugong Research Plan.

9.2 Management Strategy

Impacts to marine fauna (whales, dolphins, dugongs and marine turtles) from increased turbidity and sedimentation (e.g. direct behavioural impacts or indirect impacts through alteration of foraging habitats) are managed by application of management actions, if necessary, following visual observations during the works and through the water quality monitoring undertaken at monitored reef formations. Section 3.5 provides details on marine fauna species that may be present, their distribution and abundance is detailed in the CSMFIMP (Chevron 2012c).

9.2.1 Marine Mammals

The management of marine mammals will focus on the species most likely to be sighted (whales, particularly humpback whales, and dugongs) and will primarily involve observation and avoidance measures to minimise the risk of dredge vessel interaction with both whales and dugongs (Figure 9.1) and management measures implemented to protect marine fauna habitat.. With respect to dolphins, while their mobility and intelligence means the risk of impact is negligible interactions will be managed in accordance with the requirements for cetacean interactions specified under Part 8 of the EPBC Regulations 2000 (Cth).

Data from the Dugong Research Plan (as detailed in EPBC Reference 2008/4469 Condition 37) will be assessed to identify any impacts that could be associated the trenching activity, and adaptive management will be developed and applied as necessary during the trenching activities (EPBC Reference 2008/4469 Condition 11 b).

9.2.2 Marine Turtles

The management of marine turtles will primarily involve measures to minimise the risk of entrapment/entrainment of the marine turtles within the draghead of the TSHD including the following management actions:

- ♦ Dredge pumps will be stopped as soon as reasonably practicable after completion of dredging and the drag head will remain as close as practicable to the seabed until the dredge pump is stopped
- ♦ When operating with less than 4 m under-keel clearance, the TSHD will initially move slowly through the area before commencing dredging so that associated noise and vibration will alert marine turtles in close proximity and encourage them to leave. This will only be applied to dredging in new areas and not once the work area has been established and if tickler chains are not installed
- ♦ When initiating dredging, suction through dragheads will be initiated just long enough to prime the pumps, prior to drag heads engaging the seabed
- ♦ Tickler chains and/or deflector devices will be used on the drag head of the TSHD.

