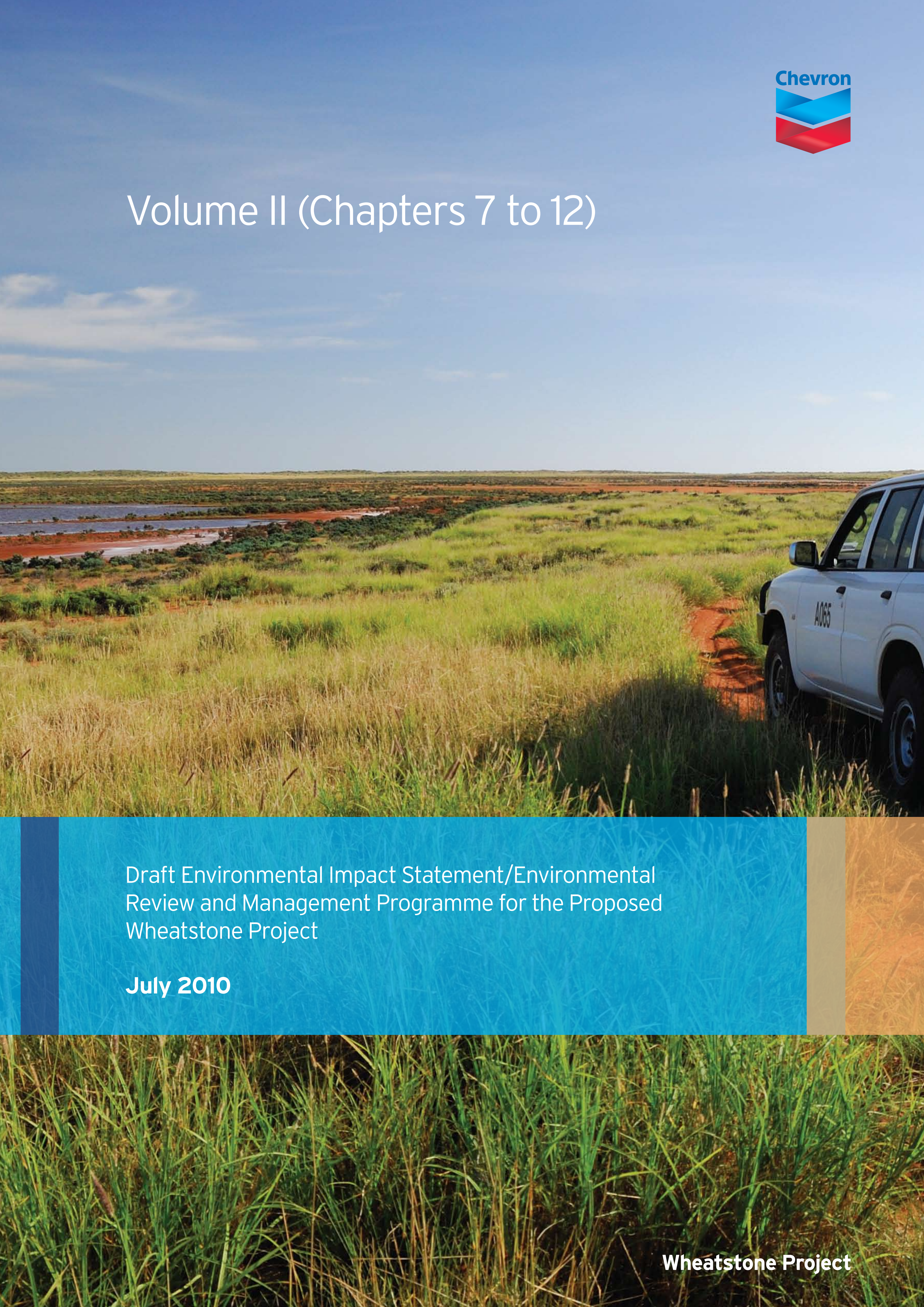

Volume II (Chapters 7 to 12)

Draft Environmental Impact Statement/Environmental Review and Management Programme for the Proposed Wheatstone Project

July 2010

Wheatstone Project

Title: Draft Environmental Impact Statement/Environmental Review and Management Programme for the Proposed Wheatstone Project: Volume II (Chapters 7 to 12)

Volume II

7.0
Impact Assessment Methodology


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7.1 Introduction

Chevron Australia Pty Ltd (Chevron) is implementing a trial of the application of a risk-based approach for environmental impact assessment at the request of the Western Australian Environmental Protection Authority (EPA). The trial is consistent with the EPA's draft guideline *Application of Risk-based Assessment in EIA*, (EPA 2009b). This guideline has been applied for the preparation of the Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP) for the proposed Wheatstone Project (Project). Experience gained from the implementation of the risk-based approach for an actual project will inform the EPA in their deliberations on how the approach may be used by the wider industry.

The risk-based approach enables the potential impacts or hazards associated with Project activities to be evaluated on the basis of potential risk to the environment. Environmental investigations, assessment and mitigation can then be focused on the factors or receptors considered to be at high and medium-level risk of adverse impact. Low and very low risks are also assessed but in less detail than medium or high risks.

Risk-based assessment offers several advantages over traditional environmental assessment. These include (EPA 2009b):

- Greater transparency in the decision-making process
- Support for informed, consistent and defensible decision-making
- Consistency with the precautionary principle
- More systematic approach to evaluating the magnitude of environmental impacts
- Prioritisation of the environmental impacts of concern, application of management and controls and focus of audit programs
- Improved proponent environmental accountability
- An effective basis for engagement of key stakeholders to influence environmental outcomes
- Provision of a sound basis for development of targeted research and development programs.

The EPA considers that a risk-based assessment approach will involve a blend of science, policy and community values, particularly where there are significant risks to highly valued and protected environmental assets.

This chapter describes the methodology used to determine environmental risks resulting from the Project. The detailed risk assessments are presented in Chapter 8, *Marine Risk Assessment and Management,* Chapter 9, *Terrestrial Risk Assessment and Management*, and Chapter 10, *Social Risk Assessment and Management*. Chapter 12, *Environmental Management Program*, outlines Chevron's approach to environmental management as well as detailing its outcome-based conditions and corresponding environmental management plans. These were developed to address the potential environmental impacts identified during these detailed risk assessments.

7.2 Assessment Framework

The draft EPA guideline provides the assessment framework for this risk-based assessment (EPA 2009b). In addition to this guideline, the risk assessment process has been developed to align with Australian Standard AS/NZS 4360:2004 Risk Management (Standards Australia/Standards New Zealand 2004).

This assessment also addresses requirements under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), specifically, matters of National Environmental Significance (NES). The Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) is supportive of the trial of the EPA risk-based approach as long as matters under their jurisdiction are addressed. Matters of NES will be addressed to the requirements under both the EPBC Act (Cth) and the *Guidelines for the Content of a Draft Environmental Review and Management Programme/Environment Impact Statement* (Appendix 5 of Chevron Australia 2009).

7.2.1 Terminology

Consistent terminology provides a basis for environmental impact assessment (EIA), whether undertaken according to a traditional or a risk-based approach. The terminology of a risk-based environmental assessment differs from the traditional language of an EIA. It is important that proponents, government agencies and stakeholders have a common understanding of these terms in order for a risk-based approach to be successfully applied.

The risk-based EIA approach in Western Australia (WA) uses terminology commonly applied in the conventional EIA process while introducing additional risk-management terms as required and as defined in HB 203:2006 Environmental Risk Management – Principles and Process (EPA 2009b).

A common understanding of the words "consequence" and "likelihood" is particularly important. Consequence is defined by the EPA as "an indication of the magnitude of an environmental impact resulting from an environmental aspect". Likelihood is "the probability or frequency of an impact or 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
- The environmental factor being affected" (EPA 2009b).

The terms "residual risk" and "inherent risk" have been presented in the draft EPA guidance. Residual risk was the term used at stakeholder workshops held in September 2009 and is the level of risk after the application of standard management measures. Residual risk has subsequently been used for the detailed risk assessments presented in this EIS/ERMP.

Table 7.1 summarises the risk-assessment terms used for this environmental assessment.

7.3 Methodology

Risk assessment is both an approach and a set of tools for systematically comparing the environmental and associated social and health costs and benefits of decision options. In the case of the EIS/ERMP, risk assessment is a tool to initially evaluate, prioritise and mitigate potential adverse impacts. It is not intended to replace a detailed environmental impact assessment, but is an important component of the impact assessment.

The EPA's risk-based approach evaluates the consequence and likelihood of environmental impacts occurring as a result of exposure of a factor (an environmental receptor such as marine fauna or terrestrial flora) to one or more aspects (activities such as dredging or earthworks). Application of this approach allows a detailed assessment to focus on those aspects that present higher potential risk to the environment. The risk-based approach provides a means to rank the relative significance of potential environmental impacts and a basis for determining priorities for mitigation, planning and monitoring. By developing management measures and controls, residual risks can be reduced to an acceptable level. Management controls identified through the risk-assessment process are included in Chapter 12, *Environmental Management Program*.

Methodology adopted for the Project is derived from the EPA draft guidelines (EPA 2009b), as outlined in Figure 7.1. This figure offers an approach that is slightly different from that proposed under Figure 2 of the EPA draft guidelines. This was based on the experiences and lessons learned from the implementation of the risk-based approach on an actual project. Lessons learned were presented to the EPA Board at meetings in April, July and October 2009.

7.3.1 Scoping

The first four steps of Figure 7.1 were completed and incorporated into the Environmental Scoping Document

Table 7.1: Risk Assessment Terminology (adapted from EPA 2009b)

Risk Assessment	Examples
Aspect	Clearing, spills, dredging, emissions, effluent discharges
Factor	Flora, fauna, wetlands, groundwater, surface water, heritage
Policy context	Regulatory and policy requirements, stakeholder values
Environmental impact	Loss of flora and fauna, damage to wetlands, contamination of water, effect on environmental values
Consequence	Magnitude of the loss of flora and fauna, damage to wetlands, contamination of water or effect on environmental values
Likelihood	Probability of the magnitude of loss of flora and fauna, damage to wetlands, contamination of water or effect on environmental values occurring
Risk	Chance of the loss of flora and fauna, damage to wetlands, contamination of water or effect on environmental values of a certain magnitude occurring
Risk treatment/mitigation	Rehabilitation, fauna relocation, spill response, waste water treatment
Residual environmental risk level	Chance of loss of flora and fauna, damage to wetlands, contamination of water or effect on environmental values of a certain magnitude after management measures have been implemented
Uncertainty	The level of confidence in the determined environmental risk level

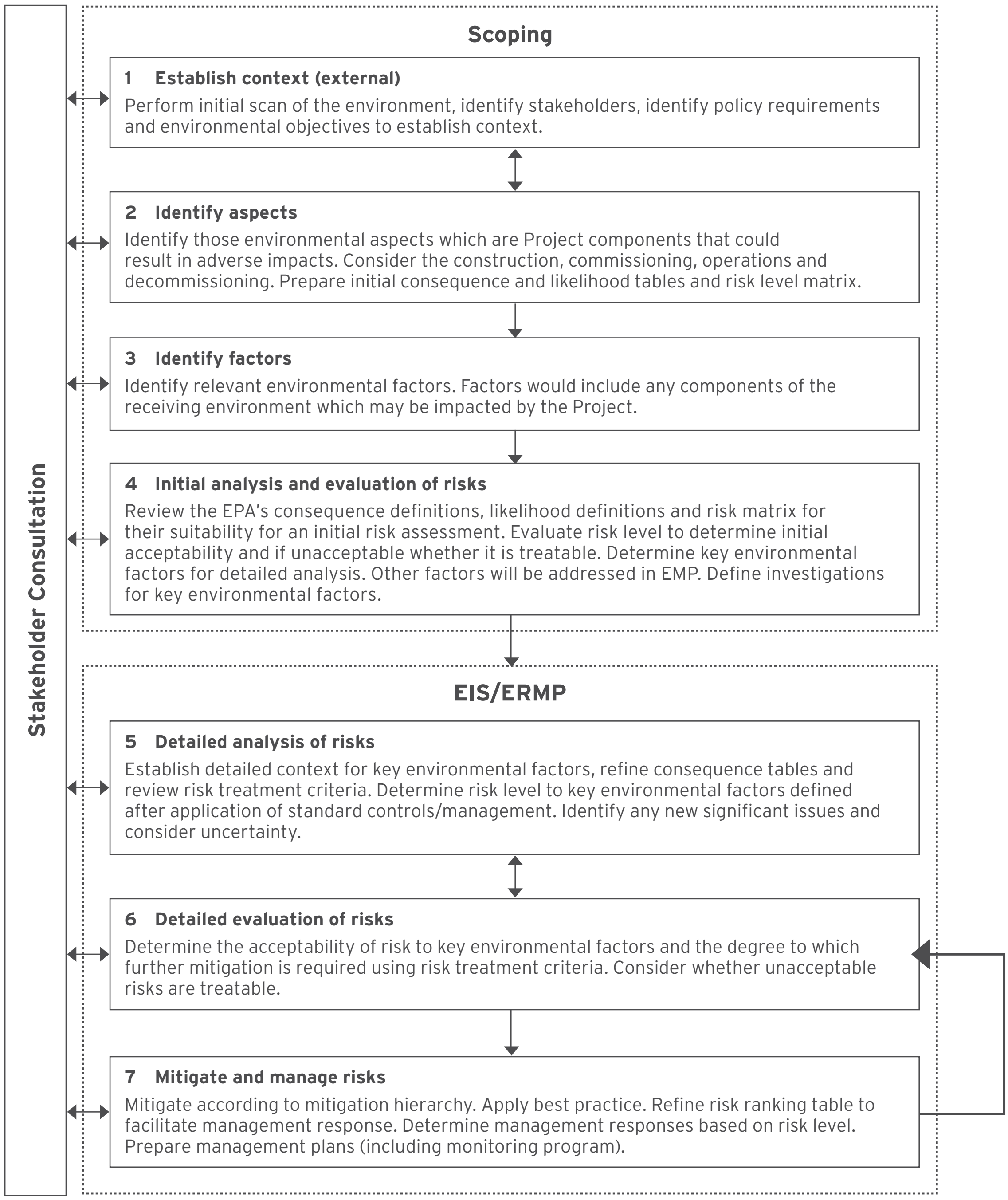

Figure 7.1: Risk Assessment Methodology

Source: Adapted from EPA 2009b

(Scoping Document), which was approved by the EPA and DEWHA in June 2009 and August 2009 respectively. The purpose of the Scoping Document was to establish the context for the assessment, identify aspects and factors, and to conduct preliminary risk assessments for the Project. The Scoping Document also defined the scope of the Project and impact assessment and presented the specific studies and methodologies to be conducted in order to reduce uncertainty and support the risk assessment. The preliminary risk assessment completed for the scoping phase was undertaken in accordance with the EPA draft guidelines (EPA 2009b).

The preliminary risk assessment was achieved through a series of internal workshops and "brainstorming" sessions, followed by workshops with government agencies, various environmental and social specialists, and Project stakeholders. This resulted in four "high", 25 "medium", 23 "low" and six "very low" preliminary risk rankings for the Project. Each environmental factor had at least one "medium" or "high" risk association (Chevron Australia 2009).

The Scoping Document included the commitment that further detailed risk assessment would be conducted during the EIS/ERMP phase to inform engineering decisions and guide appropriate management measures to reduce risks to acceptable levels. This would include:

- Validating the risk-based scoping results and reassessing risk levels
- Completing a detailed risk assessment for each medium and higher level risk
- Determining additional management measures/ mitigation to reduce risks to as low as reasonably practicable (ALARP).

Upon approval of the Scoping Document, the first four steps in Figure 7.1 were reviewed to ensure that they were still valid for the detailed risk assessment under the EIS/ ERMP. Each step presented in Figure 7.1 is discussed in more detail below.

7.3.2 Establishing the Context

The first step, described in Figure 7.1, was to perform an initial scan of the environment, and to identify stakeholders, policy requirements and environmental objectives (EPA 2009b). Identification of the context for the Project was based on a review of readily available reports, observations from preliminary site inspections and Project team experience in the region. This included examination of relevant guidance statements, policies, legislative requirements and community values and uses associated with individual factors.

The environmental and social objectives for the Project were identified during the scoping process. These objectives were subsequently re-evaluated and were left unchanged for the detailed risk assessments under the EIS/ERMP. No comments were received on the objectives during the public review of the Scoping Document.

The detailed risk assessment evaluated a number of environmental surveys and modelling studies. This informed the final assessment and addressed uncertainties or knowledge gaps identified in the preliminary risk assessment. The technical studies also helped establish the detailed context for the key environmental factors. Comments received during the public review of the Scoping Document confirmed many of the issues raised during the stakeholder workshops and consultations undertaken by Chevron.

Table 7.2: Aspects Identified for the Project

Dredging	Physical presence of onshore and marine infrastructure
Vessel movements, ship operations	Construction activities (marine – includes trunkline installation)
Discharges	Leaks and spills (marine)
Vegetation clearing	Construction earthworks
Dust emissions	Fire
Air emissions; greenhouse gas emissions	Visual impacts (includes light emissions)
Vehicular activity	Acoustic emissions
Groundwater abstraction	Spills and leaks (terrestrial)

Table 7.3: Factors Potentially Impacted by the Wheatstone Project

Marine	Terrestrial	Social
Benthic Primary Producer Habitat (BPPH)	Flora and vegetation	Ambient air quality
Marine fauna	Terrestrial fauna	European heritage
Water and sediment quality	Subterranean fauna	Aboriginal cultural heritage
Coastal Processes (Referred to in the Scoping Document as "Physical Marine Environment")	Soils and landform	Local fishing and pearling industry
	Ambient air quality	Recreational uses
		Public amenity
	Surface water	Onslow community (health risk)
	Groundwater	

Table 7.4: Risk Matrix (EPA 2009b)

Consequence category							
		6	5	4	3	2	1
		Negligible	Minor	Moderate	Major	Massive	Catastrophic
Likelihood category	1. Almost certain	Low	Medium	High	Extreme	Extreme	Extreme
	2. Likely	Low	Low	Medium	High	Extreme	Extreme
	3. Possible	Very Low	Low	Low	Medium	High	Extreme
	4. Unlikely	Very Low	Very Low	Low	Low	Medium	High
	5. Remote	Very Low	Very Low	Very Low	Low	Low	Medium

(dark brown)	Extreme Risk:	Modification of proposal may be required. Further detailed investigations and detailed discussion in EIS/ERMP. Detailed discussion and agreement with EPA/DEWHA or other government departments on proposed studies.
(red)	High Risk:	Further detailed investigations and detailed discussion in EIS/ERMP. Detailed discussion and agreement with EPA/DEWHA or other government departments on proposed studies.
(orange)	Medium Risk:	Further studies required and discussion in EIS/ERMP. Detailed discussion and agreement with EPA/DEWHA and other government departments on studies.
(yellow)	Low Risk:	Brief discussion in EIS/ERMP. To be addressed in subsequent Environmental Management Plans, works approvals and licenses for the Project. Studies may be undertaken and reported in the EIS/ERMP if confidence level is low.
(green)	Very Low Risk:	Very brief notation in the EIS/ERMP. To be addressed in subsequent Environmental Management Plans, works approvals and licenses for the Project.

7.3.3 Identifying Aspects

An aspect is a feature or characteristic of a project that has the potential to affect the environment or associated social values. Aspects were initially developed through a series of internal workshops and brainstorming sessions. These were vetted through consultation with individual stakeholders, and discussions at stakeholder workshops in February, March and September 2009.

Key Project activities were assessed for their potential to occur during the construction, commissioning, operation, maintenance or decommissioning stages. Table 7.2 lists the aspects identified for the Project. Several of these aspects were further subdivided for the detailed risk assessments presented in Chapter 8, *Marine Risk Assessment and Management*, Chapter 9, *Terrestrial Risk Assessment and Management*, and Chapter 10, *Social Risk Assessment and Management*. For example, in the case of "dredging", individual risk assessments were conducted for capital dredging, maintenance dredging, disposal of dredge spoil at sea and onshore placement.

7.3.4 Identifying Factors

The area surrounding the Project site has been the subject of several environmental investigations in recent years, including terrestrial and marine surveys for previously proposed projects and ongoing impact monitoring.

The Project team identified environmental and social factors based on a review of these existing studies and by conducting literature reviews of further relevant information. The study team's collective experience of the area and similar large-scale projects in the region also assisted in determining the factors applicable to the Project. The factors included any matters of NES. As was the case with the identification of aspects, the majority of this work was undertaken during the scoping stage. These factors were vetted through consultation with individual stakeholders, and discussions at stakeholder workshops in February, March and September 2009. The factors were reviewed during the internal risk assessments undertaken for the detailed impact assessment in August 2009 and at stakeholder workshops in September 2009. Although the number of individual risk rankings per factor increased as the Project became better defined, the factors remained unchanged. Factors identified for the Project are listed in Table 7.3.