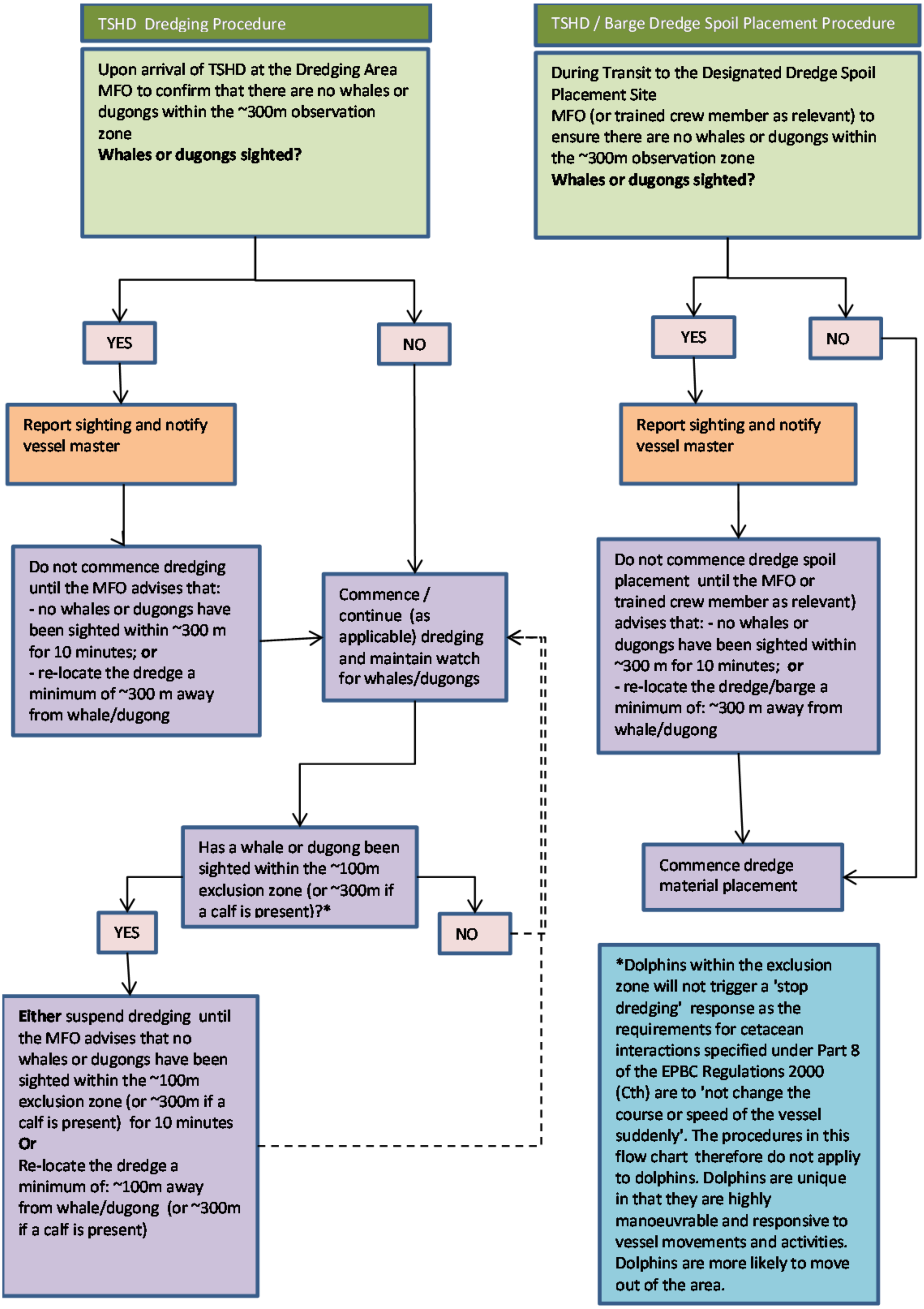

Figure 9.1: Whale, Dolphin and Dugong Interaction Procedures

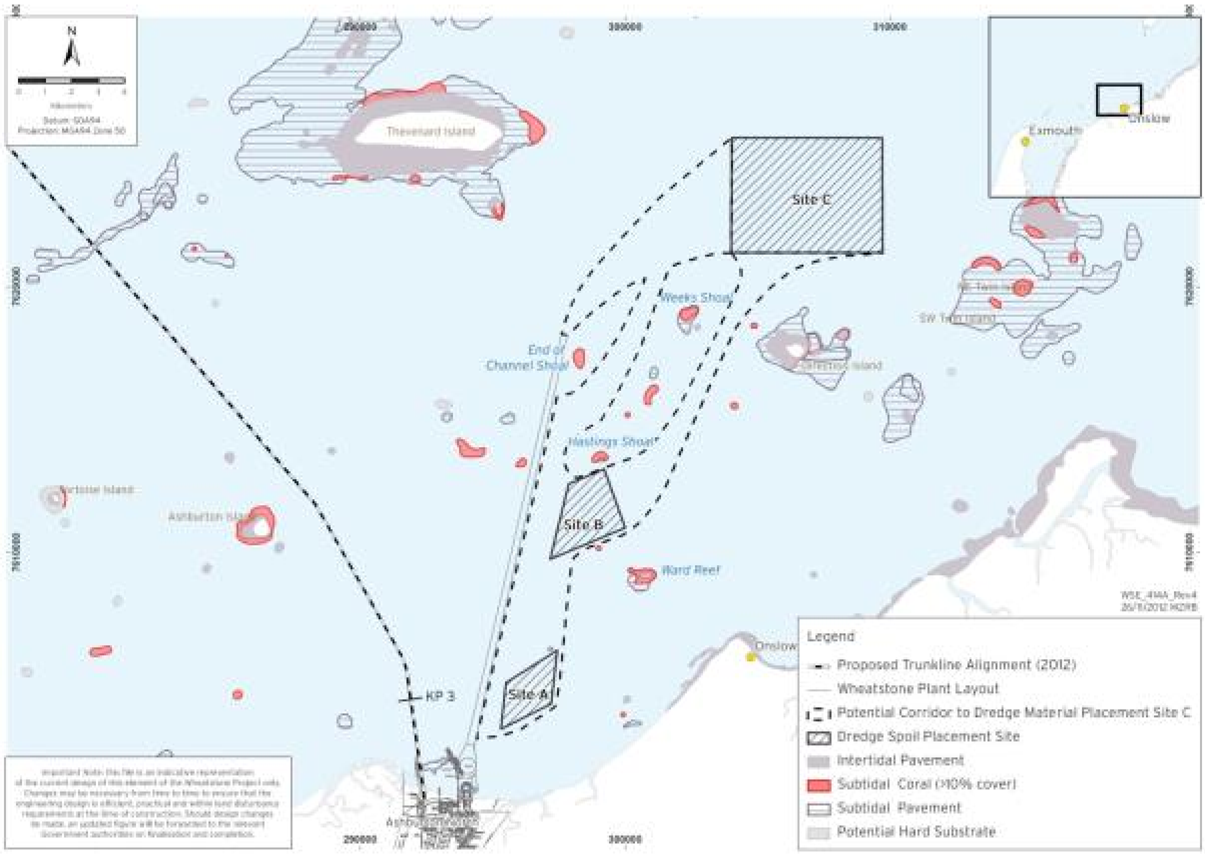

Figure 9.2: Designated Transit Routes to Dredge Spoil Placement Site C

Note: Dredge vessels associated with trunkline prelay trenching will transit along the corridors when working at the shore crossing location out to KP 3 and will utilise more direct routes that avoid sensitive receptors when working beyond this point.

9.3 Monitoring Strategy

The monitoring strategy for marine fauna focuses on the habitat monitoring as outlined in Section 6.0. Sedimentation monitoring is also undertaken at the seagrass and macroalgae sites to detect impacts on habitats potentially used by marine fauna (Section 6.4.2). Specific monitoring of dugongs is dealt with in the Dugong Research Plan.

Monitoring of marine fauna during trunkline installation activities for the Project include:

- Monitoring of draghead and overflow screens to determine if there are any turtle fatalities.
- As required by Condition 10-1 of MS 873, CSD and TSHD will have at least one MFO on active duty during daylight hours. The MFO will have no other vessel duties during on shift time.
- As required by Condition 10-3 of MS 873 vessels, other than CSDs and TSHDs, will have at least one member of the vessel crew, trained in marine fauna observation and mitigation measures, on active duty during daylight hours. The trained crew member may have other vessel duties.
- The MFO, and the trained crew members, on active duty will maintain a log of marine fauna observations (as detailed in MS 873 Condition 10-1 and 10-3).

10.0 DREDGE SPOIL PLACEMENT MANAGEMENT AND MONITORING

10.1 Background

The following dredge spoil placement management procedures will be implemented to minimise impacts from elevated turbidity and sedimentation, due to dredge spoil placement at DSPS D, to BPP and BPPH (Table 10.1).

These management measures are not relevant to:

- DSPS A, B and C which is dealt with in the DDSPEMMP (as these sites are unlikely to be used for the turbidity-generating activities associated with trunkline activities) (Chevron 2012d)
- DSPS E as there are no predicted impacts to corals, seagrass and dugong from dredge spoil placement activities at this site due to the lack of coral and seagrass at those depths.

The nearshore and offshore dredge spoil placement areas that will be utilised are shown in Figure 10.1.

Table 10.1: Summary of Management and Monitoring Measures to Reduce Impacts from Dredge Spoil Placement

Management Area:	**Dredge spoil Placement Area Management**
Performance Objective:	To undertake the dredge spoil management activities in accordance with the requirements of the SDP and Ministerial Statement No. 873: *to minimise the environmental impact of dredge spoil placement activities and any material incremental losses of dredge spoil which may occur following completion of dredge spoil placement at sites in State waters*
Management:	Management of dredge spoil placement site D (dredge spoil placement site C is dealt with in the DDSPEMMP), in State waters: ♦ Division of placement sites to determine the schedule for placement of dredge spoil based on seasonal and metocean conditions and dredge spoil ♦ The use of buffer zones within the perimeter of the placement sites provides a zone to reduce any movement of sediment outside the site boundary following placement or risk of placement of material outside the site Conditions of the SD2011/2102 required the following measures: ♦ Establish by DGPS that the vessel is within the approved dredge spoil placement area immediately prior to dredge spoil placement ♦ Marine mammal management procedures as detailed in Section 9.0 will be followed during dredge spoil placement activities ♦ Records comprising either weekly plotting sheets or a certified extract of the ship‘s log will be retained (for verification and auditing purpose), which detail: ▪ The times and dates of when each dredge spoil placement run is commenced and finished ▪ The position (as determined by DGPS) of the vessel at the beginning and end of each dredge spoil placement run, with the inclusion of the path of each dredge spoil placement run ▪ The volume of dredge spoil (in cubic metres) moved to the placement area

	and quantity in dry tonnes for the specified operational period. These quantities will be compared with the total amount permitted under the SDP Contingency measures for management of DSPSs in State waters (DSPS D): ♦ Review the division of placement sites and the schedule for placement of dredge spoil based on seasonal and metocean conditions, buffer zones, dredge spoil update to take account any impacts that have been observed
Monitoring:	1. A bathymetric survey of the dredge spoil placement areas will be undertaken of dredge spoil placement site D: a) Prior to the commencement of trenching b) Within one months of the completion of all dredge spoil placement activities authorised under the SDP 2. Mobile Vessel Monitoring

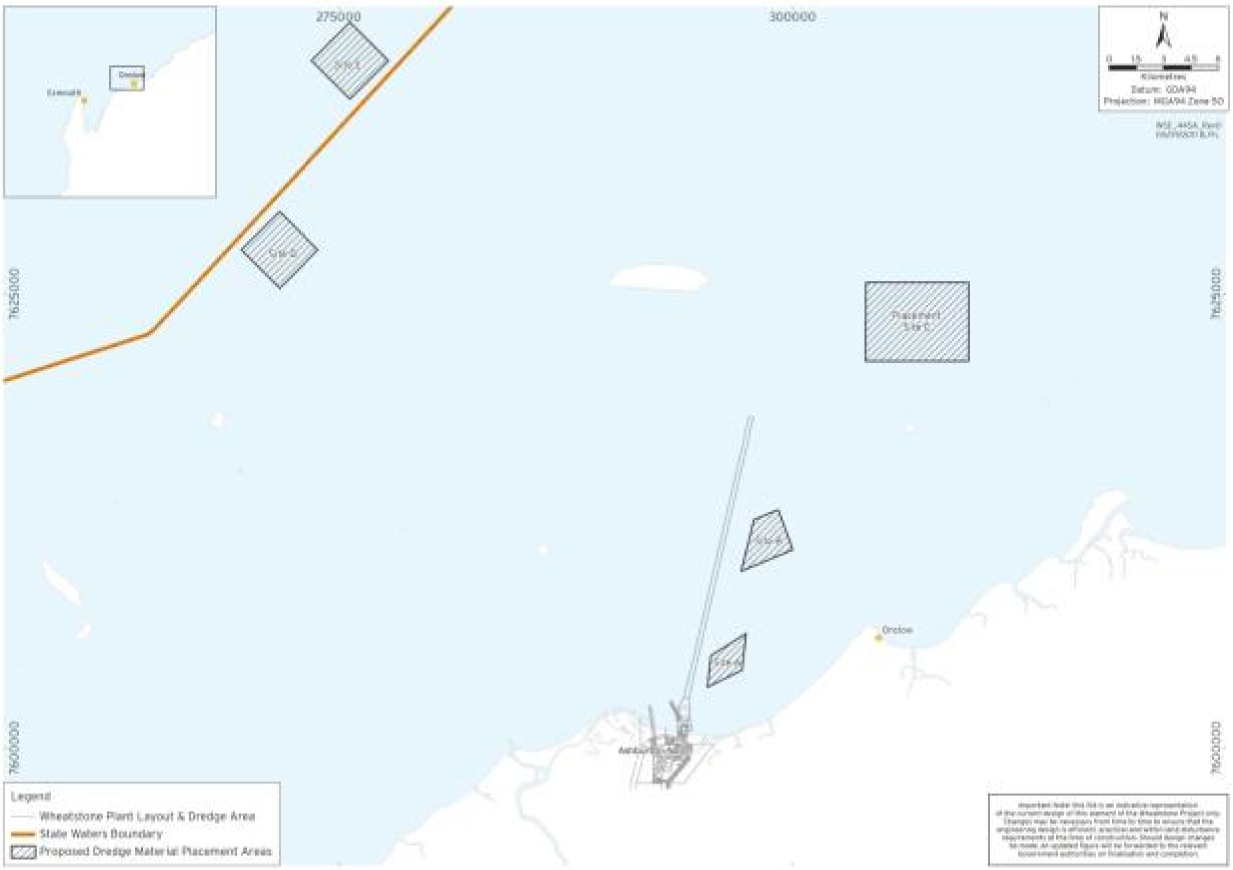

Figure 10.1: Dredge Spoil Placement Areas

10.2 Management Approach

To reduce the incremental loss of spoil from the placement site, a number of management measures will be implemented during disposal activities at Spoil Placement Site D (management of Spoil Placement Site C is dealt with within the DDSPEMMP) (Chevron 2012d). Management measures will focus on the division of the placement sites into specified areas as illustrated in Figure 10.2. These may include, but is not limited, to the following:

- ♦ Buffer zones where no material can be placed to reduce the potential for placement outside of the designated boundary as seen in Figure 10.2

- Specified cells which will be the basis for a schedule of placement of dredge spoil based on seasonal and metocean conditions to reduce plume exposure outside of the placement sites and the potential for environmental impact to nearby receptors.

Disposal tracking of each load will be undertaken to ensure accuracy of placement (established by DGPS) that the vessel is within each placement site.

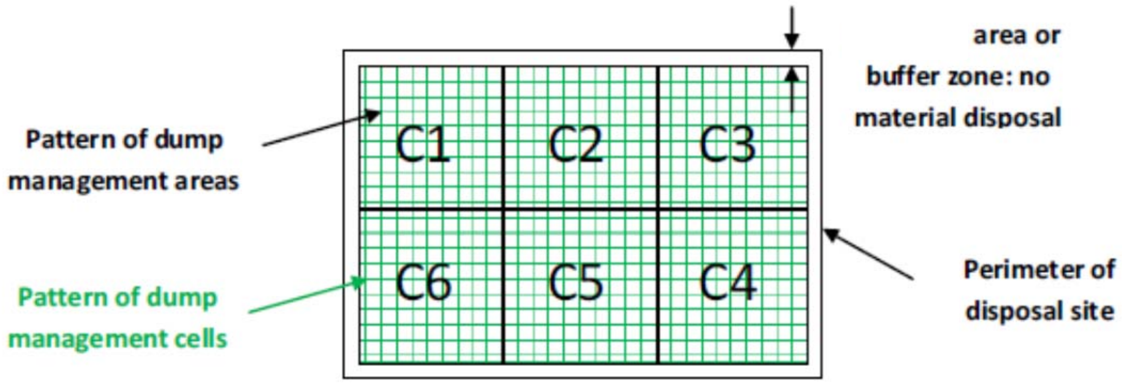

Figure 10.2: Example of Division of a Placement Site for Dredge Spoil

10.2.1 Contingency Measures

As a contingency measure, following any unexpected impacts resulting from placement activities, there will be a review of the division of placement sites and the schedule for placement of dredge spoil. Changes will be made to the schedule as necessary to reduce the potential for any further impacts.

If it is determined that changes to the division of the placement sites and the schedule for placement of dredge spoil will not mitigate impacts dredge spoil placement will be moved to another dredge spoil placement site (e.g. DSPS C or E).

10.3 Monitoring Approach

Monitoring of the retention, stability and fate of the dredge spoil at the dredge spoil placement site D (management of Spoil Placement Site C is dealt with within the DDSPEMMP) will involve both bathymetric surveys and a water quality monitoring programme.

10.3.1 Bathymetric Surveys

Surveys will be undertaken prior to placement (to establish a baseline) and within one month following the last placement at the site. Bathymetric surveys will reveal seabed features such as sand waves and mounding, including potential navigation hazards. Comparison of the surveys and consideration of disposal records will depict the movement of material within and surrounding these sites.

10.3.2 Water Quality Programme

Additional monitoring of the fate of the dredge spoil would involve the analysis of data from water quality loggers placed at monitoring sites (both reef formations and non-reef sites) and/or mobile vessel monitoring.

Mobile Vessel Monitoring

The modelling indicated that following the initial release of fines during placement, sediment release would be insignificant. This would be validated at each placement site through the monitoring of water quality using a mobile vessel.

11.0 CUMULATIVE IMPACTS MANAGEMENT AND MONITORING

11.1 Background

It is likely that the turbidity-generating activities for trunkline installation, trenching and sand backfill, will occur simultaneously with the turbidity generating activities for the nearshore and offshore marine facilities, dredging of the MOF, PLF and PLF approach channel. If these operations occur simultaneously there is risk of cumulative impacts if the sediment plumes from the two programmes overlap. The following procedures will be implemented to manage the risk of overlapping plumes (Table 11.1).