Factors were also subdivided. For example, marine fauna was divided into protected fauna—those listed under the EPBC Act (Cth) or by the State Department of Environment and Conservation (DEC)—and non-protected fauna. Similarly, flora and vegetation was subdivided into vegetation communities and species, and terrestrial fauna was subdivided into protected species, non-protected species and fauna habitat.

Each factor also considered a wide range of potential receptors. For example, "marine fauna" included whales, turtles, Dugongs, reptiles, seabirds, fish, intertidal fauna and benthic infauna. Although the risk rankings presented in Chapter 8, *Marine Risk Assessment and Management* and Chapter 9, *Terrestrial Risk Assessment and Management* generally focus on the most sensitive species or receptor, the EIS/ERMP discusses the potential impacts on all important receptors. For example, while risk rankings concentrate on turtles and Dugongs as the most sensitive marine fauna, the impact assessment addresses potential impacts on a wide range of marine fauna.

7.3.5 Analysis and Evaluation of Risk

Risk ranking is determined by first establishing the potential consequence or magnitude of an environmental impact on a factor resulting from an environmental aspect. This is followed by assigning the likelihood of the consequence on the environmental or social factor. The assigned consequence and likelihood is then plotted on a risk matrix to determine a final risk ranking or outcome.

The Project team reviewed the risk matrix provided by the EPA (Table 7.4) and considered it suitable for both the Scoping Document and the EIS/ERMP. Although further studies are not specifically required for "low" risks, they were still undertaken to address uncertainty associated with the preliminary risk rankings and where limited baseline information was available.

7.3.5.1 Consequence Definitions

"Consequence" may be expressed in qualitative or quantitative terms. The Scoping Document used the generic consequence definitions that were listed in Table 2 of the draft EPA Guidelines (EPA 2009b). As part of the trial of the risk-based approach, Chevron was asked by the EPA to develop consequence definitions for each factor to be assessed in the EIS/ERMP. The EPA draft guidelines (EPA 2009b) consider refined consequence tables to be required documentation for the detailed impact assessment.

The consequence definitions used in this EIS/ERMP were developed specifically for each factor and customised for the Project. The development of Project-specific consequence definitions was verified by the EPA as following the intent of the trial of the risk-based approach. Draft consequence definitions were developed by the study team with input from various environmental and social specialists. Definitions were developed for potential "negligible", "minor", "moderate", "major", "massive" and "catastrophic" consequences. This followed the consequence categories listed in the EPA guidance paper. These definitions were fine-tuned and presented to the EPA Board on July 23, 2009. The Board recommended that Chevron continue to develop and test these definitions.

The draft consequence definitions were tested through eight factor-specific, risk-ranking sessions. These were attended by Chevron environmental and social impact team members, Chevron's environmental and social consultants and invited environmental scientists. This proved to be a valuable exercise, which resulted in changes to the wording of the consequence definitions for each environmental and associated social factor.

The draft consequence definitions and associated risk rankings were presented at stakeholder workshops held on September 29 and 30 2009. This resulted in additional revisions, most notably shifting the consequence definitions for protected flora and fauna one column to the left. As an example, consequence definitions for protected marine fauna in Table 7.5 under the "negligible" column were moved one column to the left to become "minor". Similarly, "minor" consequences were moved to become "moderate". This was repeated for the remainder of the consequence definitions for protected marine fauna which resulted in changes to some of the risk rankings for protected fauna. For example, the residual risk to marine fauna from entrainment in the dredge changed from "low" to "medium".

The consequence definitions address potential marine, terrestrial and social impacts. Consequence definitions for the Project are included as Table 7.5, Table 7.6 and Table 7.7. Terminology including long term, short term, local and regional are defined specifically for each factor in Chapter 8, *Marine Risk Assessment and Management*, Chapter 9, *Terrestrial Risk Assessment and Management*, and Chapter 10, *Social Risk Assessment and Management*. Definitions for these terms may differ between Chapters 8, 9 and 10 as appropriate to the factors considered in each chapter.

7.3.5.2 Defining Likelihood

The definitions of likelihood proposed by the EPA were found to be suitable for both the Scoping Document and the EIS/ERMP. They are listed in Table 7.8.

7.3.6 Detailed Analysis of Risks

A series of facilitated internal risk-assessment workshops followed the development of the draft consequence definitions. The purpose of the workshops was to provide a robust process for validating the preliminary risk assessment, taking into account the outcome of technical studies, public review of the Scoping Document and any other relevant information. Each workshop was attended by specialists from Chevron, its primary environmental and social consultants, and by technical experts from related disciplines. Table 7.9 lists the workshops undertaken to complete the risk assessment process. The social factors were addressed in a single workshop.

Risk rankings were initially determined with the assumption that minimum standards would be met but without the implementation of additional management controls or risk treatment. Minimum standards would include compliance with legislative and corporate requirements or with operating practices commonly in use in WA. Public perception and government policy were also considered when assigning risk rankings.

In addition to assigning individual risk rankings, the Project team also:

- Summarised the available information for each factor
- Defined terms such as "local", "regional", "short-term" and "long-term"
- Determined uncertainties and confidence levels
- Undertook an initial determination of further management controls for potential "medium" and "high" risks
- Determined additive risk levels for each factor.

The risk ranking enabled the Project team to prioritise assessment within the EIS/ERMP, and to identify where additional management controls may be necessary.

The outcomes of the detailed risk assessments are provided in Chapter 8, *Marine Risk Assessment and Management*, Chapter 9, *Terrestrial Risk Assessment and Management* and Chapter 10, *Social Risk Assessment and Management*.

A risk-based approach was deemed not appropriate for four factors:

- Atmospheric greenhouse gas concentrations and emissions
- Aboriginal cultural heritage
- European cultural heritage
- Visual amenity.

Atmospheric greenhouse gas emissions are a global issue. As such, the study team deemed it problematic to develop consequence definitions based on local or regional impacts.

These impacts would be impossible to measure or attribute solely to the Project. Greenhouse gas emissions are discussed and assessed in Sections 3.7 and 4.2 of this EIS/ERMP.

The risk-based approach to assessing Project impacts on Aboriginal cultural heritage was discussed with representatives from the Burrabalayji Thalanyji Association Incorporated (BTAI) in July 2009. The BTAI representatives did not believe a risk-based approach was appropriate for Aboriginal cultural heritage issues and requested that impacts be dealt with in accordance with a Wheatstone Project Cultural Heritage Management Plan, to be developed between the parties.

A similar discussion on European cultural heritage was held with representatives from the Heritage Council Western Australia (HCWA) in November 2009. During this discussion it was decided a risk-based approach was not appropriate for assessing European cultural heritage, however Chevron will need to demonstrate to HCWA how it intends to manage risks to European cultural heritage.

The attractiveness of a particular view, or outlook, is highly subjective as it depends on individual perception. While it is possible to document the potential scale of change that may occur, it is difficult to assign a meaningful risk ranking to visual amenity. For this reason, potential impacts to visual amenity have not been assigned a risk category.

Potential impacts on visual amenity, Aboriginal heritage and European heritage are assessed in Chapter 10, *Social Risk Assessment and Management* using a traditional qualitative approach to environmental impact assessment.

The detailed risk assessment evaluated a number of environmental surveys and modelling studies, which were implemented to address uncertainties or knowledge gaps identified in the preliminary risk assessment. The focus of additional studies was to better evaluate the high and medium risks identified in the Scoping Document. However, areas of high uncertainty (or low confidence) associated with a low risk ranking were also the subject of detailed investigation. Where applicable, the studies complied with the relevant EPA guidance document(s). Where specific guidance was not available, studies were developed and implemented in consultation with the EPA, DEWHA or the appropriate State or Commonwealth department.

Field surveys were focused on areas within the potential Project footprint. The survey and investigation areas were refined as the Project was defined in more detail. Several field studies included samples from beyond the Project footprint. This was done to capture any subsequent changes in Project design, to better understand the surrounding area, or to reduce uncertainty in the detailed risk assessments.

Although the detailed risk assessments have benefited from additional field surveys and modelling studies, some uncertainty still exists. Consistent with the approach taken for the Scoping Document, uncertainty was addressed using conservative assumptions. For example, if there was some doubt over the exact distribution of a particular receptor, that receptor was considered to be present in the area potentially affected by a Project aspect. A conservative "reasonable-worse-case" approach was used to determine potential consequences. This was especially true if the study team was unsure if a potential consequence could fall within either of two consequence categories. In this case, the more conservative (e.g. "moderate" rather than "minor") category was selected.

For environmental factors that could be adversely affected by unplanned events (e.g. hydrocarbon spills) the risk assessment was based on the likely worst-case scenario of cumulative hydrocarbon spills.

In line with the EPA Review of EIA Process in WA (EPA 2009c), the level of confidence in the environmental risk levels determined was indicated based on the availability and reliability of the studies and data considered when conducting the risk assessments. The level of confidence was indicated as follows:

- High confidence
- Reasonable confidence
- Low confidence.

Table 7.10 outlines the criteria by which each level of confidence was determined.

7.3.7 Detailed Evaluation of Risks

It was determined that additional management controls may be required to further reduce potential risks from the Project. This was especially true for potential medium and high risks or for areas with higher uncertainty or public concern. Mitigation measures were therefore developed to reduce potential impacts on factors as far as practicable.

The study team observed that mitigation measures introduced for a particular risk ranking would often reduce the potential impacts on other factors. For example, mitigation developed for dredging to reduce potential impacts on a high risk factor such as BPPH would also apply to medium risks related to marine fauna or to low risks on water quality. This was considered in the detailed evaluation of risks.

Table 7.5: Project Marine Impacts Consequence Definitions

Marine						
	1	2	3	4	5	6
	Catastrophic	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
BPPH[1]	• Reversible, but long term localised loss of >50% of BPPH in all categories • Irreversible localised loss of > 30% of BPPH in categories D and E (Non-designated and Development Areas) • Irreversible localised loss of >10% of BPPH in Extremely Special, Development Areas where cumulative loss threshold (CLT) already exceeded, and Marine Protected Areas (MPAs) Ecosystem highly modified and integrity adversely affected • Conservation values of MPAs reduced	• Irreversible loss of BPPH >100% in excess of EPA CLT for all categories • Conservation values of MPAs seriously threatened	• Reversible, but long-term (>10 years) localised loss of BPPH • Irreversible loss of BPPH exceeding EPA CLT for all categories • Conservation values of MPAs at risk	• Reversible, short-term (5 years) localised loss of BPPH • Irreversible loss of BPPH close to but not exceeding EPA CLT for all categories except A and F (Extremely Special Areas and Development Areas where CLT already exceeded)	• Localised seasonal (<1 year) decrease in productivity of BPPH • Small irreversible loss of BPPH but well within EPA CLT for all categories except A and F (Extremely Special Areas and Development Areas where CLT already exceeded)	• Localised seasonal decrease in productivity of BPPH during short term • No irreversible loss of BPPH
Marine Fauna, Other (includes fish)	• One or more species become extinct • Species conservation status declines i.e. becomes threatened - meets criteria for listing • Regional and irreversible impact to communities and populations	• Regional and long-term impact to communities and populations	• Regional medium term or local long term impact to communities and populations	• Local medium term impact to communities and populations	• Local short term impact to communities and populations • Does not threaten viability of community and population	• No detectable impacts to communities and populations
Protected Marine Fauna	• Species of protected marine fauna becomes regionally extinct	• Species of protected marine fauna becomes locally extinct	• Loss of individuals/ taxa leading to reduced viability of population in local area • Ecologically significant proportion of local population is lost (Incompatibility, not if short term is 5 years	• Local short-term decrease in abundance, no lasting effects on population	• No detectable decrease in abundance or lasting effects (definition) on population	• No detectable impacts to communities and populations

Marine Water and Sediment Quality	• Regional long-term exceedence of background and applicable ANZECC water quality (WQ) and sediment quality (SQ) Guidelines • Regional long-term change	• Regional short-term exceedence of background and applicable ANZECC WQ and SQ Guidelines • Regional contamination of sediment	• Localised long-term exceedence of background and applicable ANZECC WQ and SQ Guidelines • Localised contamination of sediment	• Localised short-term exceedence of background and applicable ANZECC WQ and SQ Guidelines • Localised contamination of sediment	• Local short-term and small reduction in water and sediment quality with no exceedence of background and applicable ANZECC WQ and SQ Guidelines • Localised long-term exceedence of background and applicable ANZECC WQ and SQ Guidelines but within approved Low Protection Area mixing zone	• No detectable changes to background water and sediment quality • No detectable effects on marine sediments
Physical Marine Environment	• Regional loss of a unique landform and/or habitat and generation of substantial regional coastal instability • Massive intervention required to mitigate adverse effects leading to secondary environmental impacts	• Regional loss of well represented landform and/or habitat • Substantial damage to locally unique landform • Recurrent intervention required to mitigate adverse effects leading to secondary environmental impacts	• Major localised loss of a well represented landform and/or habitat • Intervention required to mitigate adverse effects leading to secondary environmental impacts	• Localised loss of well represented landform and/or habitat	• Minor disturbance of well represented landform and/or habitats • Localised coastal re-adjustment	• No measurable changes to coastal processes, landforms or habitats

1. In accordance with Environment Protection Authority (WA) Guidance Statement No. 29 Protection of Benthic Primary Producer Habitats.

Table 7.6: Wheatstone Project Terrestrial Impacts Consequence Definitions

Terrestrial						
	1	2	3	4	5	6
	Catastrophic	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Terrestrial Flora and Vegetation	• Extinction of a species • Loss of a Threatened Ecological Community (TEC) • Extinction of a vegetation community or habitat	• Regional extinction of a species • Regional extinction of a vegetation community or habitat • Long-term impact to a TEC leading to a reduction in the viability of the community • Local extinction of a Declared Rare Flora species • Local long-term reduction in the abundance of a TEC	• Local extinction of a Commonwealth or Western Australia Listed Flora species • Local long-term reduction in the abundance of a Declared Rare Flora species • Long-term impact on native vegetation outside the Project footprint • Local short-term reduction in the abundance of a TEC	• Local short-term reduction in the abundance of a Declared Rare Flora species • Local long-term reduction in the abundance of a Commonwealth or Western Australia Listed Flora species • Introduction of a non-native flora species to the Project area • Short-term impact on native vegetation outside the Project area	• Local short-term reduction in the abundance of a Commonwealth or Western Australia Listed Flora species • Increase in the abundance of an existing non-native flora species within the Project area • Local loss of a species or vegetation community • Local long-term reduction in the abundance of a species or vegetation community	• Local short-term reduction in the abundance of a species or vegetation community
Terrestrial Vertebrate Fauna	• Extinction of a species	• Regional extinction of a species	• Regional long-term reduction in the abundance of a Commonwealth or Western Australia Listed Fauna species	• Local long-term reduction of a Commonwealth or Western Australia Listed Fauna species • Regional long-term reduction in abundance of a species • Local long-term increase in the abundance of an introduced animal	• Local loss of a species • Local short-term reduction in the abundance of a Commonwealth or Western Australia Listed Fauna species • Local short-term increase in the abundance of an introduced animal	• Local short-term reduction in abundance of a species
Subterranean Fauna	• Extinction of a subterranean fauna species	• Significant reduction in the population of a subterranean fauna species resulting in a threat to the viability of the species	• Loss of majority of subterranean fauna habitat at a local scale • Long-term decrease in the abundance of a subterranean fauna species	• Loss of a substantial proportion of local subterranean fauna habitat, no threat to the survival of the species	• Local loss of a small proportion of subterranean fauna habitat	• Short-term impact to subterranean fauna habitat, full recovery expected

Surface and groundwater	• Long-term loss of surface and groundwater quality at a regional scale, which cannot be remediated	• Major changes in regional surface water hydrology and flow regimes and/or groundwater recharge patterns due to landform alteration significantly affecting critical surface and groundwater dependent ecosystems over a region • Regional short-term exceedence of background and applicable ANZECC WQ Guidelines	• Changes to water quality of local water resources resulting in localised long-term exceedence of background and applicable ANZECC WQ Guidelines • Long-term significant effects to surface and groundwater quality in a localised area with extensive, long-term remediation required to restore environmental values • Major changes in sub-catchment surface water hydrology and flow regimes and/or groundwater recharge patterns over a local area over the long term	• Short-term significant effects to local surface and groundwater quality with short-term remediation required • Changes to local water resources resulting in localised short-term exceedence of background and applicable ANZECC WQ Guidelines • Local and major change in sub-catchment surface water hydrology and flow regimes and/or groundwater recharge patterns over a local area over the long term	• Minor changes to local water resources, resulting in local short-term and small reduction in water quality with no exceedence of background and applicable ANZECC WQ Guidelines • Local and minor change in sub-catchment surface water hydrology and flow regimes and/or groundwater recharge patterns	• Localised and short-term reduction in surface and groundwater quality that can be readily remediated • Localised and short term disturbance to surface water hydrology and flow regimes and/or groundwater recharge patterns that can be readily remediated
Soil and Landforms	• Regional soil contamination that will severely threaten ecological integrity across this area and cannot be readily remediated • Extensive erosion or loss of landforms at a regional scale resulting in substantial loss of environmental values over the region	• Regional soil contamination or change in specific soil characteristics that will severely threaten ecological integrity across this area but can be remediated over the long term • Long-term loss of environmental values at a regional scale requiring extensive, ongoing remediation	• Local soil contamination that will severely threaten ecological integrity across the local area requiring long-term remediation or regional short-term change in specific soil characteristics • Extensive erosion of local landforms, or local loss of a unique landform habitat	• Local soil contamination requiring long-term remediation, or local short-term change in specific soil characteristics • Moderate erosion of local landforms • Extensive local loss of well represented landform habitats	• Local soil contamination that can be readily remediated; or minor impacts to specific soil characteristics • Minor erosion or loss of local landforms	• Localised and short-term disturbances to well represented landform that can be readily remediated
Ambient Air Quality	• Regional long-term change in air quality • Continuous exceedences of national ambient air quality standards (NEPM) over a wide population area	• Frequent exceedences of NEPM over a wide population area	• Occasional exceedences of NEPM over a wide population area	• Ground level concentrations at identified sensitive receptors represent a significant increase over the baseline conditions or reduce the remaining air-shed capacity for a particular key pollutants	• Local short-term and minor exceedence of standards • Ground-level concentrations at identified sensitive receptors represent a small increase over the baseline conditions	• No measurable air quality impacts

Table 7.7: Wheatstone Project Social Impacts Consequence Definitions

Social, Community and Health	1	2	3	4	5	6
	Catastrophic	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Local Fishing and Pearling Industry	• Commercial fishing or pearling is no longer viable in the designated local fishing areas • Extinction of target species in designated local fishing areas • Permanent loss of access to all designated local fishing areas	• Significant threat to viability of commercial fishing or pearling in the designated local fishing areas • All target species in designated local fishing areas are endangered • Permanent loss of access to more than 20 per cent of designated local fishing areas	• Commercial loss due to long term (three seasons or more) reduction in abundance of target species in designated local fishing areas • Commercial loss due to permanent loss of access to 10 to 20 per cent of designated local fishing areas	• Commercial loss due to localised medium term (two seasons) reduction in abundance of target species in designated local fishing areas • Commercial loss due to permanent loss of access to less than 10 per cent of designated local fishing areas	• Commercial loss due to localised short term (one season) reduction in abundance of target species in designated local fishing areas • Commercial loss due to temporary loss of access to any part of designated local fishing areas	• No measurable impacts on commercial fishing or pearling
Local Recreational Fishing	• Permanent loss of access to all recreational fishing grounds in the local area	• Permanent loss of access to more than 20 per cent of recreational fishing grounds in the local area • Permanent reduction (10+ years) in quality of fishing experience (catch to effort ratio)	• Permanent loss of access to less than 20 per cent of recreational fishing grounds in the local area • Temporary reduction (6-10 years) in quality of fishing experience (catch to effort ratio)	• Temporary loss of access to more than 20 per cent of recreational fishing grounds in the local area • Temporary reduction (2-5 years) in quality of fishing experience (catch to effort ratio)	• Temporary loss of access to less than 20 per cent of recreational fishing grounds in the local area • Temporary reduction (1 year) in quality of fishing experience (catch to effort ratio)	• No measurable impacts on recreational fishing
Disturbance to Other Recreational Use	• Permanent loss of ability to use all recreational areas within a region • Permanent loss of ability to use all tourist accommodation within a region	• Permanent loss of ability to use 20 per cent or more of recreational areas within a region • Permanent loss of ability to use 50 per cent or more of tourist accommodation within a region	• Permanent loss of ability to use all local recreational areas • Permanent loss of ability to use all tourist accommodation within the local area	• Permanent loss of ability to use 20 per cent or more of local recreational areas • Permanent loss of ability to use 50 per cent of tourist accommodation within the local area	• Temporary loss of ability to use less than 20 per cent of local recreational areas • Permanent loss of ability to use less than 20 per cent of local recreational areas • Temporary loss of ability to use less that 50 per cent of tourist accommodation within the local area	• No measurable impacts on recreational use • No measurable impacts on tourist accommodation
Public Amenity	• Permanent and significant reduction in public amenity in a region as a result of dust and acoustic emissions, air quality and visual impacts	• Temporary but significant reduction to public amenity in a region as a result of dust and acoustic emissions, air quality and visual impacts	• Permanent and significant reduction in public amenity in a local area as a result of dust and acoustic emissions, air quality and visual impacts	• Temporary but significant reduction in public amenity in a local area as a result of dust and acoustic emissions, air quality and visual impacts • Permanent but insignificant reduction in public amenity in a local area as a result of dust and acoustic emissions, air quality and visual impacts	• Temporary but insignificant reduction in public amenity in a local area as a result of dust and acoustic emissions, air quality and visual impacts	• No measurable impacts on public amenity