Table 11.1: Summary of Management and Monitoring Measures to Manage Cumulative Impacts from Turbidity-generating Activities associated with Trunkline Installation and construction of Nearshore and Offshore Marine Facilities

Management Area:	**Cumulative Impacts from turbidity-generating activities associated with trunkline installation and construction of nearshore and offshore marine facilities**
Performance Objective:	*To achieve the following:* *Cumulative impacts from turbidity generating activities associated with the trunkline installation undertaken simultaneously with turbidity generating activities associated with the construction of the nearshore and offshore marine facilities are managed so as to achieve the EPOs set in Condition 8-7 and Condition 6-1 (or any revised EPOs). (Condition 8-8 (iii)).*
Preventative Management:	The cumulative impacts management framework by The Project is described below and Figure 11.1 provides an overview of the management and monitoring components of the cumulative impacts management framework. Preventative management of the potential impacts on monitored reef formations will be determined via the following prior to and during activities: ♦ Prior to turbidity generating activities model combined turbidity-generating activities associated with both trunkline installation and the construction of nearshore and offshore marine facilities to identify likely critical scenarios of combinations of climatic conditions and, in particular, dredging and dredge spoil placement activities that could lead to overlapping plumes ♦ Assessment of model outputs against management triggers at all monitoring reefs and non-reef sites to assess risk of Level 2 exceedences from cumulative effects. Responsive management actions will be based on the monitoring results (as detailed below) and will follow the management actions described in Section 6.0.
Management Actions	♦ Turbidity-generating activities will be scheduled, where practicable, to avoid the risk of overlapping plumes that may result in a Level 2 exceedence based on the outcomes from the modelling of the combined operations or where not practicable, implement adaptive management measures.
Monitoring:	♦ Use of daily MODIS imagery to determine location of plumes from the turbidity-generating activities associated with trunkline installation and the construction of nearshore and offshore marine facilities. ♦ Hindcast/Forecast modelling of turbidity-generating activities

	associated with trunkline and the turbidity-generating activities associated with the construction of the nearshore and offshore marine facilities. ♦ water quality monitoring at monitored reef formations at risk of cumulative impacts

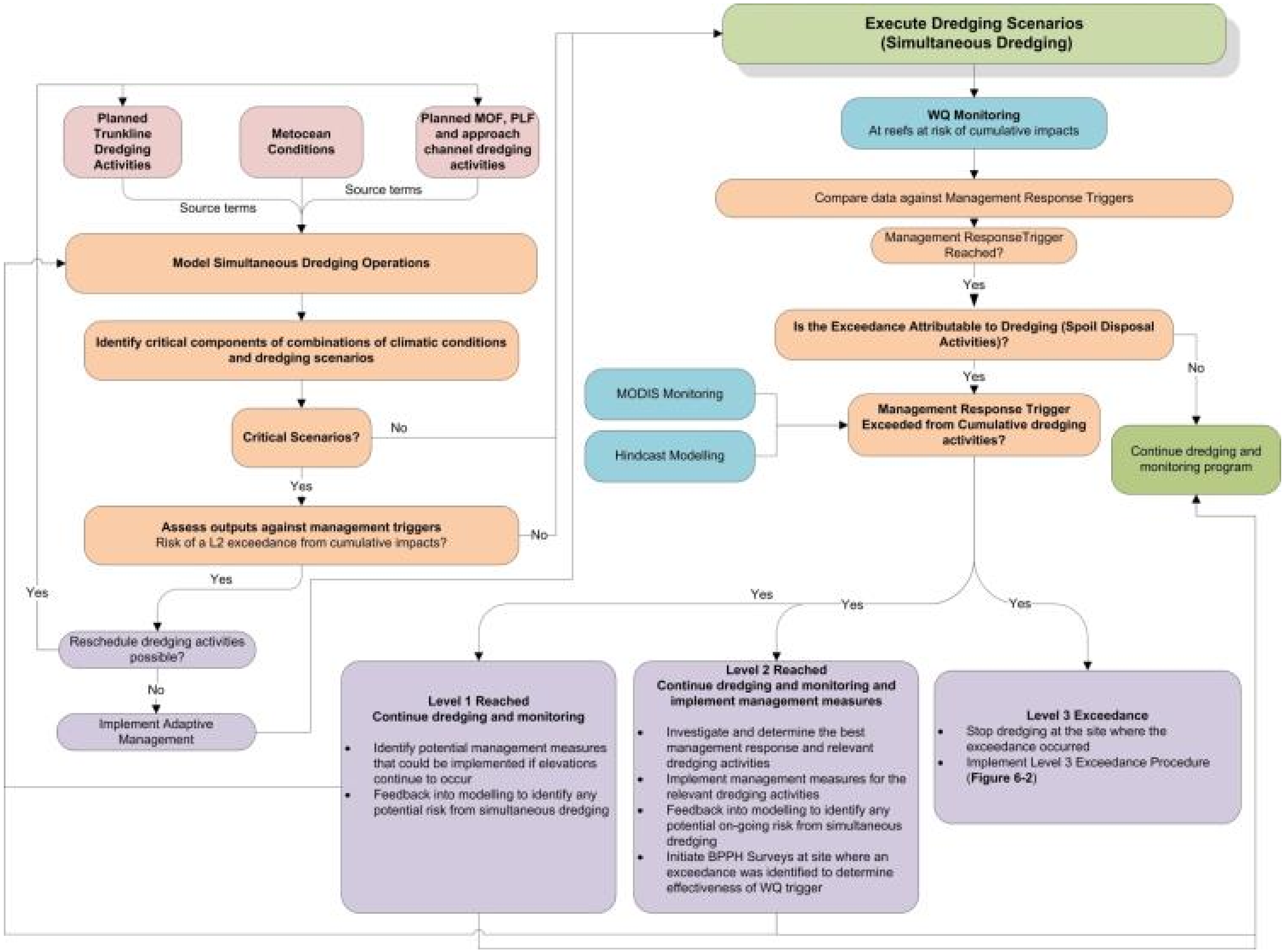

Figure 11.1: Cumulative Impacts Management Framework

11.2 Management Strategy for Cumulative Impacts

Prior to the commencement of simultaneous dredge operations an assessment of turbidity generating activities will be undertaken by The Project to minimise the risk of cumulative impacts (Figure 11.1). Modelling will be undertaken of the combined turbidity-generating programmes to identify scenarios that have high risk of resulting in cumulative impacts. The modelling will assist in the identification of likely critical scenarios of combinations of climatic conditions and locations that could result in cumulative impacts, for example, dredging and dredge spoil placement activities. The modelling outputs will also be interrogated with the BPPH tolerance limits to provide cumulative impact maps and against management triggers to assess the risk of a Level 2 exceedence from cumulative effects.

It is also recognised that the execution programmes of the turbidity generating activities may change through the works, such that forecasting of proposed activities will also be subject to assessment of turbidity generating activities. Modelling will be undertaken based on look-ahead schedules (e.g. one month) and forecast winds, tides and production data (from both the trunkline installation activities and the construction of nearshore and offshore marine facilities). This modelling will allow an assessment of risk of cumulative impacts. If a risk of an impact or Level 2 exceedence is predicted, this will be flagged immediately and, where possible, the rescheduling or activities will occur or adaptive management process implemented.