Table 7.8: Definition of Likelihood

Likelihood category	Definition
1. Almost certain	• Common repeating occurrence, ongoing • Will occur most often • Planning occurrence/action
2. Likely	• Will probably occur in most circumstances • There is at least a 50 per cent chance that it may happen
3. Possible	• Might occur at some time • Could occur but not often • 5 per cent chance it could happen
4. Unlikely	• Unusual occurrence • Unexpected
5. Rare/improbable	• May occur only in exceptional circumstances • Unheard of

Table 7.9: Risk Assessment Workshops

Marine Factors	Terrestrial Factors	Social Factors
• BPPH • Coastal Processes • Water quality and sediment • Marine flora and fauna	• Soils and landforms • Flora and fauna • Surface water and groundwater	• Noise • Visual impacts • Air quality • Beneficial uses • Cultural heritage - indigenous and non-indigenous

Table 7.10: Confidence in Predicting Risk Levels

Confidence Level	Confidence Criteria
High Confidence	• Several expert investigations/studies • Excellent survey data • Long term monitoring results available • Modelling conducted and calibration shows good adherence to real occurrences
Reasonable Confidence	• Survey data available from one expert - complies with EPA guidance • Short-term monitoring results available • Modelling conducted but calibration shows occasional aberration from occurrences • Available information is adequate
Low Confidence	• No survey data • No model verification possible • No modelling conducted • Available information is inadequate

7.3.8 Mitigate and Manage Risks

The outcomes of the risk assessment provided the basis for determining the extent of additional mitigation, if required. The EPA recommends that the following mitigation hierarchy be applied to determine appropriate re-design and controls in order to reduce risks as far as practicable to low or medium levels (EPA 2009b):

1) Avoid – avoid the impact altogether
2) Minimise – limit the severity of the impact
3) Rectify – repair affected site as soon as possible
4) Reduce – eliminate impact over time
5) Offset – significant residual impacts on critical and high value assets (unacceptable impacts cannot be offset).

Mitigation for the Project includes management objectives, project design, actions, targets and monitoring programs. Management measures are outlined in the risk assessments presented in Chapter 8, *Marine Risk Assessment and Management*, Chapter 9, *Terrestrial Risk Assessment and Management* and Chapter 10, *Social Risk Assessment and Management*. The requirement for Environmental Management Plans (EMP) was based on the outcomes of the detailed risk assessments.

The Wheatstone Environmental Management Program is structured into three tiers of management which reflects the cascading but interconnected nature of documentation required for Chevron to meet its environmental obligations. This program is outlined in Chapter 12, *Environmental Management Program*.

Tier 1 of the program comprises Chevron Corporation's Operational Excellence Management System as well as Chevron's Australian Business Unit (ABU) Policy 530 which is central to the implementation of the OEMS in Australia.

Tier 2 of the Environmental Management Program comprises a set of Outcome-based Conditions and associated Statutory Environmental Management Plans. The list of proposed Statutory EMPs is based on regulatory triggers from the West Australian *Environmental Protection Act 1986* (EP Act), EPBC Act (Cth) or the specific project guidelines that have been approved by the EPA and DEWHA for this Project.

Tier 3 comprises a set of Subsidiary plans which are defined as those environmental plans which are required by and/or impose relevant legal obligations on Chevron under legislation, but are not legally binding under the Ministerial Approvals of this EIS/ERMP. Due to their non-binding nature, management plans which are required for Chevron internal purposes but which are not legally binding in their own right are also included in the list of Subsidiary plans.

7.3.9 Cumulative and Additive Effects

The EPA draft guideline *Application of Risk-based Assessment in EIA* (EPA 2009b) provides the following guidance for the evaluation of cumulative effects:

> *"Determine cumulative risk level for each key environmental factor after taking all reasonable and practicable measures to reduce risk levels to each key environmental factor arising from environmental aspects of the proposal to the range of very low to medium."*

Two methods were implemented to determine cumulative risk. The initial step was to determine the additive risk from all aspects from the Project that could affect an individual factor. For example, Table 9.18 from Chapter 9, *Terrestrial Risk Assessment and Management,* illustrates that flora and vegetation could be subject to environmental risks from the following aspects:

- Vegetation clearing
- Earthworks
- Vehicular activity
- Fire
- Air emissions
- Alteration of surface water movement
- Dust suppression
- Operational spills and leaks
- Dredge material placement.

The additive risks to flora and vegetation from the sum of the aspects above were determined using the same consequence definitions that were used for individual risk rankings for flora and vegetation. The potential consequence of the sum of potential risks on flora and vegetation from the Project was determined to be Moderate and the likelihood of this additive consequence occurring was considered to be Likely. This resulted in a Medium risk to flora and vegetation from the Project as a whole. A similar approach was followed for each environmental and social factor subject to a risk ranking in Chapter 8, *Marine Risk Assessment and Management*, Chapter 9, *Terrestrial Risk Assessment and Management* and Chapter 10, *Social Risk Assessment and Management*.

Additive effects from the Project were then incorporated into a broader cumulative effects assessment of past, present and proposed (of which the proponent is reasonably aware) actions or proposals in the area. This cumulative effects assessment is largely qualitative, although the cumulative effects from air emissions and the total footprint from the Project and other projects at Ashburton North were quantified. The results of the cumulative effects assessment is provided in Chapter 11, *Cumulative Impacts*.

7.3.10 Consultation with Government, Specialists and Stakeholders

Stakeholder input has been sought throughout the assessment process. Chevron's approach has been a combination of stakeholder risk-ranking workshops, consultation meetings with individual government departments or stakeholders, mail surveys, interviews and community open houses and meetings. Further information on stakeholder consultation is provided in Chapter 5, *Stakeholder Consultation*.

One of the challenges of a risk assessment process is to communicate the identification and analysis of risks in such a way that the assessment process is transparent and can be understood by those outside the Project team. This is especially true given the varying viewpoints of environmental professionals, the community and the public. As a result, the following studies were subject to independent review to support the risk assessment process:

- Dredge material modelling
- Assessment of impact on benthic communities
- Marine turtle assessment.

Dredge material modelling and the assessment of potential risks to benthic communities were reviewed as a result of the high risks associated with the dredging program required for the Project. The turtle assessment was reviewed as marine turtles have been identified as an important factor for other offshore projects in WA.

8.0

Marine Risk Assessment and Management

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8.0 Marine Risk Assessment and Management

8.1 Introduction

The marine components of the proposed Wheatstone Project (Project) cross the North West Shelf (NWS) from a depth of 200 m at the gas fields, located approximately 100 km north of Barrow Island, to the shoreline at the Ashburton North Strategic Industrial Area (SIA). The Ashburton North SIA is situated adjacent to the floodplain and delta of the Ashburton River.

Development of the Project requires construction of the following marine infrastructure:

- Offshore production facilities with a nominal capacity of 9 MTPA LNG, including wells, subsea installations and offshore platforms
- An export trunkline to provide feed gas from the offshore production infrastructure to the onshore gas processing plant
- A gas processing and export facility, including 25 MTPA LNG plant and domestic gas processing plant, LNG and natural gas condensate (condensate) product storage, power generation, water supply, waste disposal, and associated support facilities
- Marine facilities including a shipping channel, turning basin, Materials Offloading Facility (MOF) and Product Loading Facility (PLF)
- A navigation channel to enable vessels to access the MOF and the PLF.

Nearshore marine infrastructure will require dredging of up to 45 Mm^3 of material to construct the MOF, the PLF and the approach channel.

Further descriptions of the above infrastructure can be found in Chapter 2, *Project Description*.

The marine environment of the Project area supports a wide range of flora and fauna communities and is largely undeveloped. Existing developments include a small boat harbour at Beadon Creek, a range of commercial fisheries including prawn trawling, Onslow Salt Pty Ltd (Onslow Salt), a solar salt field with offshore load out facilities near Onslow, and the Roller-Skate oilfields in shallow coastal waters west of Onslow. The waters around Onslow also support recreational fishing, diving and tourism activities.

This Chapter assesses the potential impacts of the Project on marine water and sediment quality, habitats, fauna and coastal processes. It discusses the design and management measures proposed to assist in reducing these impacts. An assessment of the effectiveness of these measures, and the residual risk, associated with the construction, operation, and decommissioning of the Project is also included.

Following guidance from the Environmental Protection Authority (EPA), a risk assessment was conducted on each aspect for each of the marine factors (where applicable) listed in Table 8.1. Chapter 7, *Impact Assessment and Methodology* provides more detail on the processes used in assessing the risks associated with development of the Project. The predicted impacts, management measures and residual risks, arising from each of the above aspects, are discussed in the following sections and presented in summary tables.

The key legislations for the factors listed in Table 8.1 are presented in Table 8.2. Additional legislation and guidelines relevant to specific factors or aspects are discussed in the following sections.

8.2 Marine Water and Sediment Quality

The following sections present the assessment of impacts on marine water and sediment quality associated with the Project, taking into account design modifications and management and mitigation measures applied to manage impacts.

8.2.1 Management Objectives

The management objectives are for marine water and sediment quality to remain:

- Adequate for maintaining the structure and functions of marine ecosystems
- Safe for recreational activities
- Sufficient for any seafood caught or grown in the area to be safe for human consumption
- Consistent with all of the relevant policies and standards.

8.2.2 Description of Factor

The baseline characteristics of the receiving marine environment were assessed through the studies described in Chapter 6, *Overview of Existing Environment*. Sources of data included:

- Baseline water quality assessment (MScience 2009, Appendix Q7)
- Metocean water quality data acquisition program (MScience 2009, Appendix Q7)
- API water quality data acquisition program (URS 2009, Appendix Q6 and MScience 2009, Appendix Q7)
- Water quality and sediment sampling surveys (URS 2010g, Appendix Q4; URS 2009c, Appendix Q5; URS 2009, Appendix Q6).

Table 8.1: Marine Environmental Factors and Aspects

Factors	Aspects
Marine Water and Sediment Quality (Section 8.2) Benthic Habitats (Section 8.3) Marine Fauna (Section 8.4) Coastal Processes (Section 8.5)	Dredging Dredge material placement Trunkline installation and shore crossing Discharges and wastes - cooling water (CW), process water and produced water (PW), naturally occurring radioactive material (NORM) Leaks and spills of hydrocarbons Construction activities Vessel movements during construction and operation Ship operations Noise emissions Light emissions Coastal structures Onshore infrastructure

Table 8.2: Legislation and Guidelines Relevant to Marine Environment

Legislation or Guideline	Intent
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act [Cth])	This Commonwealth Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places–defined in the Act as matters of National Environmental Significance (NES).
Environmental Protection Act 1986 (EP Act [WA])	This State Act provides for an EPA, for the prevention, control and abatement of pollution and environmental harm, and for the conservation, preservation, protection, enhancement and management of the environment.
Wildlife Conservation Act 1950 (WC Act)	This State Act provides a legal framework to protect and manage flora and fauna in Western Australia.
Offshore Petroleum and Greenhouse Gas Storage Act 2006 (OPGGS Act)	This Commonwealth Act provides a legal framework to manage and store hydrocarbons and potentially deleterious greenhouse gases that are exposed from petroleum recovery and exploration. Also provides the framework to the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulation 2009.*
Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulation 2009	These Regulations aim to ensure that any petroleum activity or greenhouse gas storage activity carried out in an offshore area is consistent with the principles of ecologically sustainable development and carried out in accordance with an approved environmental plan.

Coastal marine waters in the Project area are subject to a wide range of naturally occurring spatial and temporal influences including catchment run-off, cyclones, tides, winds, currents, seasonal and biotic community interactions. As a consequence, marine water quality can vary markedly through time at a given site. Figure 8.1 and Figure 8.2 show the spatial distribution of total suspended solids (TSS) derived from remotely sensed reflectance MODIS image analysis (MScience 2009, Appendix Q7) in coastal waters of the Project area on a winter day in 2007 (Figure 8.1) and a summer day in 2008 (Figure 8.2).

Marine sediments tend to be more stable in their constituent characteristics at any particular location compared to marine water, but can significantly vary spatially across the Project area. The major source of sediment supply to the Project area is the large and relatively undeveloped catchment of the Ashburton River, which covers approximately 78 000 km^2. The river flows sporadically in response to major rainfall events usually associated with cyclones. The estimated average annual sediment load is approximately 1 300 000 t and in years with higher than average flow approximately 5 100 000 t

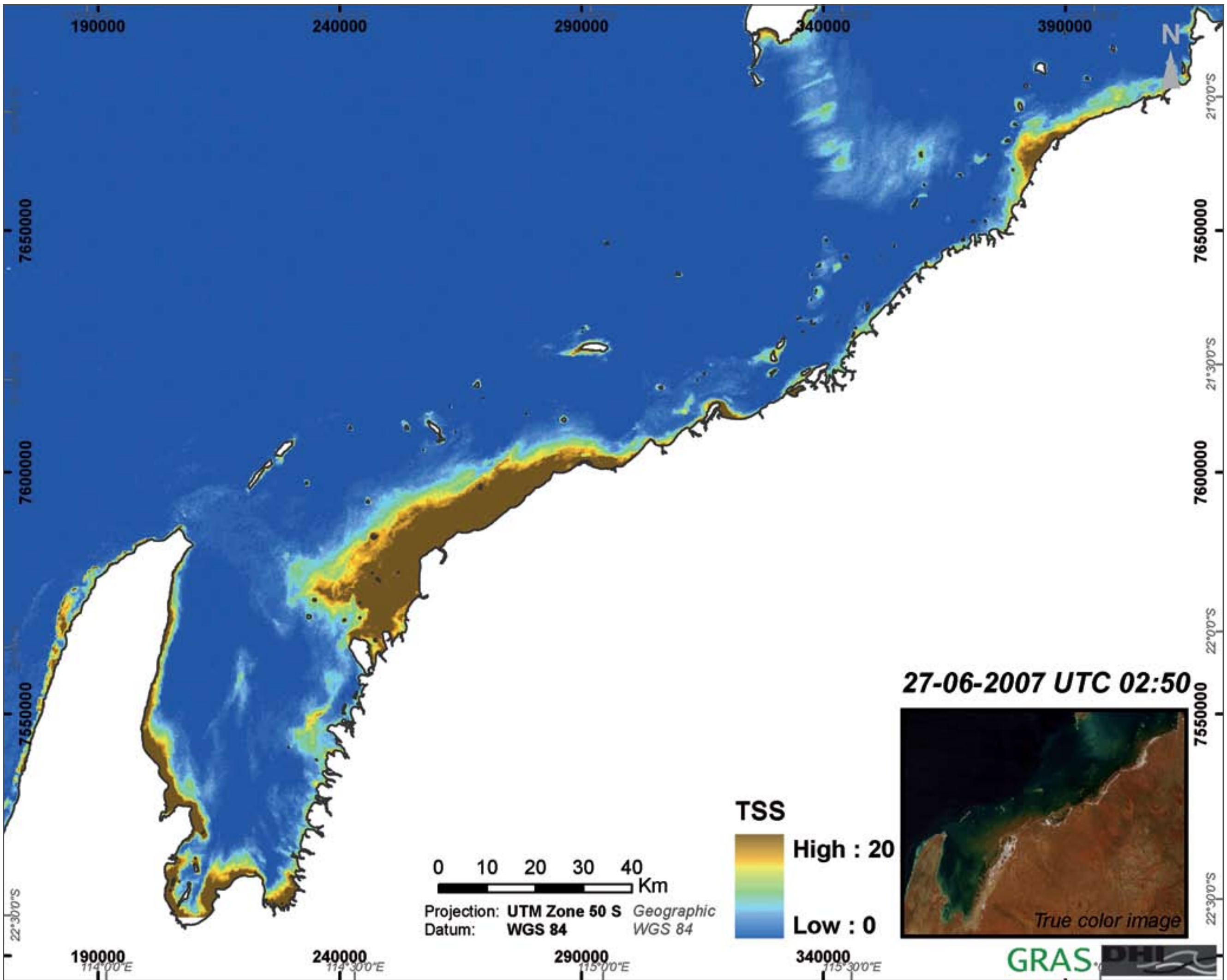


Figure 8.1: Total Suspended Solids Concentrations Derived from MODIS Image Analysis on 27 June 2007

of sediment will be deposited into the ocean (URS 2009, Appendix Q6). When the Ashburton River flows the substantial sediment load turns nearshore waters turbid for months after flooding.

Sediments can also accumulate pollutants with concentrations many orders of magnitude greater than in the associated water column. This accumulation is also influenced by tidal movement and seasonal meteorological effects. Wind re-suspension during extreme weather events (i.e. cyclones) is likely to contribute to the dispersal of particulate-bound contaminants on the inner continental shelf environment in the region (Heyward *et al*. 2006). Chains of islands and shoals form lines approximately parallel to the shore between Exmouth Gulf and Barrow Island. One line occurs in shallow waters, close to the 5 m isobath. The other is located closer to the 10 m isobath and includes Muiron, Serrurier, Bessieres and Thevenard islands. Their presence affects wave refraction, water current direction and mixing patterns, and sediment movement in the nearshore environment.

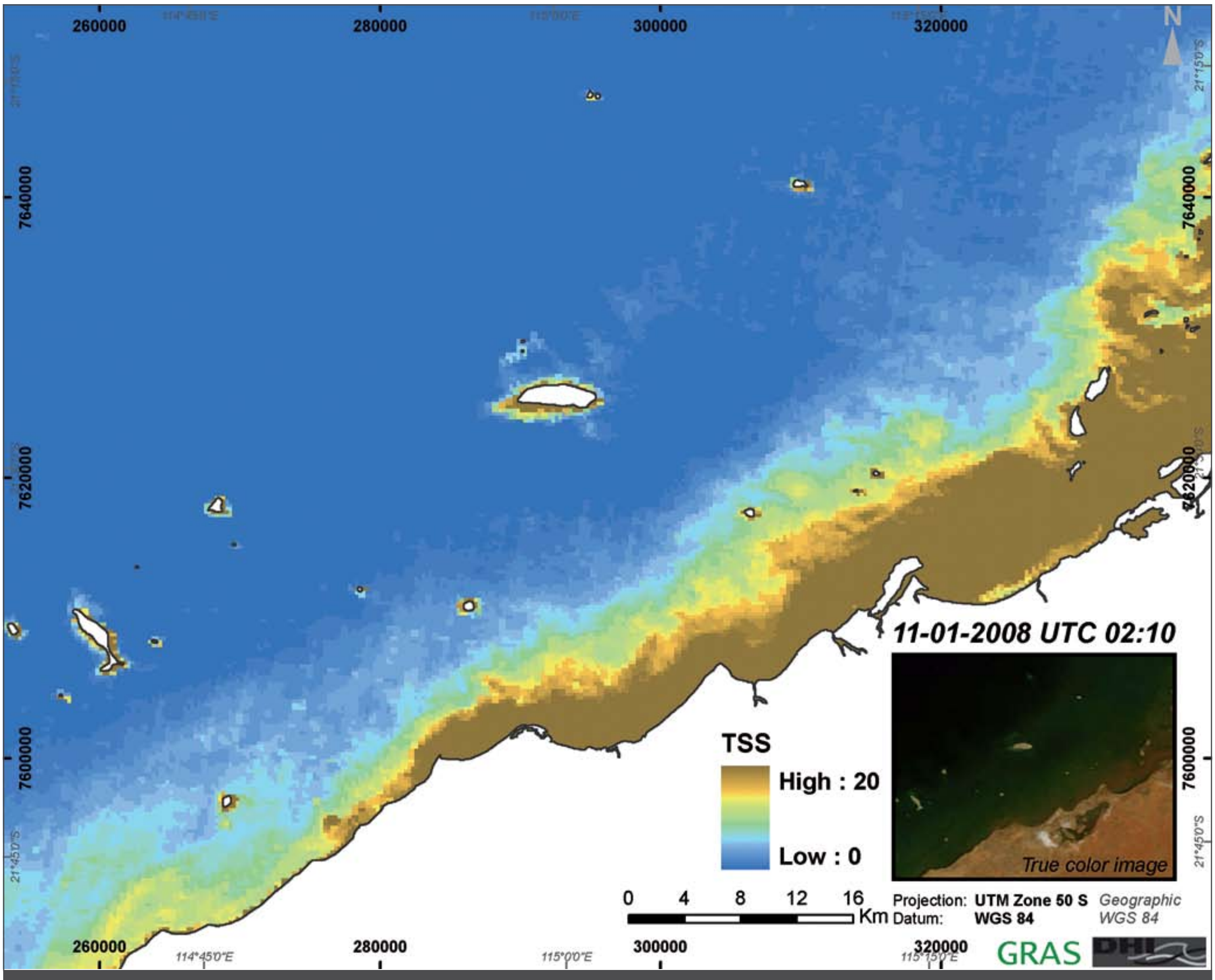


Figure 8.2: Total Suspended Solids Concentrations Derived from MODIS Image Analysis on 11 January 2008

8.2.3 Assessment Framework

Relevant assessment framework for marine water and marine sediment quality exists, at both Commonwealth and State levels. Specific policy and framework documents relating to sediment and water quality are identified in Table 8.3.

8.2.3.1 Commonwealth Waters

The Commonwealth assessment framework for water quality is the National Water Quality Management Strategy (2002). The strategy sets out a framework to ensure a standard national approach to water quality management across jurisdictions. The strategy is based on policies and principles for water quality management *"...to achieve sustainable use of the Nation's water resources by protecting and enhancing their quality while maintaining economic and social development."* The strategy includes guidelines covering key elements of the water cycle. This strategy is applied through State and Territory action plans, which flow from national policies and guidelines after taking local conditions and community needs into account. Section 8.2.3.3 provides details of the State strategy.

Under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulation 2009, the operator of a petroleum activity is also required to submit and comply with an Environment Plan. The plan must include a description of:

- The activity
- The environment
- Associated environmental risks and impacts
- Performance targets and an auditable framework.

8.2.3.2 National Assessment Guidelines for Dredging

The National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia 2009) require the preparation of a Sediment Sampling and Analysis Plan (SAP). This plan assesses the proposed dredging program and available historical data on the physical and chemical characteristics of sediments in the vicinity of the dredge and dredge material placement sites (Phase I assessment). The NAGD requires sampling and analysis of sediments in the dredge area for contaminants of potential concern (COPC), in accordance with the contaminants list included in the NAGD, and a comparison with recommended screening levels (Phase II assessment). The guidelines provide an assessment framework for dredge material placement and determining management and monitoring requirements.

Table 8.3: Legislation and Guidance Documents Specific to Water and Sediment Quality

Document	Description
National Water Quality Management Strategy (2002)	This strategy, and the related Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) guidelines, provide a framework for conserving ambient water quality in aquatic environments.
State Water Quality Management Strategy No. 6 (2004)	The State Water Quality Management Strategy No.6 (Department of Environment (DoE) 2004) outlines the overarching framework for implementing regional and local strategic plans for protecting fresh and marine water quality, and water quality monitoring and reporting in WA.
National Assessment Guidelines for Dredging (2009)	These guidelines set out the framework for the environmental impact assessment and permitting of the ocean disposal of dredged material.
Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009	These Regulations aim to ensure that any petroleum activity is carried out in a way that is consistent with the principles of ecologically sustainable development.
Guidelines for Naturally Occurring Radioactive Materials (NORM) 2002	These guidelines, formulated by the Australian Petroleum Production and Exploration Association Limited (APPEA), provide guidance on NORM monitoring, management of occupational radiation exposures, and decision-making regarding NORM waste disposal.
Petroleum Guidelines - Drilling Fluids Management 2006	All drilling proposals in Commonwealth waters require an Environment Plan. The Department of Mines and Petroleum (DMP) assesses the acceptability of drilling fluid proposals as part of the proposed Drilling Environment Plan.

8.2.3.3 State Water Quality Management Strategy

The State Water Quality Management Strategy No.6 (DoE 2004) outlines the overarching framework for implementing regional and local strategic plans for protecting fresh and marine water quality, and water quality monitoring and reporting in WA. The framework requires that all significant water resources in WA are spatially defined on a priority basis and that Environmental Values are developed for each of these regionally defined resources. Environmental Values are those that are *"important for a healthy ecosystem or for public benefit, welfare, safety or health and that require protection from the effects of pollution, waste discharges and deposits"*. The strategy sets out a process for establishing Environmental Values and associated Environmental Quality Objectives on a regional basis. These objectives translate the environmental values into water quality parameter concentrations of key potential stressors. These are referred to as Environmental Quality Criteria appropriate to the region and *"these criteria are used as formal benchmarks against which to assess the results of monitoring programs and as triggers for management actions designed to protect the environmental values of the region"* (DoE 2004).

The Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (PCWQCO) (DoE 2006a) sets out how the Environmental Quality Objectives and their Levels of Ecological Protection (LEP) are allocated spatially throughout the Pilbara region, which encompasses the Project area. The Environmental Values and Environmental Quality Objectives for the Onslow region are defined in Table 8.4. Where relevant, this is the basis for the assessment of risks, arising from Project-attributable impacts.

LEP are defined in Table 8.5 and are indicated for the Ashburton River to Cape Preston in Figure 8.3 (Department of Environment and Conservation [DEC] 2009). The majority of the marine area adjacent to Onslow is presently considered as having a high LEP.

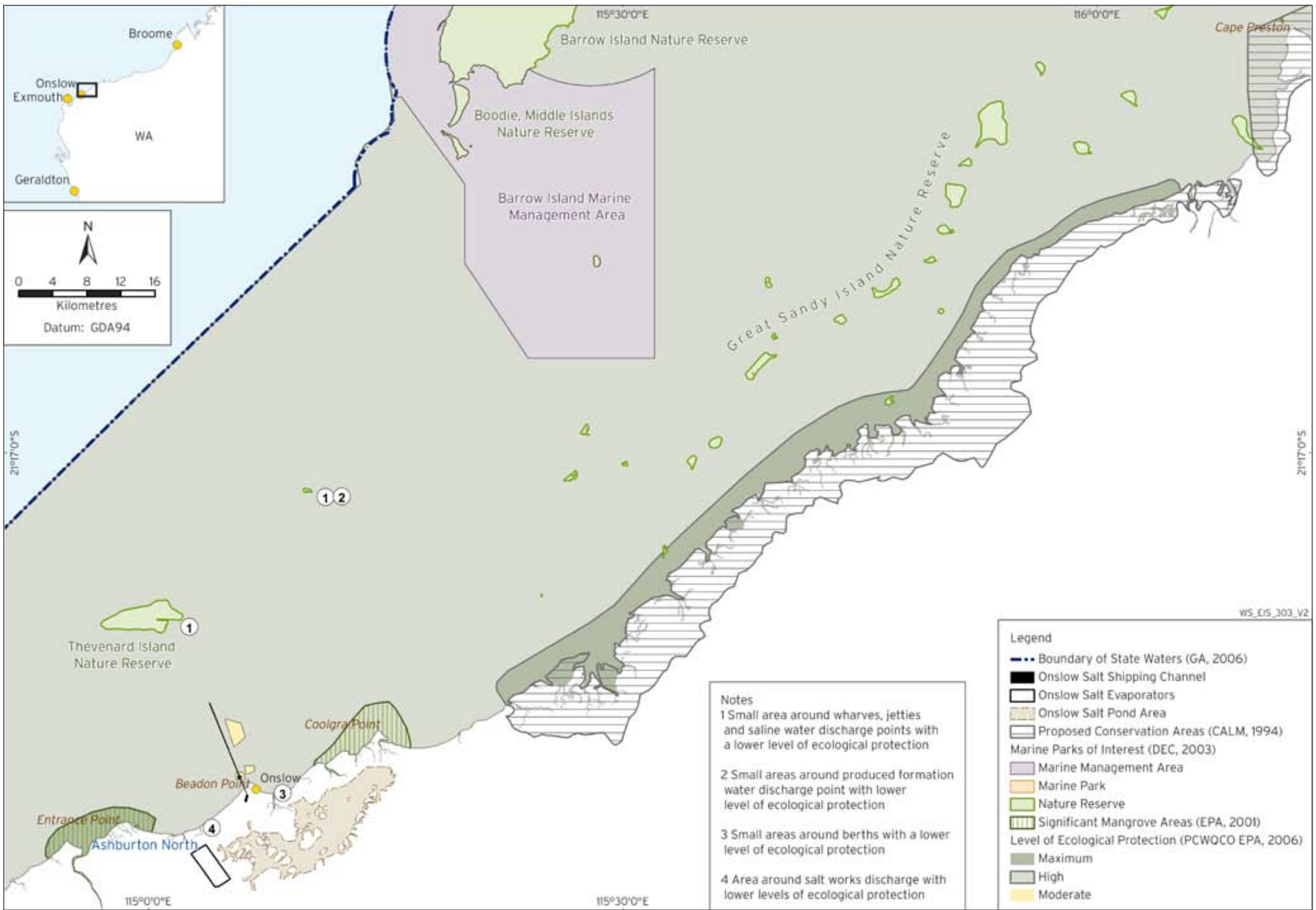


Figure 8.3: Indicative LEP for Waters from the Ashburton River to Cape Preston

Table 8.4: Water Quality Environmental Values and Quality Objectives for the Pilbara Region

Environmental Value	Context	Environmental Quality Objective	Relevant Environmental Quality Criteria*
Ecosystem health (ecological value)	Majority of the marine area adjacent to Onslow has a high LEP. The saltworks jetty and berths and saltworks discharge have a moderate LEP. Small areas of significant arid zone mangroves adjacent to the mouth of the Ashburton River have a maximum LEP. Proposal that inside the mixing zones for nearshore discharge be managed in accordance with a low LEP. Proposal that dredge material placement sites and nearshore infrastructure, including PLF and MOF, be managed in accordance with a moderate LEP. No existing or proposed marine conservation reserves nearby. Areas south of the Ashburton River mouth and around Serrurier Island are currently classified as study areas (DEC 2008).	Maintain ecosystem integrity.	Impacts on water and sediment quality are restricted to achieving ANZECC/ARMCANZ guidelines.
Recreation and aesthetics (social value)	Recreational boating occurs from the Onslow Maritime Facility in Beadon Creek. Diving and snorkelling around reefs and islands.	Water is safe for recreational swimming activities. Water is safe for recreational activities on the water (boating). Aesthetic values of the marine environment are protected.	
Fishing and aquaculture (social value)	Onslow Prawn Managed Fishery (OPMF) Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF). Onshore and offshore recreational fishing, including recreational facilities on the Mackerel Islands.	Seafood caught or grown within the operational area is safe to eat. Water quality suitable for aquaculture purposes.	Relevant criteria from Food Standards Australian New Zealand code. Relevant ANZECC/ ARMCANZ guidelines for LEP.

** EQC are for the long-term management of water quality. Short-term guidelines appropriate to dredging are detailed in the Dredging and Spoil Disposal Management Plan (DSDMP, Appendix S1).*

Table 8.5: LEP for "Maintenance of Ecosystem Integrity"

LEP	Environmental Quality Condition (Limit of Acceptable Change)	
	Contaminant Concentration Indicators	**Biological Indicators**
Maximum	No contaminants – pristine	No detectable change from natural variation
High	Very low levels of contaminants	No detectable change from natural variation
Moderate	Elevated levels of contaminants	Moderate changes from natural variation
Low	High levels of contaminants	Large changes from natural variation

Source: DoE 2006a

However, for example, areas around the Onslow Salt dredge material placement sites, jetty and discharge area have been allocated a moderate or low LEP. The management objectives for water quality in the Project are consistent with the PCWQCO and use these LEP in deriving the proposed water quality management framework associated with Project operations.

8.2.4 Consequence Definitions

To enable the assessment of risks associated with the Project, specific consequence definitions have been developed. Table 8.6 provides the consequence definitions that have been used in the risk assessment of marine water and sediment quality.

8.2.5 Impact Assessment and Management

Impacts to marine water and sediment quality will occur to some extent as a result of Project activities. The following sections summarise the aspects and activities that may directly and indirectly affect marine water and sediment quality in, and surrounding, the Project area. Chapter 7, *Impact Assessment and Methodology* contains the risk matrix used to assess the likelihood and consequence of the impacts occurring. The potential impacts and the management measures to be implemented to be implemented are discussed in detail. Table 8.18 in Section 8.2.7 provides a summary of the potential impacts, management and mitigation measures and residual risk to marine water and sediment quality as a result of Project activities. The aspects which are considered in this section include:

- Construction dredging
- Maintenance dredging
- Placement of dredge material offshore
- Placement of dredge material onshore
- Nearshore construction activities
- Discharges from onshore construction
- Discharges from onshore operations
- Discharges from offshore construction
- Discharges and wastes from offshore operations (including NORM)
- Vessel movements
- Hydrocarbon leaks and spills.

This section includes the following information:

- A brief description of the activity
- An explanation of the potential impacts of that activity
- A brief description of the risk ranking for that activity
- A summary.

Each subsection begins with a table summary of the level of residual risk related to that activity. Residual risk is the risk remaining following implementation of all mitigation options. In the following section, Table 8.18 provides more detailed mitigation options for different activities and provides a ranking of residual risk for marine water and sediment quality. Risk ratings are created from an assessment of the likelihood of the risk occurring, and the consequence if it did occur. Risk ratings are explained further in Chapter 7, *Impact Assessment and Methodology*.

8.2.5.1 Construction Dredging

This subsection provides a summary description of the proposed dredging works program and the effects of dredging on nearshore water quality criteria, with particular reference to elevated suspended sediment concentration (SSC) generated by dredging activities. The ANZECC/ARMCANZ guidelines (2000) specify that SSC for tropical marine waters should not exceed 20 mg/L. It explains the approach adopted to model dredge plumes, including set-up and validation and the selection of various dredging and climatic scenarios.

Table 8.6: Consequence Definitions for Marine Water and Sediment Quality

Marine						
	1	2	3	4	5	6
	Catastrophic	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Marine Water and Sediment Quality	• Regional long-term exceedence of background and applicable ANZECC/ ARMCANZ Water Quality (WQ) and Sediment Quality (SQ) Guidelines • Regional long-term change.	• Regional short-term exceedence of background and applicable ANZECC/ ARMCANZ WQ and SQ Guidelines • Regional contamination of sediment.	• Localised long-term exceedence of background and applicable ANZECC/ ARMCANZ WQ and SQ Guidelines • Localised contamination of sediment.	• Localised short-term exceedence of background and applicable ANZECC/ ARMCANZ WQ and SQ Guidelines • Localised contamination of sediment.	• Local short-term and small reduction in water and sediment quality with no exceedence of background and applicable ANZECC/ ARMCANZ WQ and SQ Guidelines • Localised long-term exceedence of background and applicable ANZECC/ ARMCANZ WQ and SQ Guidelines but within approved mixing zone.	• No detectable changes to background water and sediment quality • No detectable effects on marine sediments.

Long-term: *>10 years (2x construction period) |* ***Short-term:*** *<5 years (construction period) |* ***Seasonal:*** *<1 year |* ***Local:*** *Within Benthic Primary Producing Habitat (BPPH) Management Unit |* ***Regional:*** *Outside BPPH Management Unit within Interim Marine and Coastal Regionalisation for Australia (IMCRA) Pilbara Bioregion (Chapter 6, Overview of Existing Environment)*

Results of selected short-term scenarios modelled are presented, followed by a representation of the anticipated maximum plume impact zone for the full dredge program (FDP). It concludes with a summary and a risk ranking.

Residual risk to marine water quality from construction dredging of the channel and berthing area is	High

The development of nearshore infrastructure at the Ashburton North SIA requires the dredging and placement of up to 45 Mm^3 of dredge material to construct navigable approach channels and basins for both a nearshore MOF and a PLF. The Dredging and Disposal Plan (DDP) (LWI 2010) contains a description of the dredging to be carried out, including information on the type of equipment, procedures, cycle times and sediment spill release rate. The material to be dredged is either sand intermixed with variable fractions of clays, silts and or gravels; or rock (siltstone, claystone and sandstone) that is generally weathered and weak (Coffey 2009; DHI 2010a, Appendix Q1). Both the sand and the rock contain and high content of fines in places (up to 40 per cent <63um).

Two options are presented for the placement of dredged material. The preferred option is to place all dredged material in the nearshore and offshore marine Project area. The alternative option is to place up to 10 Mm^3 of dredged material onshore, with the remainder being placed at the nearshore and offshore placement sites. For the purpose of modelling the dredge area plume (DHI 2010a, Appendix Q1), the assumption has been made that most material is to be placed at one or more of five proposed nearshore dredge material placement sites. These sites are situated in waters of between six and 15 m in depth, to the east of the proposed navigation channel. A small volume of fine material will be relocated to one of two proposed offshore dredge material placement sites, situated in waters exceeding 30 m in depth, during the final clean-up campaign of the dredging program. The location of the proposed dredge areas, including the location of dredge material placement sites, is shown in Figure 8.4.

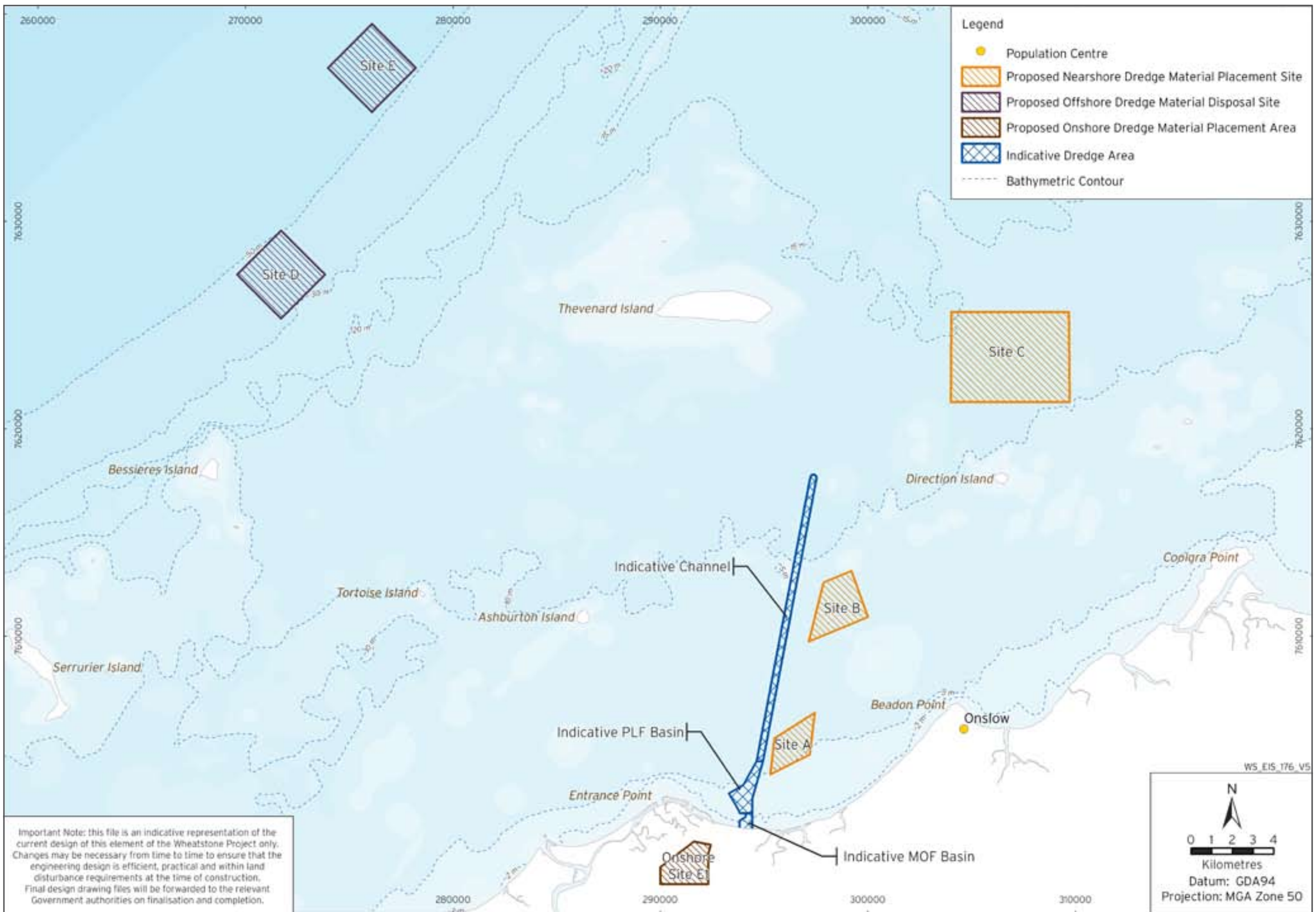


Figure 8.4: Indicative Dredge Area and Offshore, Nearshore and Onshore Dredge Material Placement Sites

The specific dimensions of the dredging works for the approach channels are as follows:

- The MOF approach channel will be approximately 1 km long, 120 m wide and 7 m deep
- The PLF navigation channel will be approximately 16 km long, 260 m wide and 13.5 m deep.