11.3 Monitoring Strategy for Cumulative Impacts

To ensure that the management of turbidity generating activities has been effective in avoiding impacts from overlapping plumes, the following three monitoring programmes will be undertaken

1. water quality monitoring at monitored reef formations at risk of cumulative impacts
2. MODIS imagery acquisition and analysis; and
3. Hindcast modelling of turbidity-generating activities.

11.3.1 Water Quality Monitoring

Water quality at monitored reefs at risk of cumulative impacts (see Section 11.2) will be assessed on a daily basis to determine whether the management triggers (see Section 6.0) have been exceeded due to simultaneous turbidity generating activities. The variables, data collection, methods and data analysis will be the same as described in Section 6.3.1. If it is determined that a management trigger has been exceeded or an EPO has not been achieved the appropriate monitoring and management measures will be implemented (see Figure 11.1). MODIS imagery (Section 11.3.2) and hindcast modelling (Section 11.3.3) will be used to determine how the different turbidity generating activities have contributed to the exceedence of the management trigger. This will allow the implementation of targeted management actions.

11.3.2 MODIS Imagery

MODIS imagery will be collected on a daily basis, weather permitting. Both light attenuation algorithms and TSS algorithms will be developed to allow near real time delivery of TSS and light attenuation maps. These maps will allow the identification of the sediment plumes from turbidity-generating activities and determine whether additional management measures are required to reduce the risk of impacts from overlapping plumes e.g. move location of the dredging activities.

11.3.3 Hindcast Modelling

Modelling will be undertaken with measured winds and production data (from both the trunkline installation activities and the construction of nearshore and offshore marine facilities). This modelling will allow an assessment of risk of cumulative impacts. If a risk of an impact is predicted, this will be flagged immediately and incorporated into the adaptive management process.

These plots will allow the identification of the sediment plume from turbidity-generating activities and determine whether additional management measures are required to reduce the risk of overlapping plumes e.g. move the location of the dredging activities.

12.0 REPORTING AND REVIEW PROCEDURES

This section provides a framework for external reporting to regulatory authorities relevant to this Plan, including scheduled and unplanned reporting.

12.1 Annual Compliance Reporting

Both a state and Commonwealth annual Compliance Assessment Report (CAR) are required by MS 873 and EPBC 2008/4469 respectively. Both reports assess compliance against Ministerial conditions within the compliance reporting period being 31 August to 30 August of each compliance year, with each CAR due by 30 November. As part of the preparation of the annual CARs, Chevron Australia will assess its compliance status against this Plan, which will be guided by the Action Table provided in Appendix A.

12.2 Incident and Other Reporting

Table 12.1 summarises the regulatory reporting requirements associated with the turbidity-generating activities associated with trunkline installation.

Table 12.1: Reporting Requirements for Turbidity-Generating Activities associated with Trunkline Installation

Report	Content (content will be provided where available, relevant, after QA/QC verification)	Timeframe	Recipient
Dredge Spoil Placement Site Monitoring			
Final report	Data to present: ♦ Bathymetric & dump plot survey results ♦ Management measures Data to incorporate as needed: ♦ water quality data ♦ Sediment trap results ♦ Metocean conditions ♦ MODIS data Conclusion	Three months following completion of dredge spoil placement.	OEPA
Water Quality Monitoring			
Zone of Influence			
Characterised Zone of Influence	Will detail the spatial extent of the Zone of Influence and compare with the predicted extent of the Zone of Influence derived through modelling predictions	Annually – First report to be submitted 15 months after turbidity-generating activities, associated with trunkline installation, commences (with first 12 months of data)	OEPA

Report	Content (content will be provided where available, relevant, after QA/QC verification)	Timeframe	Recipient
Level 2 exceedence			
a. Formal report (proforma)	Results of investigation (water quality results at selected sites, metocean conditions, trenching and backfill activities, MODIS data, management measures)	Within 5 days following identification and confirmation of a trigger exceedence	OEPA/DTAP/ DotE
b. Close out report (proforma)	water quality results at selected sites, metocean conditions, trenching and backfill activities, MODIS data, management implemented and effectiveness	5 days following reduction of water quality to below Level 2 trigger intensity levels	OEPA/DTAP/ DotE
Level 3 exceedence			
a. Notification of Exceedence	Notification of exceedence and that all dredging activities that have or may have caused or contributed to the exceedence have ceased	Within 48 hour cessation of relevant trenching and/or backfill activities	OEPA/DTAP/ DotE
b. Re-commencement report of dredging activities found to have not contributed to the exceedence	Results of investigation (water quality results at selected sites, metocean conditions, trenching and backfill activities, MODIS data, modelling)	Within 2 days of recommencement of relevant trenching and/or backfill activities	OEPA/DTAP/ DotE
Confirmation of non exceedence of the Level 2 or Level 3 management triggers			
Water quality trigger assessments (non exceedence)	Results of the water quality trigger assessment, associated inference assessments and conclusions on non exceedence.	6 business days after the last daily WQ download	OEPA/DTAP/ DotE
Regular Reporting			
Water quality triggers assessments	Results of the water quality trigger assessment, any associated inference assessments and conclusions.	On a 6-weekly basis	DTAP/ DotE
		When a Level 1 Management Trigger has been exceeded	OEPA
Coral EPO Assessments			
Achievement of EPOs			
1. Recommence ment of all trenching and backfill activities	Results of investigation including the inference assessment (water quality results at selected sites, metocean conditions, trenching and backfill activities, MODIS data, management measures, latest BPPH data and coral EPO assessments	Within 2 days of re-commencement of relevant trenching and backfill	OEPA/DTAP/ DotE

Report	Content (content will be provided where available, relevant, after QA/QC verification)	Timeframe	Recipient
	and modelling)	activities	
Non Achievement of EPOs			
2. (a) Notification of Exceedence	Notification that all turbidity-generating activities associated with trunkline installation have been suspended	Within 24 hours of the suspension	OEPA/DTAP/ DotE
3. (b)Report to minister (cond. 8-13)	Results of investigation (water quality results at selected sites, metocean conditions, dredging activities , MODIS data, management measures)	Within 48 hours after implementation of Condition 8-13	OEPA/DTAP/ DotE
4. (c)Recommencement report (cond. 8-15)	Results of investigation (water quality results at selected sites, metocean conditions, trenching and backfill activities , MODIS data, management measures, latest BPPH data, modelling, revision of EPOs if required)		OEPA/DotE/DTAP
BPPH monitoring			
Exceedence feedback monitoring			
a. Close out report after 2nd survey	BPPH results, conclusion on effectiveness	Within 10 days following the completion of field survey	OEPA/DTAP/ DotE
Verification Monitoring			
b. Verification that water quality criteria are affording appropriate protection	Results of BPPH surveys and water quality verification investigations including light and sediment deposition	Annually – First report to be submitted 15 months after trenching commences (with first 12 months of data)	OEPA/DTAP/ DotE
Marine Fauna			
Injury to, or mortality of an EPBC listed threatened or migratory species from dredging activities	NA	Within 24 hours of observation	DotE/DPAW

Condition 4-5 (MS 873) requires reporting of any potential non-compliance.

Condition 3 requires reporting of any non-compliance with the conditions of EPBC Approval 2008/4469.

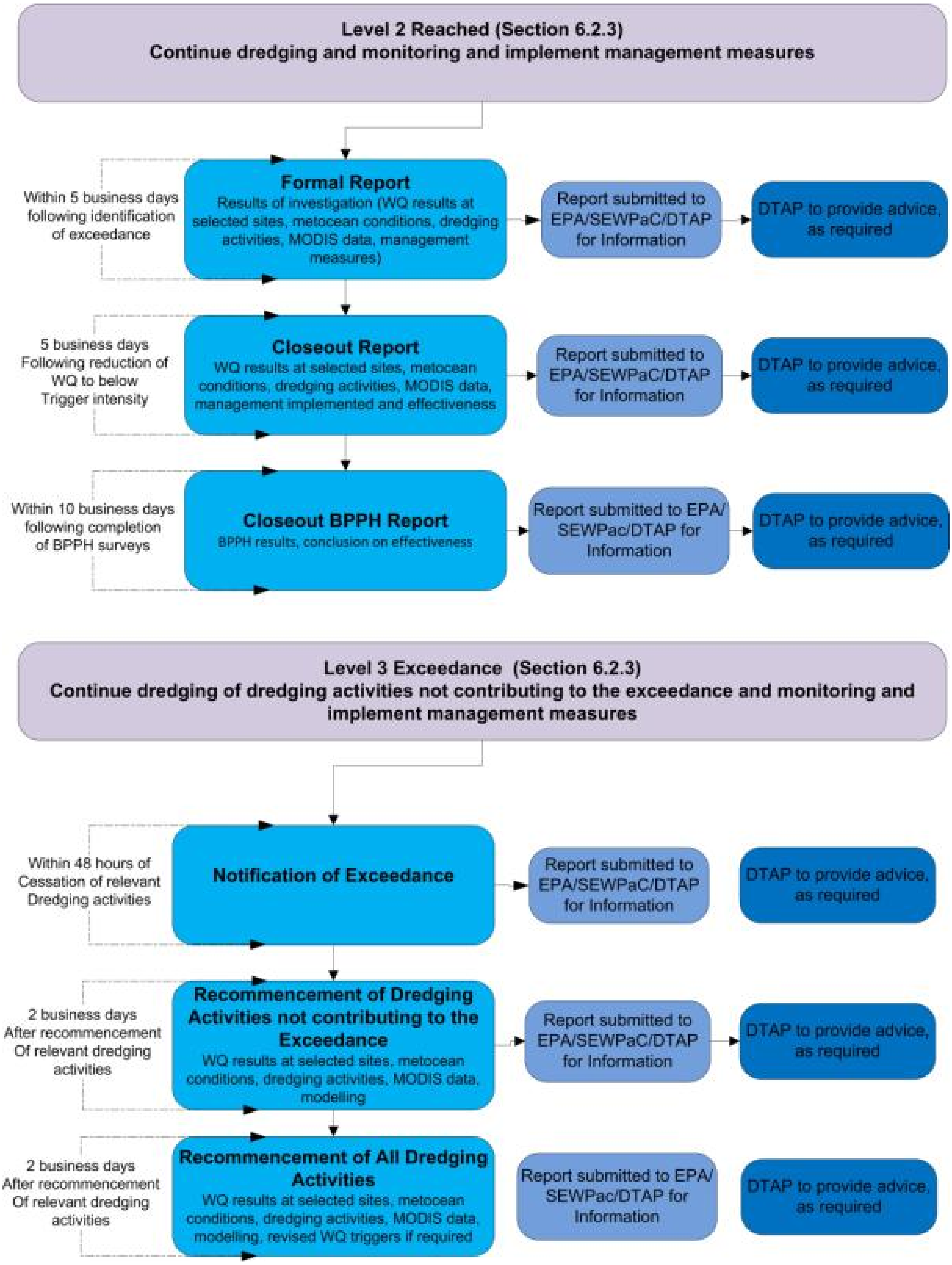

Figure 12.1: Reporting Requirements if a Level 2 trigger and/or a Level 3 Trigger are Exceeded

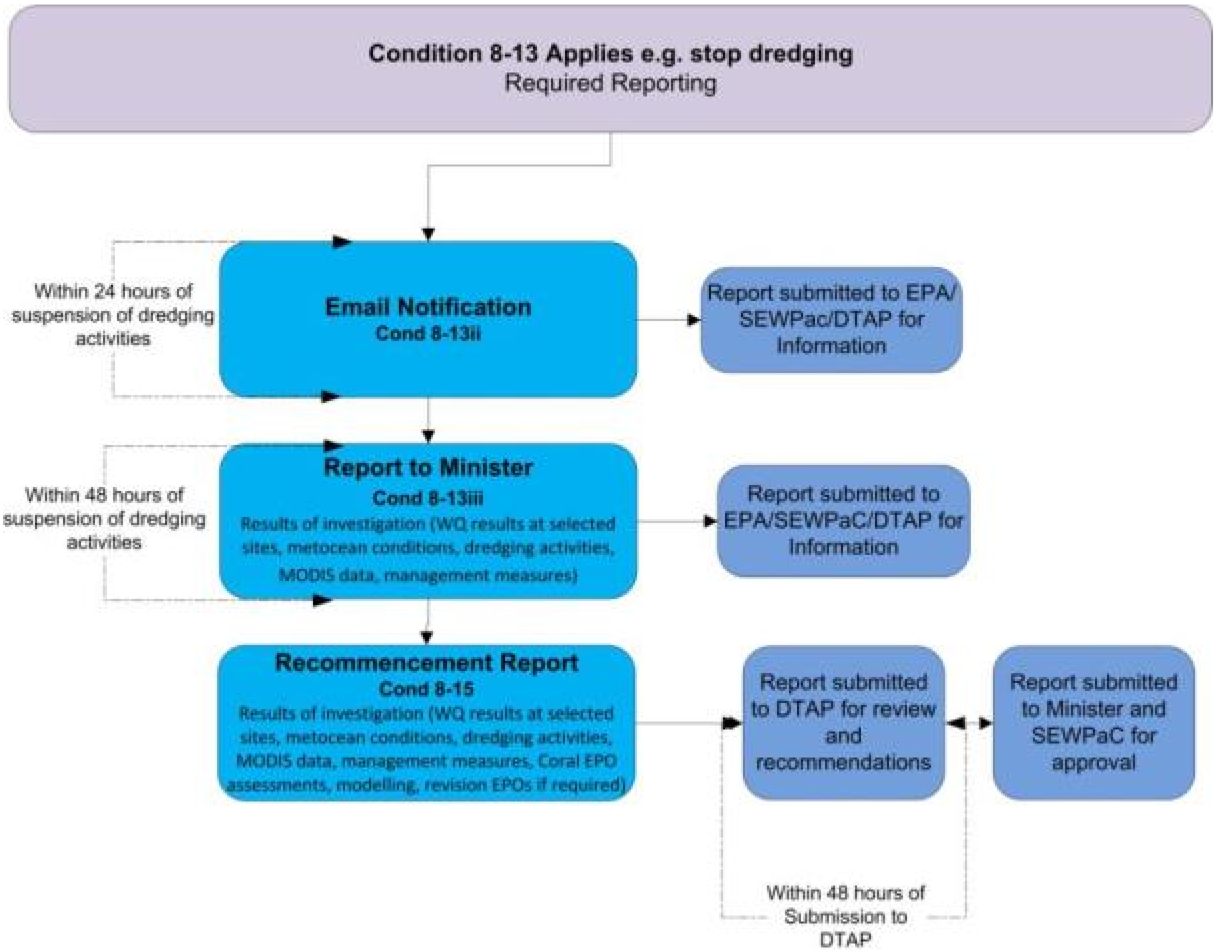

Figure 12.2: Reporting required to recommence Dredging Activities following a Non-achievement of the Coral EPOs