The proposed DDP (LWI 2010) indicates that the duration of dredging works will be approximately three to four years and may involve the use of:

- One large (4 000 kW) Cutter Suction Dredge (CSD)
- Two large (10 000 m^3) Trailing Suction Hopper Dredges (TSHD)
- One small (5 000 m^3) TSHD
- One large backhoe excavator
- Self-propelled barges
- A range of ancillary small craft (approximately seven) to service the dredges, transport crew and survey the channels.

The choice of dredging plant will be specified by the selected dredging contractor and will be based on plant availability, schedule and environmental requirements. It is therefore possible that other dredging plant may be selected for this task at the time of contract execution. Depending on the selected contractor, this could come from a wide range of plant available internationally. For example, dredges of the following sizes are known to exist and could conceivably be selected for the Project:

- 6 000 kW (at cutter head) CSD
- 20 000 m^3 size TSHD.

The dredging program has been divided into discrete work packages as follows:

- Temporary access channel which is subsequently incorporated into the MOF and approach channel
- MOF basin and approach channel
- PLF basin (expansion to 25 MTPA of LNG)
- PLF navigation channel.

The approximate volumes of material that will be dredged from each of the above work locations are given in Table 8.7.

The dredge material volumes presented in Table 8.7 relate to dredging required for the key marine infrastructure, and which have been used in this impact assessment. These volumes do not include dredging volumes that may be generated from the installation of the trunkline. An additional 3 Mm^3 of dredge material may be generated from trunkline installation and is discussed separately in Section 8.2.5.5. Completion of the MOF basin and approach channel is the first priority to allow construction material to be imported to the site by sea.

An example of the potential dredging sequence is as follows. A large CSD will be the first dredging plant on site and will be used to remove existing high spots along the MOF and PLF approach channels and place this material at nearshore placement site A. The CSD will then complete the MOF basin and access channel before moving on to complete the PLF basin to -8 m lowest astronomical tide (LAT). Most of this material will be pumped to a large TSHD for placement at nearshore site C. The CSD work is anticipated to be completed within one year, after which it will be replaced by three TSHDs (one small and two large).

Table 8.7: Dredge Volumes Split by Depth and Dredge Area

Dredge Area	Total for Area (m^3)
Temporary access channel	935 000
MOF basin	1 580 000
PLF basin	16 445 000
PLF navigation channel	20 160 000
Total construction dredge volume	39 120 000
Design uncertainties	5 880 000
Estimated Total Construction Dredge Volume	**45 000 000**

The small TSHD will be used to remove sandy material in the PLF navigation channel from -6 m LAT to -8 m LAT and place this material into nearshore site C. It will then undertake clean-up dredging of fines in the MOF basin and channel and place these at offshore site D or site C. One of the two large TSHDs will commence dredging the PLF navigation channel, while the other will complete the PLF basin to -15 m LAT, before joining the first TSHD to complete the PLF navigation channel to required depth. The TSHD work program is anticipated to require almost 2 years to complete. All material dredged by the TSHDs (except clean-up fines) will be placed at nearshore site C.

A large backhoe may be brought to site towards the end of the dredging program to remove hard spots that may be remaining. The backhoe will place rocky material into small barges, which will place the excavated material into nearshore site B. One of the large TSHDs will undertake clean-up dredging to complete the dredging program for placement of high fines material at offshore site D, or sand at nearshore site C.

Effects of Dredging Program on Nearshore Water Quality

The dredging and dredge material placement operations described above will release a wide range of sediment particles to the adjacent water body during the cutting and barge/TSHD loading operations. Large and coarse sediments (>63 µm) will settle quickly to the seafloor adjacent to the channel, while small fine sediments (<63 µm) will take some time to settle. This will create a visible plume of suspended sediment carried by the currents across the Project area from both the dredging location and the dredge material placement sites. The extent of the plume will depend on a range of factors including: season; wind strength and status of tide; location and type of dredge; dredge working methods and productivity; and the particle size distribution of the sediments generated and suspended in the water column during the dredging and dredge material placement operations. A critical factor affecting the scale of effects is the "release rate" – defined as the rate of release into the marine environment of fine seabed material generated from dredging activities including materials going into suspension and those settling on the seabed outside the dredging areas. The release rate is, usually expressed as kg/s or t/day.

Specific activities with potential to locally increase suspended sediments in the marine waters include:

- Overflow from TSHD dredging and barge loading
- Disturbance of seabed by CSD, drag head and TSHD
- Placement by bottom dumping at nearshore and offshore sites
- Discharge to sea bed at sites A and B by CSD
- Return of decanted seawater discharge from onshore placement.

Based on experience from other dredging programs in the north-west of WA, dredging will increase TSS and turbidity to above baseline levels, but is likely to have little impact on salinity, pH or dissolved oxygen concentrations in receiving waters (Stoddart & Anstee 2005).

To determine the scale of sedimentation and turbidity impacts arising from the above activities, DHI was engaged to simulate the dispersal of sediments released by the proposed dredging program via their range of MIKE 21 mathematical models. DHI have developed an approach for impact assessment and management of dredging and reclamation projects in Europe and Singapore which is considered international best practice by both the World Association for Waterborne Transport Infrastructure (PIANC) and the World Dredging Congress (Doorn-Groen & Foster 2007). Their approach has been documented in a publication that is planned to be jointly released by PIANC and the United Nations Environment Program (UNEP) in 2010 (M Jury [DHI] 2010, pers. comm. May).

The following sub-sections summarise work completed by DHI:

- Development of a modelling approach, which is appropriate for the Project area and the simulation task
- Set up of a mathematical hydrodynamic model for the Project area
- Calibration and validation of the model
- Development of a range of dredging and climatic scenarios to be modelled
- Simulation of the selected scenarios in the model and reporting of findings.

Full details on the above works, including all scenario results, can be found in DHI (2010a, Appendix Q1).

Overview of Dredge Material Modelling Approach

The key role of modelling the transport and fate of the dredge sediment plume is to identify any and all significant impact areas/zones, and incorporate sufficient and appropriate mitigation measures into the DSDMP (Appendix S1). For the purposes of this report, TSS has been defined as the mass of suspended particulate matter in the water column at a given time. Conversely, SSC is defined as the value generated by modelling and does not take into account background levels.

The modelling methodology adopted for the Project provides a conservative upper bound on the potential impacts from dredge plume sediment, based on the degree of uncertainty that is inherent in the Project description. The key uncertainties associated with the proposed dredging program include:

- The actual sediment release rates and release characteristics that will occur. This is highly dependent upon the type of dredging equipment used and the local sediment characteristics
- The final details of the dredging program which will ultimately be defined by the dredging contractor
- The precise nature of the climatic conditions that will be experienced across the entire dredge area during the three year dredging program as well as the impact.

The uncertainty in the release rate that will occur at the time of dredging has been addressed by the assessment of "high" (i.e. worst-case) and "low" (i.e. realistic) rates of sediment release associated with the dredging activities. Estimates of high release rates are associated with the 90th percentile release rate per travel cycle of a dredger and is based on information presented in DHI (2010a, Appendix Q1). Thus, model results for high spill rates are indicative of short-term events (i.e. less than one day) and results presented for the climate scenarios (14-day time scale) are considered highly conservative. Due to the episodic nature of the high spill events, representation of these results for either the seasonal or annual timescale is not considered appropriate.

In order to address the uncertainties in the implemented dredge program, a scenario approach has been adopted that identifies key stages within the dredging program and assesses impacts from each component in isolation. Uncertainty associated with climatic conditions at the time of dredging has been accommodated by the use of a climate scenario approach, which includes a range of worst-case climatic conditions. Note that the concept of "worst-case" with respect to the areal extent of the plume occurs under different climatic conditions as opposed to "worst-case" impacts associated with (for example) sediment deposition or increased turbidity. By investigating the transport and fate of sediment for each dredge scenario under a range of worst-case climatic conditions, the sequencing of dredging activities becomes unimportant thereby reducing the influence of uncertainties associated with the dredge program.

The scenario approach adopted for this assessment (and as recommended by PIANC) thus involves the modelling of the dredging program using combinations of short-term (i.e. 14-day tidal cycles) climate scenarios, dredge scenarios, and release rates thereby ensuring that the bounds of the range of plausible conditions are adequately assessed. Importantly, the short-term scenario approach also facilitates the quantification of the effectiveness of potential dredging-related mitigation options designed to manage the potential for adverse environmental impacts due to their reduced computational requirements.

Motivated by the results of the analysis of available observational metocean data (DHI 2010a, Appendix Q1), and the configuration of the dredge program, the hydrodynamics used to drive the sediment model have been developed using a two-dimensional depth-averaged approach. For this assessment, a (semi)-three dimensional sediment transport model was used in which the vertical shear-structure within the water column was assumed to be associated with a logarithmic velocity profile. This approach to the modelling of the transport and fate of the dredge sediment incorporates key three-dimensional sediment dynamics, which result in variations in sediment concentration through the water column.

The need to explicitly resolve the vertical shear structure (i.e. the use of fully three-dimensional hydrodynamics) must be guided by the observational data balanced against the increased computational requirements. Consideration must also be given to the loss of horizontal resolution typically associated with fully three-dimensional modelling. This is because good horizontal resolution is important when considering potential impacts to highly demarcated habitats such as island coral reefs. For the purposes of this assessment, it was concluded (DHI 2010a, Appendix Q1) that the semi-three-dimensional approach based on two-dimensional depth averaged hydrodynamics would provide conservative results when compared with an approach based on a fully three-dimensional approach.

A number of studies have been undertaken in support of the study methodology. These include a comparison of the spatial extent of the impact zones on sediment transport modelling driven by two-dimensional and three-dimensional hydrodynamics. Results of these studies confirm that the applied methodology is sufficiently conservative for this application and the details of the studies are included in DHI (2010a, Appendix Q1).

Details of the results of the data analysis and discussions associated with modelling methodology options, such as advantages and disadvantages of two-dimensional compared with three-dimensional models, are presented in DHI (2010a, Appendix Q1).

An independent review of the dredge material modelling has been undertaken by Dr. Des Mills, the results of this review can be found in Appendix JJ within Appendix N1. The dredge material modelling approach has also been reviewed by HR Wallingford. The results of this review can be found in Appendix II within Appendix N1.

Dredge Model Set-up, Calibration and Validation

To ensure that the models (hydrodynamic, wave and sediment transport) produce reliable results, it is important that the models are calibrated and that the validity of the model predictions are verified as far as practicable based on the availability of observational data. Calibration is the process by which model parameters are adjusted within reasonable limits so that model predictions match observational data at specified location(s).

In general, the quality of model results is determined by the quality of the model inputs. The key inputs into the hydrodynamic model for the Project include bathymetry, tides, and wind fields. The key inputs into the sediment transport model include the hydrodynamics, waves (developed using a wave model and which are particularly critical in the nearshore), and winds. All available data at the time of the model setup and calibration phases of the assessment were reviewed by DHI and assessed for suitability for the purposes of calibrating model parameters and the validation of model output.

The calibration of the hydrodynamic model primarily focused on refinement of the extensive bathymetric data set and bottom roughness. Bathymetry plays an important role in steering the wind and tidally driven circulations. Refinements on the model bathymetry were assessed against available current data at critical locations within the study region.

DHI has applied the internationally recognised UK Foundation for Water Research (UKFWR) Guidelines for quantitative assessment of the adequacy of the hydrodynamic model setup, calibration and validation. These guidelines are a series of quantitative measures of the accuracy of numerical hydrodynamic models and have been previously used in international court cases to establish the validity of model outputs. DHI's model for the Project has met all of the quantitative criteria specified by the UKFWR.

Output from the wave model was validated against data from the offshore dredge material placement site D, the proposed site for the PLF, and in the vicinity of Ward Reef which is east of the proposed navigation channel. Details of the setup, calibration and validation of the hydrodynamic, wave and sediment transport model are found in DHI 2010a, Appendix Q1.

Selection of Climatic and Dredging Scenarios

As discussed above, a conservative approach has been adopted that includes the use of short-term climate and dredge scenarios.

The climatic and dredge scenario selection process has been based on extensive iterative testing runs in the model and included modelling of an evolving dredging program. This has enabled extensive evaluation of plume behaviour and ensures that the chosen scenarios adequately cover the full range of dredge program activities. Only the final selection applied for the impact assessment is documented in DHI (2010a, Appendix Q1) in full. The following subsection presents a summary of DHI (2010a, Appendix Q1).

The climatic scenarios were selected after DHI reviewed the available wind data record. The most complete wind records available to the study are from 2006 and 2007. Comparison to previous years indicate that these 2 years follow fairly typical patterns, although 2006 encompassed cyclonic events in March and April, and 2007 had higher than average winds in January. In addition to the tides, the main climatic conditions governing the sediment plume dispersion are related to winds and waves. The waves are well correlated to the local winds, and the scenario selection can thus be based primarily on the winds and the resulting net currents.

The Project area has dominant summer and winter conditions for wind driven net currents that cause the sediment plumes to travel in a predominant direction according to season. A number of scenarios with best estimates of "strong" (represented by an "A") and "representative" (represented by a "B") wind conditions (Table 8.8) are required to develop an envelope of potential plume impact scale. There is also significant variability throughout the "calm" seasonal period occurring in April and May. Consequently, there are two representative calm periods to capture the variability during this "transition" time; one for April, the other for May.

Based on a review of model simulated currents, the periods listed in Table 8.8 have been selected to define six climatic scenarios using real wind data for the month of the condition period shown in the table.

The other important parameters governing the model outputs for the plume dispersion and impact assessment are the release volume and sediment characteristics introduced from the dredging. The dredge and release scenarios will remain uncertain until actual dredging has commenced.

However, estimations of the potential sediment release rates for the Project have been provided by LWI and DHI based on their review of local geotechnical data and their extensive experience in alteration of sediment characteristics by dredges.

For this assessment, two release rates have been selected. One (termed "Low") is considered by LWI to be a realistic estimate of "most probable" sediment release from the proposed program. The other (termed "High") is considered to be a conservative "worst-case" over-estimate of likely sediment release rate by DHI. All selected climate scenarios have been modelled twice; once using the "Low" release rate, the other using the "High" release rate.

In accordance with advice presented in the EPA's *Environmental Assessment Guidelines. No. 3: Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment* (EAG 3; EPA 2009d), proponents should present the most realistic case for assessment. It is proposed that this impact assessment be based on the findings of conservative, "worst-case" simulations (i.e. strong winds in summer and winter, and calms during the transition season) arising from the "realistic" (or Low) release rates. Justification of this approach and of the release rates used is provided in (DHI 2010a, Appendix Q1).

The dredging scenarios are derived from the DDP (LWI 2010) which is summarised earlier in this section and information on sediment characteristics at the site from the geotechnical study (Coffey, 2009). The dredge plan has been evolving as the Project design progresses and more geotechnical information is becoming available from the site. As a result several rounds of interim modelling have been carried out for development of the modelling and impact matrix presented later in this impact assessment.

As indicated previously, there will be a range of dredging plant operating concurrently during some parts of the dredging program. It is therefore important to simulate the results of all concurrent sets of activities on SSC in local waters. The dredge plan has therefore been separated into seven major pieces of work, each representing the proposed activity at a particular stage of the dredge plan and at different locations along the channel alignment. Each scenario has been modelled for the six climatic scenarios described earlier, for both Low and High release rates, which corresponds to 84 simulations (i.e. two release rates multiplied by six climate scenarios multiplied by seven dredging scenarios). All 84 simulations are presented in DHI (2010a, Appendix Q1) but only selected scenarios are presented in this Chapter. These scenarios are based on a "realistic" spill rate.

A review of the results of Dredge Scenario 7, presented below, indicated that an additional dredge scenario required investigation to incorporate dredge spill (i.e. overflow) restrictions along parts of the proposed navigation channel. This was required to manage potential impacts at nearby sensitive receptor locations, such as Ashburton Island. The additional modelling resulted in a total number of 96 simulations DHI (2010a, Appendix Q1).

Figure 8.5 shows the location of the proposed navigation channel sections used for modelling each of the dredge scenarios. The PLF approach channel has been divided into four equal lengths (4.5 km) termed Sections 1 to 4 (S1 – S4). Section 5 (S5) represents both the PLF basin and the MOF basin and approach channel.

A detailed description of the release rates used and all assumptions adopted for modelling is provided in DHI (2010a, Appendix Q1). The following short-term dredge scenarios have been selected:

Dredging Scenario 1

- Nearshore dredging in the temporary access channel (S5) by CSD pumping to placement site A.

Dredge Scenario 2

- Nearshore dredging in the PLF basin (S5) by CSD and pumping dredged material to hopper barges located at the -3 m LAT contour for transport and placement at site C.

Dredge Scenario 3

- Nearshore dredging in the MOF basin (S5) by CSD and pumping dredged material to hopper barges located at the -3 m LAT contour for transport and placement at site C
- Offshore dredging by 5000 m^3 TSHD in S4 of the PLF approach channel and placement of dredged material to site C.

Dredge Scenario 4

- Nearshore dredging of weak rock in the PLF basin (S5) by 10 000 m^3 TSHD and placement of dredged material at site C
- Offshore dredging of sand in S1 of the PLF navigation channel by 10 000 m^3 capacity TSHD with placement of dredged material at site C.

Table 8.8: Selected Climatic Scenarios

Condition Period	Period
Summer A*	January 2007
Summer B^	February 2007
Winter A*	June 2007
Winter B^	July 2007
Transition* A	April 2007
Transition ^B	May 2007

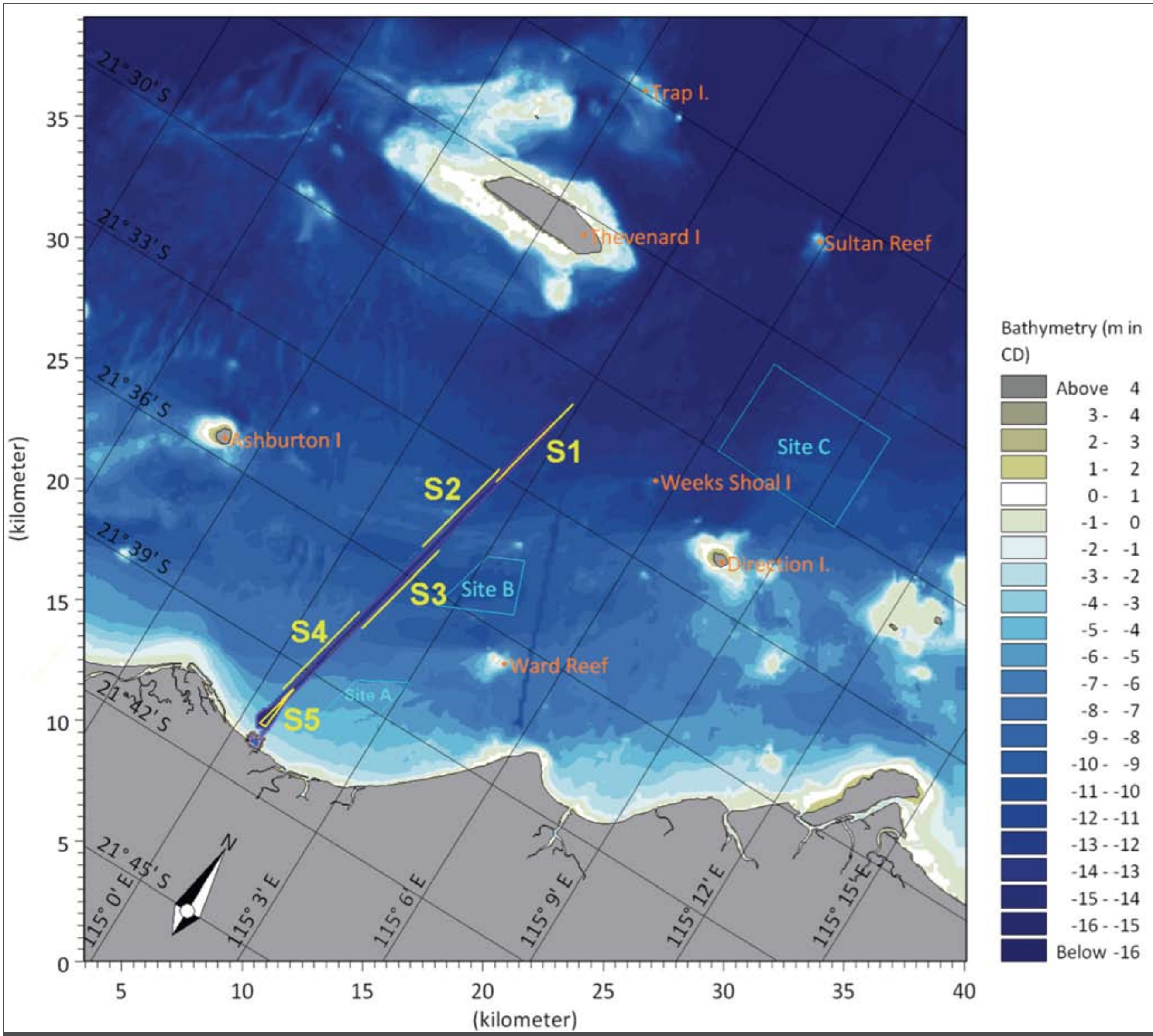


Figure 8.5: PLF Approach Channel Dredge Sections 1 to 4, and PLF and MOF Dredge Section 5

Dredge Scenario 5

- Offshore dredging of sand in S3 of the PLF navigation channel by 10 000 m³ TSHD with placement of dredged material at site C
- Offshore dredging of weak rock in S1 and S5 of the PLF navigation channel by 10 000 m³ TSHD with placement of dredged material at site C.

Dredge Scenario 6

- Offshore dredging of sand in S4 of the PLF navigation channel by 10 000 m³ TSHD with placement of dredged material at site C
- Offshore dredging of weak rock in S3 and S4 of the PLF navigation channel by 10 000 m³ TSHD with placement of dredged material at site C.

Dredge Scenario 7

- Offshore dredging of sand in S2 of the PLF navigation channel by 10 000 m³ TSHD with placement of dredged material at site C.

Dredge Scenario 7A (Optimised Dredge Scenario)

- 10 000 m³ TSHD dredging sand with placement of dredged material at site C
- Dredging along Section 2 and parts of Sections 1 and 3 with operational mitigation to manage the risk of overflow during specific periods when potential impacts are likely (based on monitoring results and current forecasts) in "restricted" zone
- For each dredge cycle, the TSHD starts dredging at the centre of the "restricted" zone within Section 2. It takes about 25 minutes, corresponding to a sailing distance of 1.5 km for a speed of 1 m/s (approximately 2 knots) before overflow starts. The dredger keeps dredging for another 3 km with overflow. The dredger dredges towards south and north, respectively, on alternate trips. This leads to a 3 km interval with restricted overflow, and 3 km at both ends with overflow occurring (i.e. the total channel section being dredged is 9 km).

The location of the area being dredged, the restricted spill zones and the placement site associated with Dredge Scenario 7A are shown in Figure 8.6. The need for the

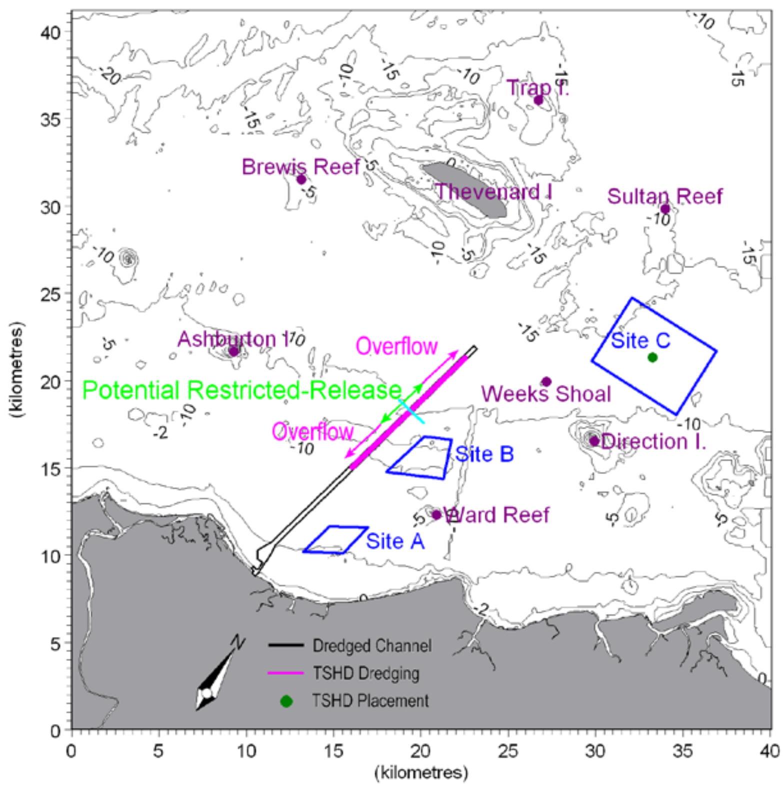


Figure 8.6: Dredging Scenario 7A: Incorporating Potential 'Restricted-Release' Zone (green) Along the Channel

restricted overflow will be considered prior to dredging if sensitive receptors were considered to be at risk. Under certain climatic conditions it is possible that there will be no need to restrict the overflow.

Short-term Scenario Modelling Results

Results from Dredge Scenario 3 and Dredge Scenario 7 as well as the optimised Dredge Scenario 7A are presented within this section. These scenarios have either the largest and most concentrated plumes, or plumes which impact on sensitive receptor locations. Dredge Scenario 3 is associated with the site C placement base case, with two dredges (a CSD and small TSHD) working in close proximity to each other in the nearshore. Dredge Scenario 7 is associated with a large TSHD working in sand adjacent to the coral shoals, which occur along the 10 m isobath. These two scenarios are responsible for most of the dredging-related Benthic Primary Producer Habitat (BPPH) impacts presented in Section 8.3. Results from Dredge Scenario 7A have been presented to highlight the potential environmental benefit that can be achieved by incorporating ''restricted-release'' zones into the dredge program.

For each of the three dredging scenarios, the mean SSC for each of the six climate scenarios associated with "realistic" release rates is presented. Additional results are presented in DHI (2010a, Appendix Q1).

Figure 8.7 shows the results for Dredge Scenario 3. It also depicts the corresponding dredge scenario (top figure). The results for the mean SSC for the six climate scenarios for Dredge Scenario 3, based on realistic release rates, are presented in the lower figures. Results highlight the extension of the sediment plume along the nearshore and to the east of the dredging activities during summer and westward during winter periods. Periods in which localised impacts are maximised (i.e. during the transitional climatic periods) are associated with the highest mean SSC. Elevated levels of SSC in the vicinity of dredge material placement site C are also noted.

Figure 8.8 shows the results for the six climate scenarios for Dredge Scenario 7, based on realistic release rates. It also depicts the corresponding dredge scenario (top figure). Results highlight the influence of the prevailing winds during the winter and summer periods. Transitional periods are associated with the highest mean SSC values in close proximity to the channel. Sediment plumes associated with dredging activities in this region are predicted to extend westward to Ashburton Island during the winter period and eastward towards Weeks Shoal during the summer period.

In order to manage the potential for impacts to coral shoals from sediment plumes associated with dredging activities in this region, ''restricted-release'' zones have been proposed and modelling undertaken (Dredge Scenario 7A). Figure 8.9 shows the results for the six climate scenarios for Dredge Scenario 7A, based on realistic release rates. The effectiveness of the ''restricted-release'' zones is clearly identifiable with reductions in the mean SSC during the winter and summer periods in the vicinity of sensitive receptors.

Representation of the Full Dredge Program

As discussed in Overview of the Modelling Methodology, one of the advantages of the scenario approach is the ability to assess the impact of dredging without the need for prior knowledge of the order of dredge-component implementation nor the time of year that these activities will occur. Estimates of "worst-case" impacts associated with the FDP can be inferred from results obtained for each of the individual dredge components.

The first step in developing a representation of the FDP is to determine the worst-case impacts for each dredge scenario based on a composite of all of the climatic scenarios. A composite of worst-case impacts has been created for Dredge Scenario 3 by overlaying the results of all six climate scenarios and taking the maximum value at each point within the domain (Figure 8.10, compare with results presented in Figure 8.7). When interpreting the results presented in the following figures, it is important to recall that these are not snapshots in time and therefore do not represent the areal extent of the dredge sediment plume at any given time. Instead, these plots are the composite of a number of simulated 14-day periods that have been superimposed to give an estimate of a maximum plume, associated with each dredge scenario.

Figure 8.11 shows the climate composites for Dredge Scenario 7 (unmitigated, left side) and Dredge Scenario 7A (mitigated option, right side). The effectiveness of the proposed "restricted-release" zones is clearly evident with the reduction in the mean SSC in the vicinity of Ashburton Island and Weeks Shoal.

The final step in developing a representation of worst-case impacts on water quality associated with the FDP is to combine each of the composites for each of the seven dredge scenarios. The resultant plot of worst-case impacts for the mean of the SSC is presented in the top figure of Figure 8.12 for the FDP based on Dredge Scenario 7 and in the bottom figure for the FDP based on Dredge Scenario 7A (which incorporates "restricted-release" zones in areas that may impact on sensitive receptor locations).