12.3 Reviews of the Plan

Chevron Australia is committed to conducting activities in an environmentally responsible manner and aims to implement reviews of its environmental management actions as part of a programme of continuous improvement. This commitment to continuous improvement means that the Proponent will review the Plan to address matters such as the overall effectiveness, environmental performance, changes in environmental risks and changes in business conditions on an as needed basis (e.g. in response to new information).

In accordance with Condition 24-1 of MS 873, Chevron Australia will implement any amendment to this Plan from the date of the amendment. Significant amendments may only be implemented from the date of approval of the amendment by the CEO. Significant amendments are those amendments which alter the obligations of Chevron Australia, that is, are not minor or administrative.

If new EPOs and additional management measures are approved by the Minister under Condition 8-16, Condition 8-17 provides that these are taken to have effect as if they were part of the approved Plan. An updated Plan will be provided to the CEO and made publicly available when practicable after the changes take effect.

In accordance with Conditions 5 and 6 of EPBC 2008/4469, Chevron Australia may only implement the Project otherwise than in accordance with the provisions of this Plan which regulate the matters of NES relevant to this Plan from the date of approval of any variation to this Plan by the Commonwealth Minister. Any new EPOs and any additional management measures approved by the State Minister in accordance with Conditions 8-16 and 8-17 of MS 873 that regulate matters of NES relevant to this Plan will require an update to the Plan.

12.3.1 Dredging Technical Advice Panel Reviews

EPBC Reference 2008/4469 requires the establishment, funding and management of a Dredging Technical Advice Panel (DTAP) prior to and for the duration of the dredging programme. In accordance with Condition 17 and 21 of EPBC Reference 2008/4469 the role of DTAP is to undertake reviews for adaptive management purposes. The timing, frequency, scope and objective of DTAP reviews of this Plan are outlined within the DTAP Terms of Reference (ToR) as amended from time to time.

12.3.2 Additional Reviews

At the time of the DTAP reviews (as detailed in Section 12.3.1) any results from the Dugong Research Plan and any seagrass surveys undertaken will be considered and any changes to the adaptive management processes, if applicable.

13.0 REFERENCES

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APPENDICES

CONTENTS

Appendix A Action Table

No.	Reference	Action	Timing
Water Quality and Benthic Primary Producer Habitat Management			
1	Table 6.1	TSHD overflow pipes will be equipped with a turbidity-reducing green valve	Prior to commencement of TSHD operations
3	Table 6.1	Raising the overflow pipe to avoid spillage during transit of the TSHD, where equipment permits	During all sediment transport by TSHD
4	Table 6.1	TSHD bottom doors and split-hopper barges hull seals inspected prior to mobilisation	Prior to commencement of TSHD operations
5	Table 6.1	Well-maintained and properly calibrated dredging equipment will be utilised	Prior to commencement of dredge
6	Table 6.1	Transiting via designated corridors to Dredge Spoil Placement Site C	Throughout TSHD/barges operations
8	Table 6.1	Maintaining a 0.5 nautical mile buffer zone around coral reefs to the east of the approach channel to limit stress associated with sediment re-suspension from propeller wash	Throughout TSHD/barges operations
9	Table 6.1	GPS, monitoring and automation systems on specified equipment	Throughout trenching and backfill
10	Table 6.1	Flexibility within the dredge execution plan allows adaptive management of dredging activities	Throughout trenching
11	Table 6.1	Route selection to minimise turbidity caused by vessel props, where practicable	Throughout trenching
12	Table 6.1	Employing appropriate cutter heads for differences in soil types to reduce suspended solids generation	Throughout CSD operations
Water Quality and Benthic Primary Producer Habitat (Hard Coral) Management			
13	Section 6.0	Responsive water quality monitoring and associated tiered responsive management and coral EPO assessment monitoring will be implemented to manage any potential impacts that increased turbidity may have on monitored reef formations. *Water Quality Monitoring*	Throughout trenching and backfill

No.	Reference	Action	Timing
		Water quality measurements will be logged at approximately 30 minute intervals at monitored reef formations throughout the duration of the dredging and dredge spoil placement works. Water quality monitoring will be achieved through the use of *in-situ* water quality data logging instruments. Refer to Section 6.4 for further details of the water quality monitoring programme. The results of the water quality monitoring will be: ♦ Assessed against management triggers, as detailed in Section 6.3.2. ♦ Used to assist in inferring the cause of any observed impacts to benthic communities. *<u>Coral EPO Assessment Monitoring</u>* Coral cover will be surveyed at the ‘affected reef formation’ following an exceedence of a Level 3 management trigger. Refer to Section 6.4.1.3 for further details of the EPO assessment monitoring programme. The results of this monitoring will be used to assess if net live coral cover at the affected reef had declined as a result of dredging and if this decline was greater than the EPOs defined in MS 873 Condition 6-1. *<u>Verification Monitoring</u>* Monitoring will consists of: ♦ Quarterly routine monitoring of benthic communities at the monitored reef formations (Figure 6.5) to provide verification of the appropriateness of water quality criteria. ♦ Verification monitoring which will be triggered by an exceedence of the Level 2 management trigger. Monitoring of benthic communities will be at the monitored reef formations (Figure 6.5) at which triggers were exceeded, and at associated reference reefs. Note: Data collected under this monitoring programme will not be used to assess achievement of the EPOs or MOs.	
Subtidal Benthic Primary Producer Habitat Management (Seagrass, macroalgae and filter feeder communities)			
14	Section 7.0	*<u>Responsive Water Quality Monitoring</u>* Responsive water quality monitoring and associated management triggers will be implemented to manage any potential impacts that increased turbidity may have on seagrass. Water quality measurements will be logged at approximately 30 minute intervals at	Throughout trenching and backfill