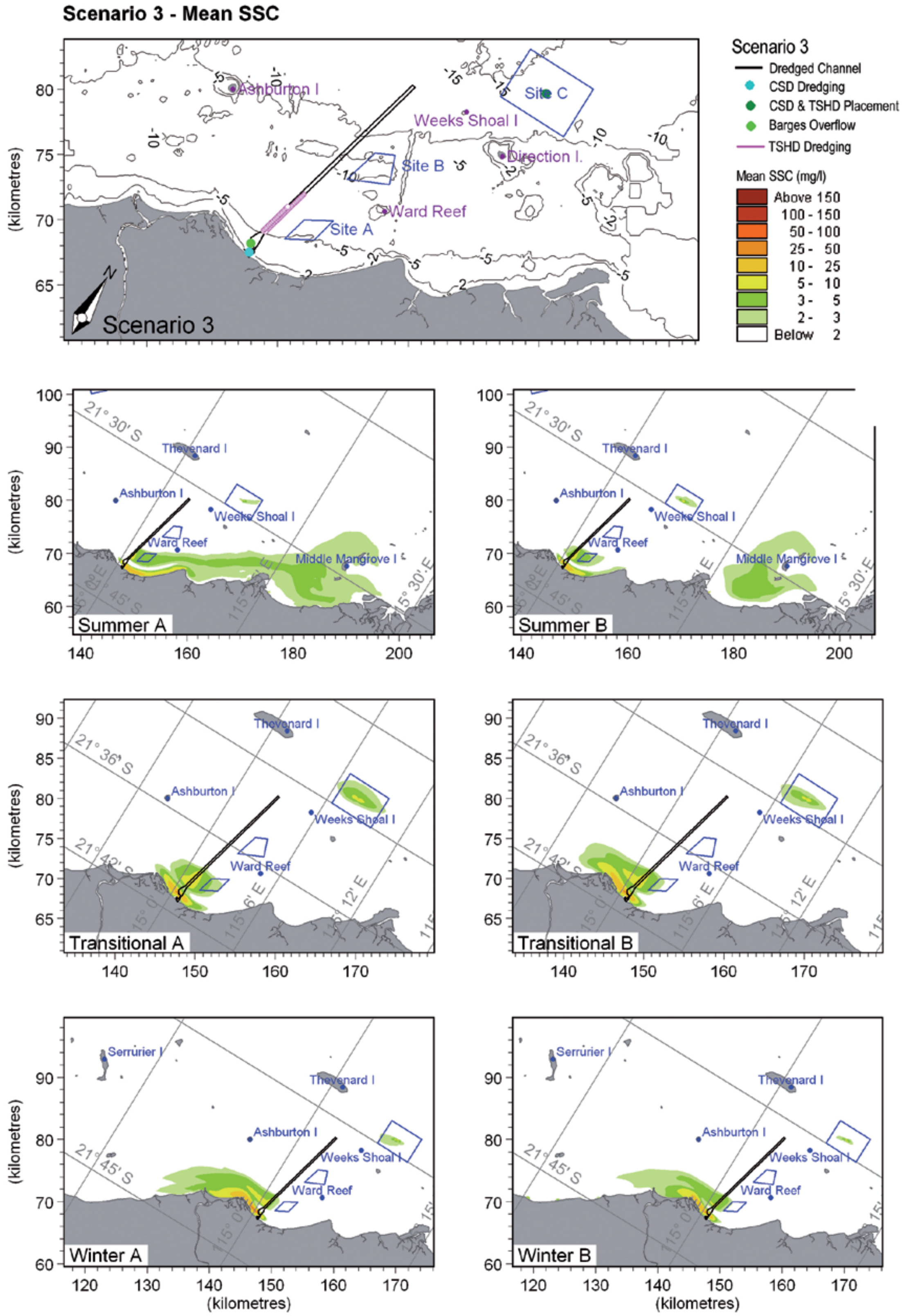


Figure 8.7: Mean SSC for Dredge Scenario 3 with Realistic Release Rates

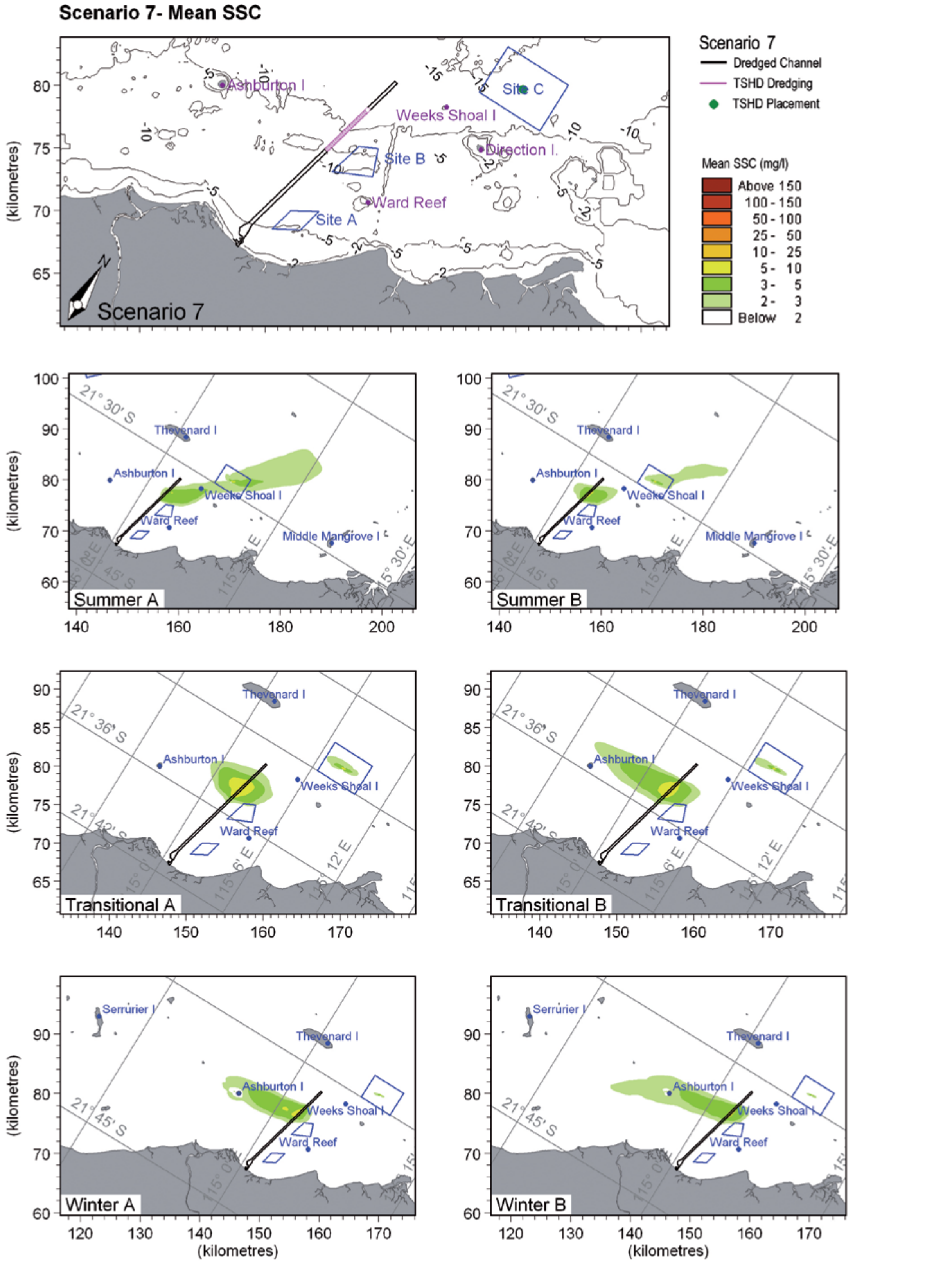


Figure 8.8: Mean SSC for Dredge Scenario 7 with Realistic Release Rates

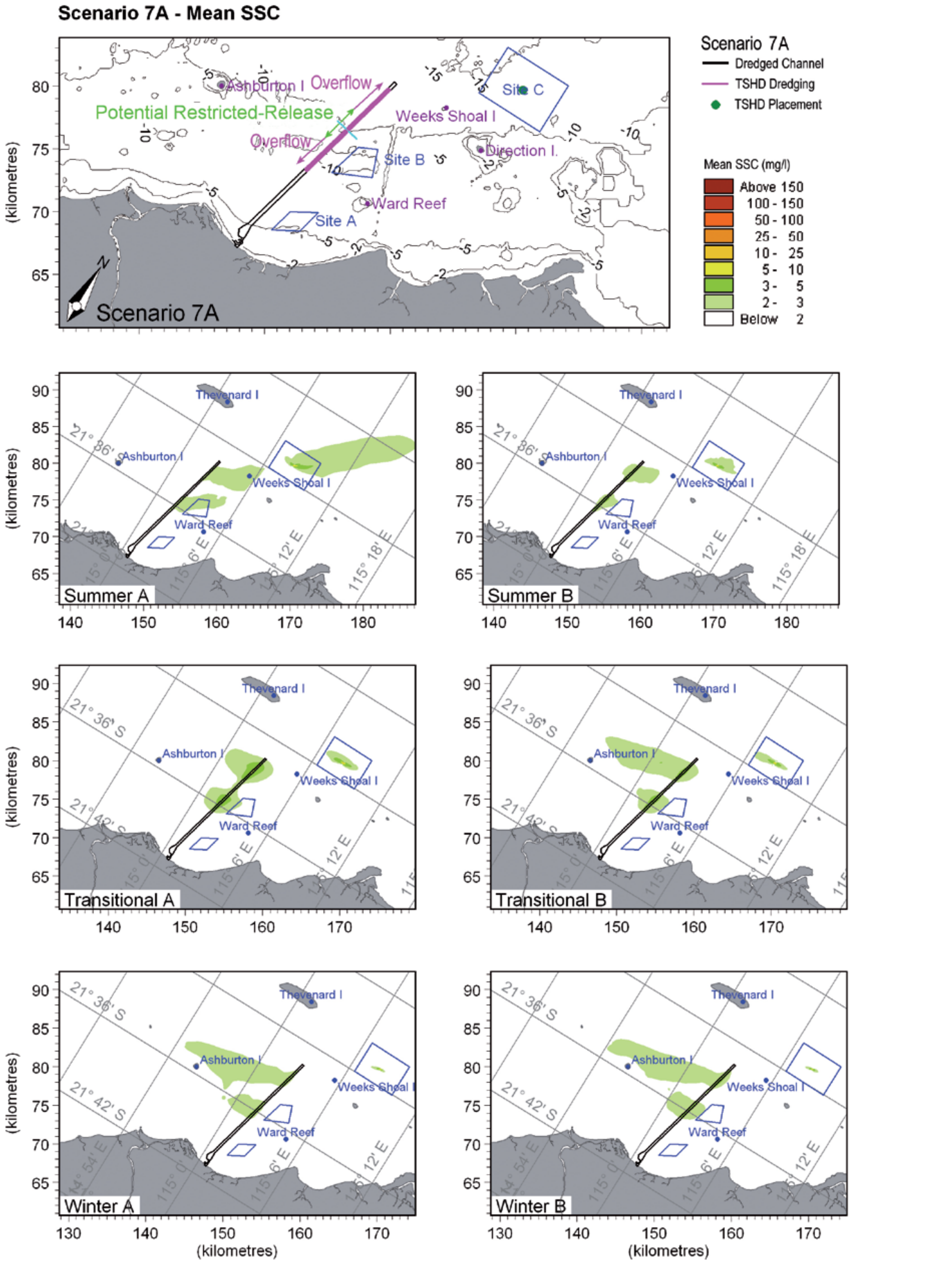


Figure 8.9: Mean SSC for Dredge Scenario 7A with Realistic Release Rates

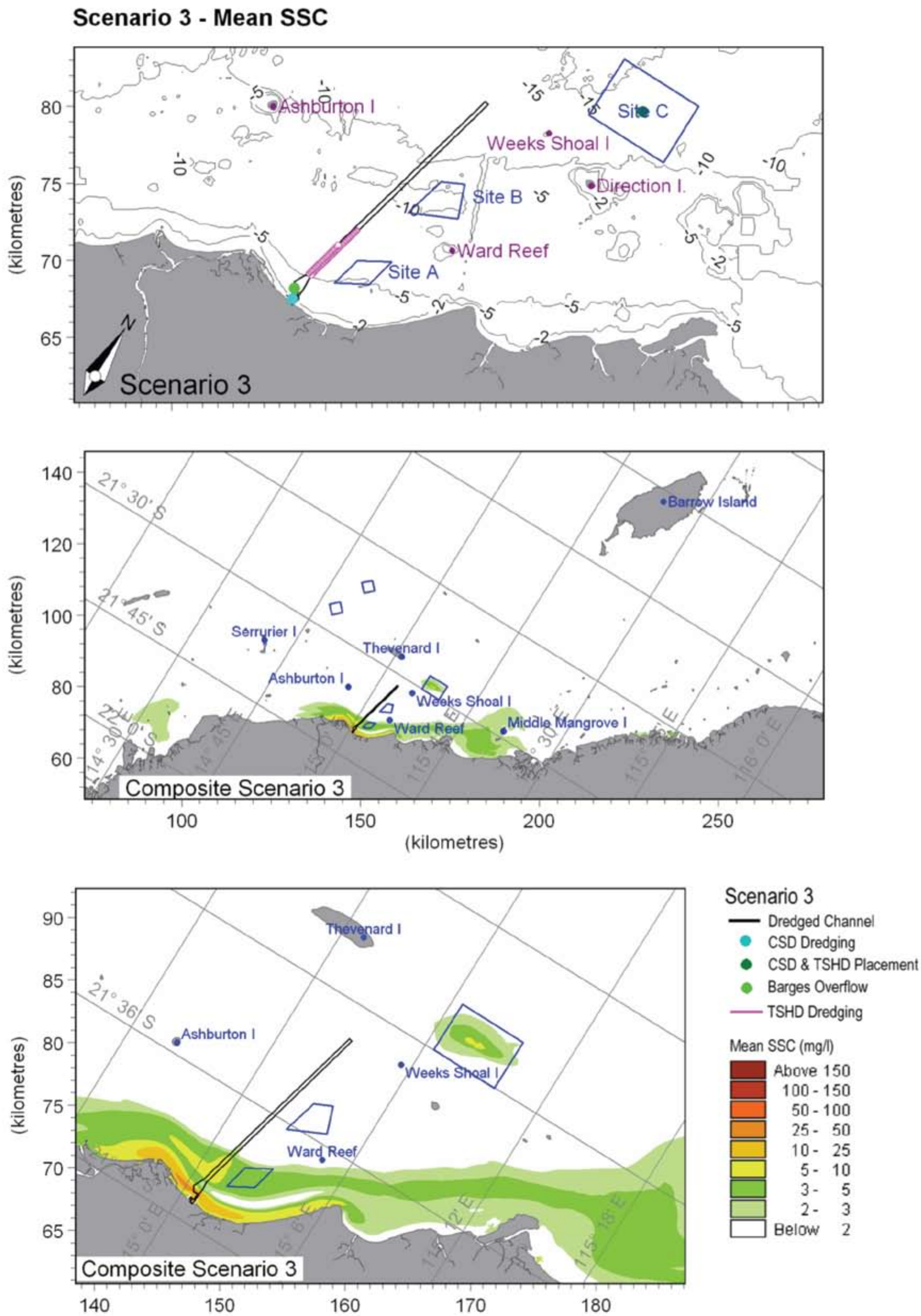


Figure 8.10: Composite of the Mean SSC for Dredge Scenario 3 with Realistic Release Rates, All Climate Scenarios Combined

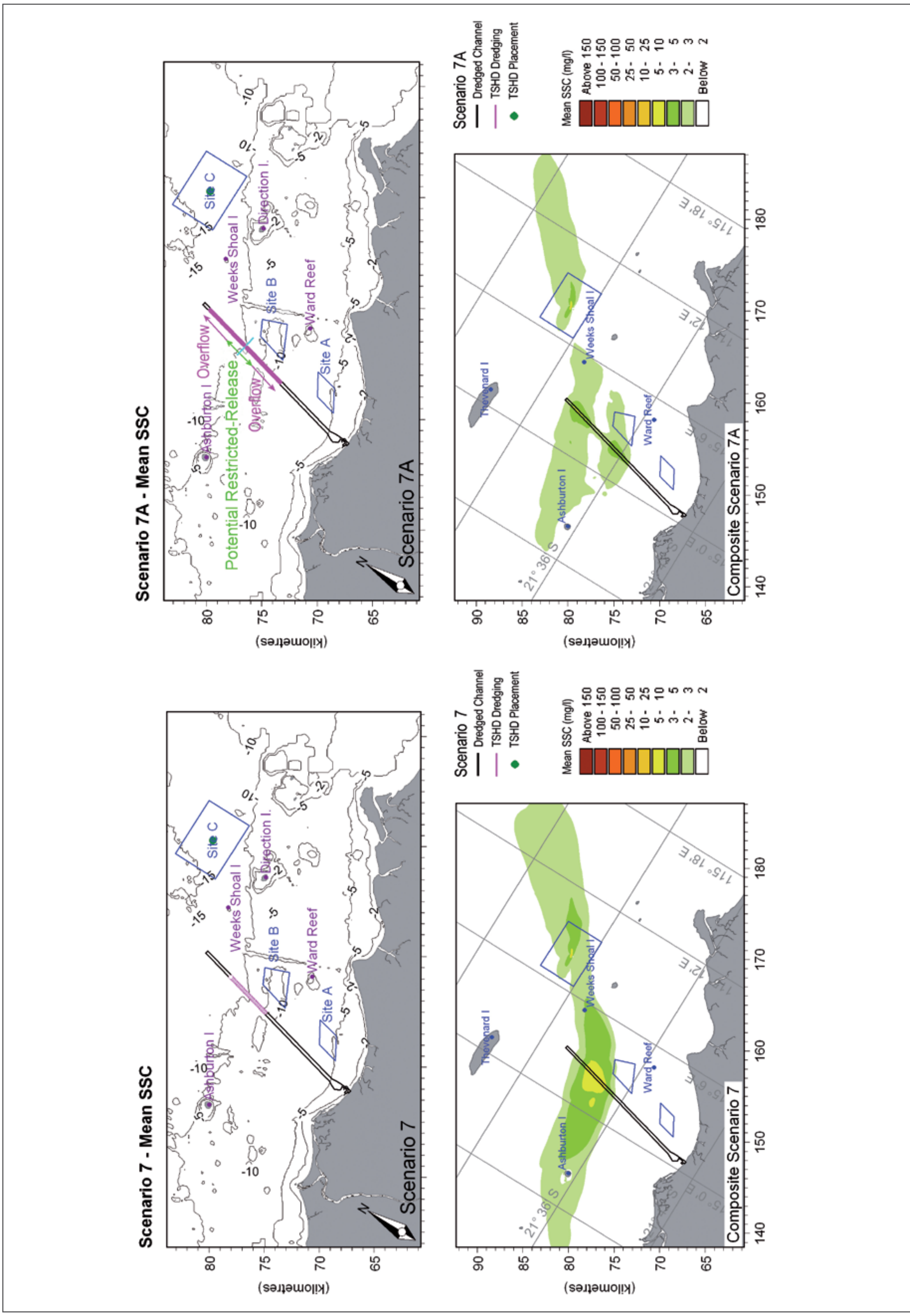


Figure 8.11: Mean SSC for Scenario 7 (left) and Scenario 7A (right) with Realistic Release Rates, All Climate Scenarios Combined

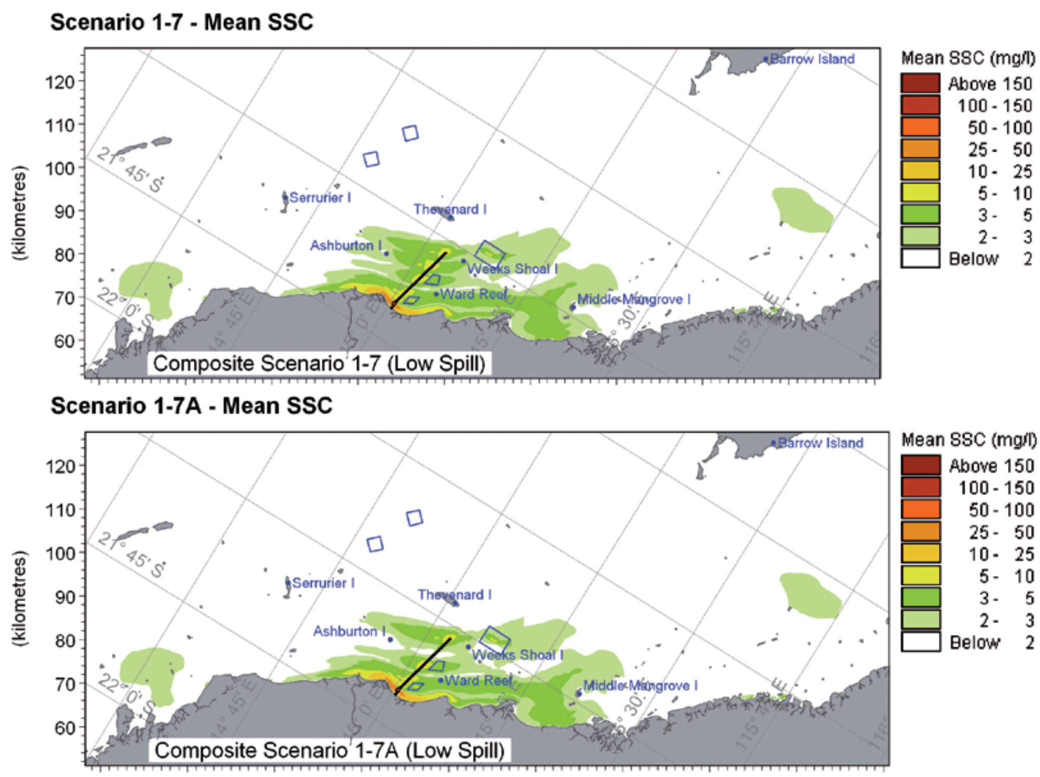


Figure 8.12: Mean Excess Concentration for the FDP based on Dredge Scenario 7 (top) and Dredge Scenario 7A (bottom) with Realistic Release Rates

Summary

The composite scenarios provide an overall predicted plume extent for SSC elevations in marine waters under all scenarios in the Project area due to dredging and dredge material placement. The modelling predicts that the most intense plumes (> 10 mg/L SSC) are anticipated in very nearshore waters between Ashburton River and Onslow depending on the season and dredging operations.

The modelling results indicate that:

- There is a strong seasonal plume dispersion pattern in response to seasonal wind strength and direction (towards the west in winter and towards the east in summer)
- The most intense plumes (and hence the most potentially damaging) occur during calm, transitional periods when dispersion remains localised, potentially causing high sedimentation on two of the adjacent coral shoals
- The FDP for SSC, presented in Figure 8.12, indicates that exceedences of the ANZECC/ARMCANZ guideline (2000) for SSC may occur in the nearshore dredge area
- Suspended sediment plumes will travel greater distances in nearshore waters due to wind driven nearshore currents and resuspension by waves in the shallower waters. During summer, nearshore turbidity plume excursions to the east are likely to extend upwards of 50 km from the dredge area. Similarly, plumes created during winter are excepted to travel up to 70 km to the west of the dredge area
- Waters in the vicinity of Onslow will undergo seasonal increases in turbidity over a period of at least three years as a result of the proposed dredge works.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that construction dredging will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "High" – of "Moderate" consequence to marine water quality and of "Almost Certain" likelihood. To restrict, and potentially further reduce, the risk ranking to "High", the implementation of the management and mitigation measures outlined in Table 8.18 will be required.

8.2.5.2 Maintenance Dredging

Residual risk to marine water quality from maintenance dredging is	Low

Periodic maintenance dredging will be carried out to ensure that the shipping navigation channels, turning circles and berth pockets remain at the required depth. Under average conditions the annual infill is likely to be modest. Annual sedimentation volumes and average sedimentation rates have been modelled along the navigation channel, PLF and MOF. The highest sedimentation rates are predicted to occur in the MOF approach channel. Total volumes are, however, small and manageable (DHI 2010, Appendix Q1). A brief assessment of discharges from the Ashburton River following a cyclone showed that the plume did not impact the navigation channel with high sediment concentrations. However, simulations of a direct hit from Cyclone Vance (1999) gave rise to very high mobility of the seabed throughout the area and resulted in approximately 1 Mm^3 of infill into the dredged areas from an individual event.

Annual dredging of the MOF channel may therefore be required. This may result in the removal of approximately 50 000 to 100 000 m^3/yr. Less frequent dredging may be required every 3-5 years for other dredged areas. This may be equivalent to approximately 300 000 m^3/yr. An estimate of total planned maintenance dredging for 25 years of operation is in the region of 10 to 15 Mm^3.

The maintenance dredging plan will therefore be based on an annual short-term dredging of the area by a TSHD in the absence of a major cyclone event and a contingency plan developed to mobilise all available equipment to site immediately following a major cyclone event (with the MOF access channel the most sensitive area, which may require a shallow draft stationary dredger to remove the material).

Given the small volumes of material involved in maintenance dredging, and the short timeframes over which dredging will occur, plumes resulting from maintenance dredging have not been modelled. Localised, short-term increases in turbidity are anticipated from this activity.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that maintenance dredging will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Low" – of "Minor" consequence, arising from localised, short-term exceedence of background and applicable ANZECC/ARMCANZ water quality guidelines in the vicinity of the dredge area and dredge material placement sites, and of "Possible" likelihood.

8.2.5.3 Placement of Dredge Material Offshore

This subsection begins with a summary of the selection of the nearshore and offshore dredge material placement sites and is followed by a discussion of the contaminant status of the dredge material. The stability of material to be placed at the nearshore and offshore sites is examined, as is the stability of existing bed material. The subsection concludes with a summary of the subsection.

Residual risk to marine sediment quality seabed stability from placement of dredge material nearshore an offshore is	Medium

Selection of Dredge Material Placement Sites

The location of the dredge material placement sites has been selected on the following basis:

- No interference with navigation
- No significant impact on the current Onslow Salt channel
- Practicality from a dredging perspective
- Relocated material should be comparable to the naturally occurring sediment
- Low potential for secondary re-suspension after placement
- Relocated material should not be a significant source of sediment back into the channel
- Placement should not have a negative effect on the hydrodynamics within the area or the shoreline processes
- Reduced potential for loss of BPPH.

A summary of the key assumptions applicable to each nearshore and offshore dredge material placement site is presented in Table 8.9.

Contaminant Status of Dredge Material

The sampling and analysis of sediments in the dredge areas for contaminants of potential concern (COPC), in accordance with the contaminants list included in the NAGD, and a comparison to recommended screening levels (Phase II assessment) is detailed in URS (2009c, Appendix Q5).

Table 8.9: Characteristics of Dredge Material Placement Sites

Site	Assumptions	Mean bed level change (m)	Capacity (Mm^3)
Nearshore Dredge Material Placement Sites			
A	For use to establish temporary access channel. Approximately 1 Mm^3 of dredged material will be placed by CSD using a diffuser just above the seabed. The naturally deep water areas are the primary target for placement within site A. Depth <7 m.	0.375	1.5
B	Contingency site B may be used for placing weak rock removed from the PLF navigation channel and basin by the backhoe dredge. Depth 10–12 m.	0.6	3
C	The primary placement site capable of receiving the full dredge volume. Material placed either by TSHD or split hopper barges. Depth 12–15 m.	1.7	40
Offshore Dredge Material Placement Sites			
D	Primary placement site for approximately 300 000 m^3 fine material from cleanup operations. Material placed by either TSHD or split hopper barges but lower preference than nearshore site C. Depth 38–48 m.	4.45	40
E	Same as offshore site D, but lowest preference due to higher sailing distances. Depth >60 m. Unlikely to be used and will be retained for contingency only.	Contingency only	

Chemical analysis of sediment samples obtained from the navigation channel and turning basin (URS 2010, Appendix Q5) found that concentrations of total petroleum hydrocarbons (TPH), benzene, toluene, ethyl benzene and xylene compounds (BTEX group) and tributyltin (TBT) were below the detectable limit of reporting or below the relevant NAGD screening levels.

All metal COPCs were found to be below the NAGD sediment quality guideline values except for arsenic and nickel, both of which occurred in concentrations which exceeded the guideline value in several samples. However, natural enrichments of arsenic and nickel above NAGD sediment quality guideline values have been shown to occur regionally (i.e. in the proposed placement sites and onshore) and are therefore not limited to the proposed dredge area (URS 2010, Appendix Q5). A study undertaken by DEC estimated natural background concentrations of trace metals in marine sediments on the Pilbara coast. The study found that natural background concentrations of arsenic were above the ANZECC/ARMCANZ (2000) guideline value (equivalent to the NAGD guideline value). All other mean trace metal concentrations in sediments around the Ashburton River mouth and Onslow were below their relevant ANZECC/ARMCANZ (2000) guideline values (DEC 2006).

The contaminant status of the surface sediments to be dredged and relocated to the placement sites has been assessed to be acceptable for "unconfined disposal" at one or more of the proposed dredge material placement sites without the requirement for further geochemical and eco-toxicological assessments based on the guidance by the NAGD. It is also considered suitable for onshore placement.

URS (2010g, Appendix Q4) has investigated the acid soil potential of the nearshore sediments that are to be dredged by the CSD. The results of the chromium reducible sulfur (CRS) analytical suite indicate that the sediment and rock profiles are generally not acid generating. Concentrations slightly above or at the action criteria trigger value were detected; however, in the shallow unconsolidated surface sediments at a small proportion of the core locations sampled. Results of acid-neutralisation-capacity (ANC) analytical tests indicate that the sampled sediments have an ANC of 17-620 kg H_2SO_4/t. ANC values of all the samples analysed correspond to alkalinity forms (chiefly reactive carbonates) whose rates of availability for circum-neutral buffering are "chemically non-limiting". In summary, if onshore placement of dredge material were to be undertaken then the dredge material contains more than sufficient buffering capacity in the associated carbonate sands to neutralise any small amount of acid that may be generated as a result of oxidation.

Stability of Material to be Placed at Placement Sites A, B and C

During the placement process some of the fines in the dredged material will be released to the wider environment. The effects of this have been assessed through sediment plume modelling, discussed in Section 8.2.5.1. Some of the fines however, along with coarser particles and clasts, will be placed at the sites. This finest fraction of the placed material will, at times, be mobile at the placement sites under the prevailing flow and wave conditions. The sediment plume modelling has established that, after placement of the material at the sites, the rates at which any fine sediment (< 75 μm) might be released from the sites is likely to be insignificant compared to the fines released during the placement operation, except under cyclonic conditions.

The stability of the sand fractions of placed material has been examined through modelling (DHI 2010a, Appendix Q1). This modelling indicates that the smallest grain at rest for 95 per cent of the time is estimated to be between 200 and 300 μm at site A and between 200 and 450 μm at site C. During cyclone conditions the mobility of the seabed will be enhanced.

Given the predicted mobility of the finer material placed on the seabed at any of the placement sites, there will be a degree of natural sorting of that material after placement. This will commence at the time of placement, and may be influenced by subsequent placements at the site. This will result in some degree of loss of the finer fractions of material that are not well buried within the placed material. The surface of the placed material is likely to have an overlying veneer of fine material in patches on completion of the placement activities in one area of a placement site. This fine material will, over time, be reworked by the action of waves and currents such that the fine material is winnowed out and, on average, the surface of the placed material will coarsen. The nature of material buried within the placement site is not likely to change over time. The mixed nature of the material on the surface of the placement site will act to stabilise the placed material compared to the situation if the placed material were homogenous fine sand. Coarsening of the placed material will also act to armour the bed over time. Where the placed material contains fines arising from the dredging of the very weak rock, the coarser clasts will further help to stabilise the bed. Where the placed material has high fines content, consolidation processes will take place over time further reducing the erosion potential of the bed material.