No.	Reference	Action	Timing
		seagrass communities throughout the duration of the turbidity-generating activities which are part of the construction of the nearshore and offshore facilities. Water quality monitoring will be achieved through the use of an *in-situ* water quality data logging instrument. Refer to Section 6.4 for further details of the water quality monitoring programme. The results of the water quality monitoring will be: ♦ Assessed against management triggers, as detailed in Section 6.3.2. ♦ Used to assist in inferring the cause of any observed impacts to benthic communities. *Verification Monitoring* Monitoring will consists of: ♦ Quarterly routine monitoring of seagrass (Figure 7.2) to provide verification of the appropriateness of water quality criteria. ♦ Verification monitoring which will be triggered by an exceedence of the Level 2 management trigger at the seagrass location (Figure 7.2) at which the triggers were exceeded. Note: Data collected under this monitoring programme will not be used to assess achievement of the EPOs or MOs. *Habitat Monitoring* Pre/during/post surveys assessments of seagrass, macroalgae and filter feeders under the State of the Marine Environment SoW.	
Marine Fauna Management			
15	Table 9.1	Condition 10-1 of MS 873 requires at least one dedicated Marine Fauna Observer (MFO), to be on active duty on vessels actively engaged in dredging during all daylight hours when dredging is conducted.	Throughout trenching
16	Table 9.1	Condition 10-3 requires at least one member of the vessel crew (on vessels other than those with an MFO on active duty), trained in marine fauna observation and mitigation measures, to be on active duty during daylight hours during vessel movement. The trained crew member may have other vessel duties.	Throughout TSHD and CSD operations
17	Table 9.1	Whale and dugong observations and response procedures including application of ~300 m observation zone and ~100 m exclusion zone will be implemented during dredging and dredge spoil placement works as outlined in Figure 9.1. If calves are	Throughout trenching

No.	Reference	Action	Timing
		present the exclusion zone will be extended to ~300 m.	
18	Table 9.1	Dolphin observations and response procedures including application of ~150 m observation zone will be implemented during dredging and dredge spoil placement works (Figure 9.1).	Throughout trenching
19	Table 9.1	A trained crew member will maintain a watch, during daylight hours, for whales and dugongs while any dredge is en route to and from the dredge area to DSPSs. If sighted, direction/speed will be adjusted to avoid potential impact (within the safety constraints of the vessel) to marine mammals.	Throughout trenching
20	Table 9.1	Dredge vessels associated with trunkline prelay dredging will transit along the corridors when working at the shorecrossing location out to KP 3 and will utilise more direct routes that avoid sensitive receptors when working beyond this point (Figure 9.2) these may be reviewed if required.	Throughout trenching
21	Table 9.1	Management of whale, dolphin and dugong interactions will be in accordance with the requirements for cetacean interactions specified under Part 8 of the EPBC Regulations 2000 (Cth), the Australian National Guidelines for Whale and Dolphin Watching as amended from time to time.	Throughout trenching
22	Table 9.1	The presence of cetaceans/dugongs in or near exclusion zones established for key dredging and construction activities will be recorded.	Throughout trenching
23	Table 9.1	All sightings of whales, dolphins or dugongs that result in any management measures being implemented will be recorded.	Throughout trenching
24	Table 9.1	Details of at risk conservation significant marine fauna (CSMF) sighting within vessel work areas and/or corridors of vessel movement between work areas will be communicated to the coordinator of Project vessel movements (or equivalent) to warn other vessels operating in the area, as soon as it is safe to do so.	Throughout trenching
25	Table 9.1	Vessels engaged in construction of the Project (excluding any vessels engaged in emergency response) will adhere to speed limits presented in the Conservation Significant Marine Fauna Interaction Management Plan (CSMFIMP) or any speed limit designated by the Department of Transport or relevant Port Authority; whichever is lesser (MS 873 Condition 10-4).	Throughout trenching
26	Table 9.1	Dredge pumps on TSHD will be stopped as soon as practical possible after completion of dredging and where practical the drag head will remain as close as practicable to the	Throughout TSHD operations

No.	Reference	Action	Timing
		seabed until the dredge pump is stopped.	
27	Table 9.1	When operating with less than 4 m under-keel clearance, the TSHD will initially move slowly through the area before commencing dredging so that associated noise and vibration will alert marine turtles in close proximity and encourage them to leave. This will only be applied to dredging in new areas and not once the work area has been established and if tickler chains are not installed.	Throughout TSHD operations
28	Table 9.1	When initiating dredging, suction through dragheads will be initiated just long enough to prime the pumps, prior to drag heads engaging the seabed.	Throughout TSHD operations
29	Table 9.1	Tickler chains and/or deflector devices on the drag head of the TSHD will be used as a management mitigation approach to reduce turtle entrainment.	Throughout TSHD operations
30	Table 9.1	Overflow screens will be used on TSHD to visually assess for turtles and turtle remains associated with entrainment during dredging after each load.	Throughout TSHD operations
31	Table 9.1	A MFO will maintain watch, during daylight hours, for whales, dolphins and dugongs during dredge operations	Throughout trenching works from Nov-April
32	Table 9.1	All observations of marine fauna will be recorded by the MFO, or trained crew member (as appropriate), and submitted to DPAW and DotE annually.	Throughout trenching
33	Table 9.1	All CSMF incidents will be reported to the Department of Environment and Conservation (now DPaW) within 24 hours of the observation as per MS 873 Condition 10-16ii.	Throughout trenching
34	Table 9.1	All CSMF and EPBC Listed Threatened or Migratory species incidents will be reported to the Minister responsible for administering the EPBC Act within one business day of observation as required by EPBC 2008/4469 Condition 26(e).	Throughout trenching
35	Table 9.1	Observations of any at risk marine fauna will be reported to the vessel master (or their delegate) as soon as practicable	Throughout trenching
36	Table 9.1	Prior to commencement of dredging and dredge spoil placement, selected crew will receive training in marine fauna observations, including procedures in the event of injury or death	Throughout trenching
Dredge Spoil Placement Area Management			
37	Table 10.1	At the offshore sites the placement of dredge spoil will comply with the requirements of	

No.	Reference	Action	Timing
		the Sea Dumping Permit (SDP), including: ♦ Establish by Differential Global Positioning System (DGPS) that, immediately prior to dredge spoil placement, the vessel is within the approved dredge spoil placement area. ♦ Any dredge used in connection with the dredge spoil placement activities and any associated towing vessels must be capable of disposing dredged material at the DSPSs in accordance with the SDP. ♦ Marine mammal management procedures as detailed in Section 9.2 will be followed during dredge spoil placement activities. ♦ Records comprising either weekly plotting sheets or a certified extract of the ship‘s log will be retained (for verification and auditing purpose), which detail: ▪ the times and dates of when each dredge spoil placement run is commenced and finished ▪ the position (as determined by DGPS) of the vessel at the beginning and end of each dredge spoil placement run, with the inclusion of the path of each dredge spoil placement run; and ▪ the volume of dredge spoil (in cubic metres) dumped and quantity (in dry tonnes) for the specified operational period and compare these quantities with the total amount permitted under the SDP.	
38	Table 10.1	Division of placement sites to determine the schedule for placement of dredge spoil based on seasonal and metocean conditions and dredge spoil	Throughout dredge spoil placement activities
39	Table 10.1	The use of buffer zones within the perimeter of the placement sites provides a buffer zone to reduce any movement of sediment outside the site boundary following placement or risk of placement of material outside the site	Throughout dredge spoil placement activities
40	Table 10.1	A bathymetric survey of the dredge spoil placement areas will be undertaken: ♦ Prior to the commencement of dredging ♦ Within one months of the completion of all dredge spoil placement activities authorised under the SDP	Pre-dredging and one month post-dredging