In essence, over time the initial irregular form of the placed material will be smoothed. There will inevitably be some migration of placed material away from the placement site in the directions of dominant transport mixing into the natural transport pathways that already exist. Small amounts of fine sand placed at site A would, at times, be transported towards the Onslow Salt channel, in the east, and towards the proposed navigation channel, in the west. Rates of such transport are unlikely to be significantly greater than that presently occurring because of the distances involved and the presence of fine sand fractions on the seabed in these areas.

Material placement at site A is scheduled to occur in the early stages of the dredging program. The main stabilisation and winnowing out of fines from site A will gradually reduce with time after placement, and by the end of the dredging period, the rate of reworking and change is expected to be low. The risk of significantly enhanced infill of the Onslow Salt channel as a result of migration from proposed placement at site A following completion of dredging works is considered to be low.

Stability of Existing Bed Material

Modelling results for sand transport by LWI (M Dearnaley [LWI] 2010, pers. comm.) indicate that transport fluxes of 200 μm sand are weak in the study area, and are not expected to give rise to significant infill in the existing Onslow Salt channel or the future offshore dredged areas of the Project. This is consistent with the limited observational information available regarding infill in the Onslow Salt channel.

The Onslow Salt channel is about 9.5 km long and 120 m wide and dredged to a reported depth of -10.8 m Chart Datum (CD). The channel extends north-westward from about 1 km offshore of Onslow. The channel is to the east of the proposed navigation channel. Information, based on Fugro Survey Pty Ltd (2006) data, has shown that, in the approach channel to Onslow Salt over the period from July 1999 to December 2008, parts of the channel experienced up to 0.5 m of sediment deposition (up to 1 m reported in the berth pocket). During this period a Category 2 and two Category 3 cyclones made landfalls close to Onslow. While none of these were anticipated to have been as severe as Cyclone Vance (Category 5), which passed Onslow in March 1999, the Onslow Salt channels modest rate of infill is consistent with the findings of the LWI study (M Dearnaley [LWI] 2010, pers. comm.).

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that the placement of dredge material offshore will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Moderate" consequence, arising from localised short-term exceedence of background and applicable ANZECC/ARMCANZ water quality guidelines in the vicinity of the nearshore dredge material placement sites, and "Likely" to occur in most circumstances during the placement of dredge material.

8.2.5.4 Placement of Dredge Material Onshore

This subsection discusses the potential placement of dredge material onshore and potential impacts on marine water and sediment quality related to this activity.

Residual risk to marine water quality from placement of dredge material onshore is	Medium

Up to 10 Mm^3 of dredged material may be placed onshore in a specially constructed placement site. Assessment of the dredge material has been discussed previously in this section. The location and layout description of the dredge material sediment ponds and related groundwater considerations are described in Section 9.3. Groundwater modelling of this activity to examine potential seepage pathways from the placement site (URS 2010e, Appendix F1) concluded that changes to the water and salt budgets of the Ashburton River Delta are expected to be insignificant. It is anticipated that discharge of drained seawater from the sediment ponds will operate continuously for at least 18 months and possibly longer (i.e. during and, for a period, following cessation of the sediment placement activities). Once dredging has ceased, the remaining (if any) run-off from the area arising from natural dewatering of the placed material and rainfall will be allowed to follow the natural drainage path for surface water and groundwater into the south-west catchment. The run-off will be stilled in a settlement pond prior to release and will therefore not contain high concentrations of suspended sediments. As discussed earlier, URS has investigated the acid soil potential of the nearshore sediments that are to be dredged by the CSD (URS 2010g, Appendix Q4). That study concluded that the dredge material contains more than sufficient buffering capacity in the associated carbonate sands to neutralise any small amount of acid that may be generated as a result of oxidation if onshore placement of dredge material were to be undertaken.

Decant water will be discharged to the nearshore marine environment at a location west of the MOF. This water will also have been stilled in settlement ponds. This discharge is a very minor contribution to nearshore water turbidity in comparison to that arising from the dredging operations, hence dredging operations will have by far the greatest scale of impact on water quality. The dredge material has very low carbon content and is therefore unlikely to contain a significant biological oxygen demand. Experience with monitoring dredge material decant water elsewhere on the NWS has not indicated a problem with low dissolved oxygen content at the decant outfall site (I Baxter [URS] 2010, pers. comm.). As noted in the factor description, this nearshore environment also experiences naturally occurring frequent high turbidity excursions due to re-suspension of silt-laden sediment during periods of increased wave height and spring tides.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that the placement of dredge material onshore will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Moderate" consequence, arising from localised short-term exceedence of background and applicable ANZECC/ARMCANZ water quality guidelines in the vicinity of the decant water discharge outfall, and "Likely" to occur.

8.2.5.5 Nearshore Construction

This subsection explains the nearshore construction activities and considers their possible impacts. The construction of the PLF and MOF are discussed first. This is followed by a detailed description of construction of the trunkline, trenching in both the nearshore and offshore areas, as well as the shore crossing. The subsection concludes with a summary.

Construction of PLF Including Rock Placement for MOF Breakwater Walls

Residual risk to marine water quality from construction of the PLF and Rock Placement for MOF is	LOW

Construction of PLF

The optimised layout for the MOF and PLF for the Project is shown in Figure 2.14. The PLF will consist of the piles supporting an access trestle (sub structure), including passing lanes and turn-out platforms, loading platform structures (including concrete "table-top"), mooring and berthing dolphins and a Marine Operations Platform.

The access trestle will be constructed by driving piles from a crane located on a temporary work platform alongside the trestle, installing the pile caps, placing a roadway and then moving forward to drive the next set of piles (i.e. all plant will be located above the water and the work-front will be fed from the shore along the completed trestle). Alternatively, the access trestle could be completed in part using floating plant where there is sufficient water depth.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that the construction of the PLF will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Low" – of "Minor" consequence, arising from localised short-term exceedence of background and applicable ANZECC/ARMCANZ water quality guidelines in the vicinity of the PLF, and of "Possible" likelihood.

Construction of MOF

The MOF will be built up by depositing rock material (from a yet-to-be identified source) into the nearshore waters to create the land area required.

The MOF comprises two combined breakwater and sediment infill protection walls which enclose a small boat harbour and cyclone shelter on the western side, plus three large-vessel berths that can all be operated concurrently. These berths will accommodate roll-on/roll-off (RORO) and load-on/load-off (LOLO) vessels and dumb barges. The berths and wharves will be backed by a substantial clear hardstand area for the storage and handling of goods.

The breakwaters will be constructed from the shore using earthmoving equipment to place engineered core material into the nearshore waters. The breakwater will be armoured by heavy rock, concrete armour units or both. Wharves, tug pens and berths will be piled, and wharves will be constructed of pre-cast concrete structures.

No attempt has been made to quantify the potential scale of turbidity created during the rock dumping process. This is because the size of core material and armour rock required is so large that the scale of turbidity anticipated is very small, short term and localised in comparison to that created by the nearshore dredging works.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that the construction of the MOF will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Low" – of "Minor" consequence, arising from localised short-term exceedence of background and applicable ANZECC/ARMCANZ water quality guidelines in the vicinity of the MOF, and of "Possible" likelihood.

Trunkline Trenching and Stabilisation

Residual risk to marine water and sediment quality from trunkline trenching and stabilisation is	**Medium**

A detailed description of the works anticipated for installation of the subsea trunkline in nearshore waters (>40 m CD) is presented in Section 2.3.2. The base case trunkline corridor is shown in Figure 8.13. Further engineering work is being undertaken to confirm the feasibility if this corridor. It is possible that this further work will identify alternative trunkline corridors shown in the hatched area in Figure 8.13 that result in reduced trunkline length and easier installation. The environmental assessment presented in this section and in Section 8.3 is based on the base case trunkline corridor. If the corridor route does change further environmental assessment will be undertaken, where necessary.

In summary, the baseline trunkline will be up to 122 cm outside diameter and weight coated. It will be installed using either a conventional third-generation moored laybarge or fourth-generation dynamically positioned laybarge in deep waters, and a second-generation flat bottomed laybarge in shallow waters nearshore. The second and third-generation laybarges are stabilised by way of an eight or twelve point anchor mooring system. The anchors are continually moved by dedicated anchor handling vessels, as the barge winches itself along the trunkline alignment. Anchor placement can cause disturbance to the seabed over an area of approximately 50 m^2.

In waters deeper than -40 m CD, the trunkline will be laid directly onto the seafloor and stabilised using continuous concrete weight coating. In waters shallower than -40 m CD, the trunkline will be stabilised by burial and/or rock placement.

It is currently anticipated that the trunkline will require mechanical trenching and backfill with engineered fill (coarse sand and/or rock) out to the start of the shelf break which is approximately the -40 m CD isobath. The trench and area of disturbed seabed will be approximately 26 m wide, however engineered backfill will be confined to the trench area, which will be approximately 5 m wide and no more than 1 m above nominal seabed level.

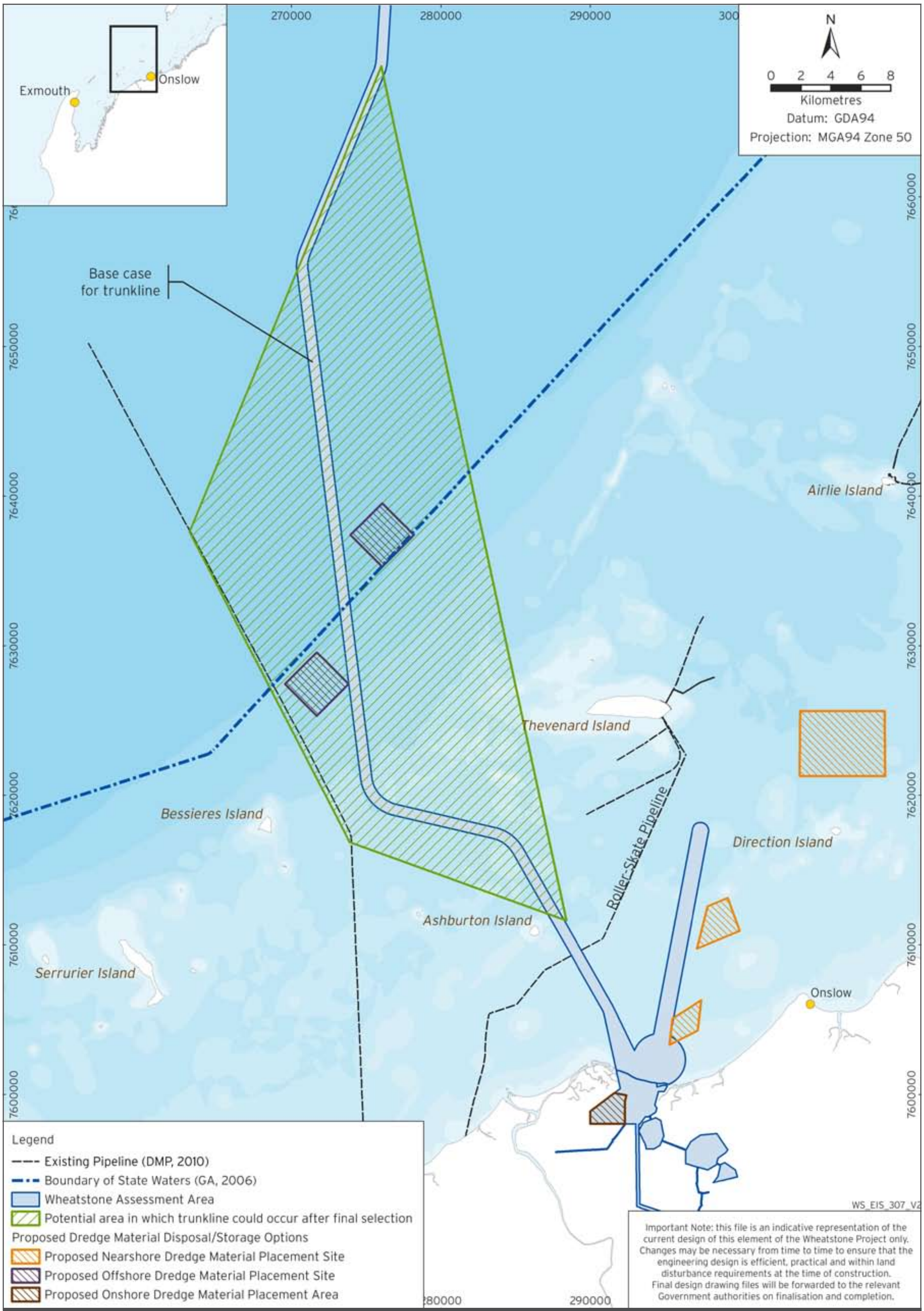


Figure 8.13: Base Case and Potential Alternative Trunkline Route

Two proposed methods of trunkline installation in nearshore waters exist and are:

Option A (preferred option). In water depths less than approximately -10 m CD between the Roller-Skate pipeline crossing and the shore crossing interface point (in 2 m of water, a distance of approximately 8 km) it is anticipated that trench excavation will be undertaken using a backhoe dredge over a period of approximately three months. Up to 700 000 m^3 of dredged sediments will be transported in small hopper barges and placed at Site C from this operation. In water depths greater than approximately -10 m CD out to approximately -40 m CD between the Roller-Skate pipeline (Figure 8.13) and the shelf break – a distance of approximately 26 km – a mechanical trencher will be used for most of the length. The mechanical trencher deposits removed material directly to the adjacent seabed, so there is no transport and placement of dredged material at a remote site. Once the trunkline is laid, the trench will be backfilled using engineered fill to achieve a relatively flush reinstated seafloor such that prawn trawling is still possible above the trunkline. In areas where the substrate is too hard to be trenched, the trunkline will be laid on the seabed and stabilised (e.g. by rock armouring), which will create a profile 1-2 m above the existing seabed in these areas. Based on available geotechnical data, it is expected that up to 4 to 8 km of the 26 km section of the route may be too hard to trench.

Option B (contingency case). The contingency case—in which the pipelay is performed using larger dredging equipment—may be used, particularly if the geotechnical conditions do not favour mechanical trenching methodology. In this case, it is possible that a combination of CSD and TSHD dredging may be used to create a trench for the trunkline. This may be undertaken from a water depth of approximately -5 m CD, out to approximately -40 m CD – a distance of approximately 33 km. The dredging volume could be up to 2.4 Mm^3, removed over a period of approximately 6 months. Dredged material out to approximately -10 m CD would be placed at site C, while material from approximately -10 m CD to -40 m CD would be placed at site D.

In order to be conservative, dredge plume modelling has been undertaken based on this contingency case, though it is noted that the actual impacts are expected to be much lower if the preferred methodology is used.

The dredging plume modelling utilised the same methodology applied to the modelling of the channel, which involved the definition of short-term dredge scenarios and the use of six climatic scenarios, as outlined in Section 8.2.5.1. The short-term trunkline dredge scenarios covered a 14-day segment of the trunkline dredge program and were associated with sediment loading of 1029 t per day.

Figure 8.14 and Figure 8.15 indicate the potential scale of turbidity plumes anticipated to result from excavation of the trunkline using a CSD at the two locations modelled. Such plumes are likely to be short-term in duration, given that the CSD is anticipated to move along the trunkline route at a rate of between 150 and 200 m per day.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that trunkline trenching and stabilisation will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Moderate" consequence, arising from localised short-term exceedence of background and applicable ANZECC/ARMCANZ water quality guidelines during the trunkline trenching operation, and "Likely" to occur.

Trunkline Shore Crossing

The proposed shore crossing will traverse the lagoon system that forms the current eastern entrance to the Ashburton River. This lagoon system and dynamic spit-chenier have been described in Section 8.5, Chapter 6, *Overview of Existing Environment*, and further discussed in Damara WA (2010, Appendix P1). Figure 8.16 shows a plan map of the distribution of both terrestrial and marine habitat types that occur in the immediate vicinity of these potential works. It is the result of general surveys of the Ashburton Delta (URS 2010h, Appendix N14) and a specific field survey undertaken in December 2009 to inspect and map the distribution of marine benthic habitats. Fish surveys and water quality monitoring were also conducted in the lagoon in May 2010 (URS 2010i, Appendix O5). Superimposed on the map is the potential location of the shore crossing described below.

Four options for bringing the trunkline to shore at this location have been considered. These are:

1. Horizontal Directional Drilling (HDD) from onshore out beneath the lagoon and barrier spit to a location seaward of the spit where minor excavation will be required to enable later pull-in of the trunkline
2. Microtunnelling beneath the lagoon from a site onshore to a location on the seaward side of the barrier spit, also requiring minor offshore excavation to enable later pull-in of the trunkline

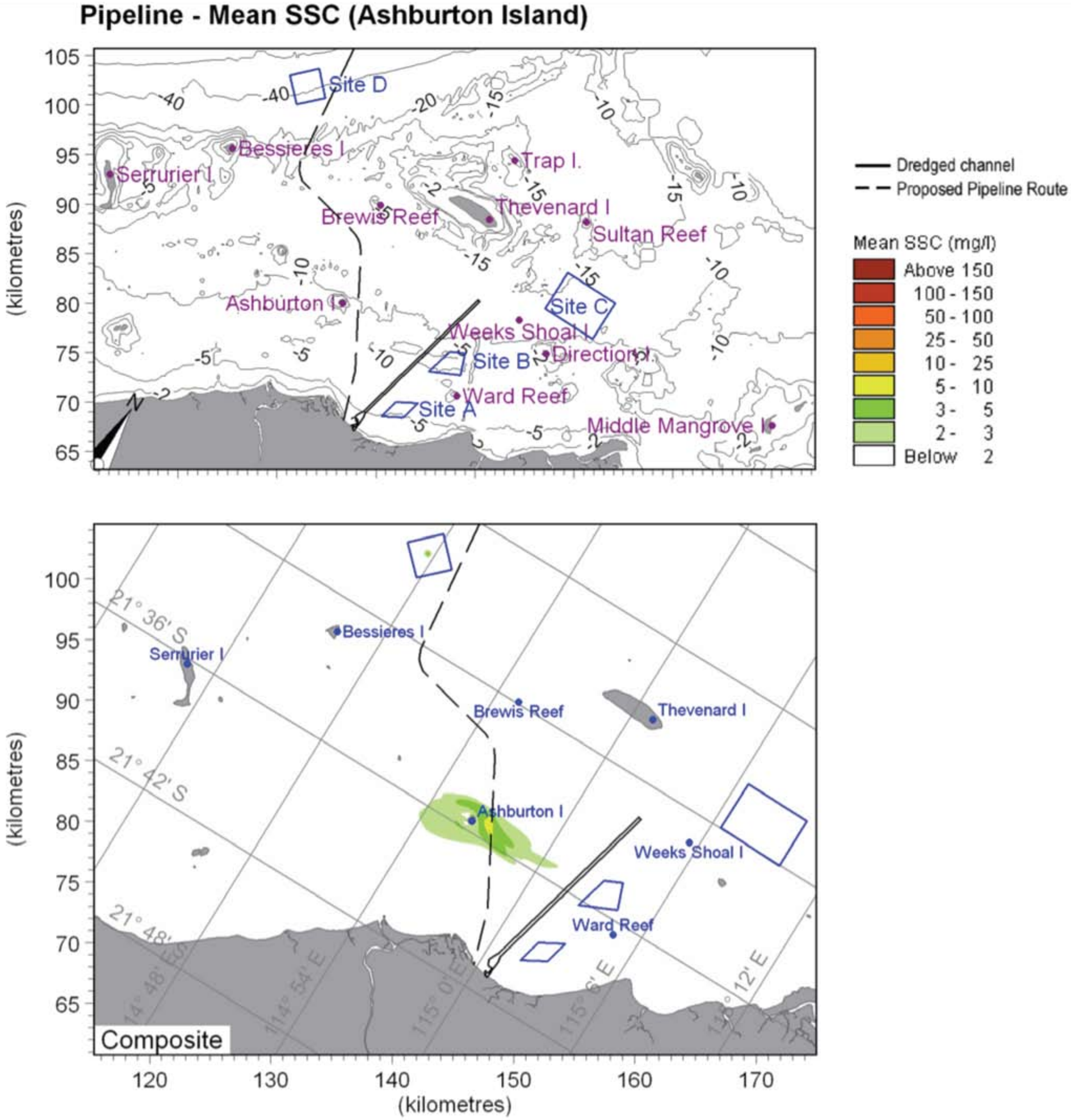


Figure 8.14 Mean SSC for Ashburton Island Trunkline Dredge Scenario based Contingency Plan Spill Rates – Climate Composite

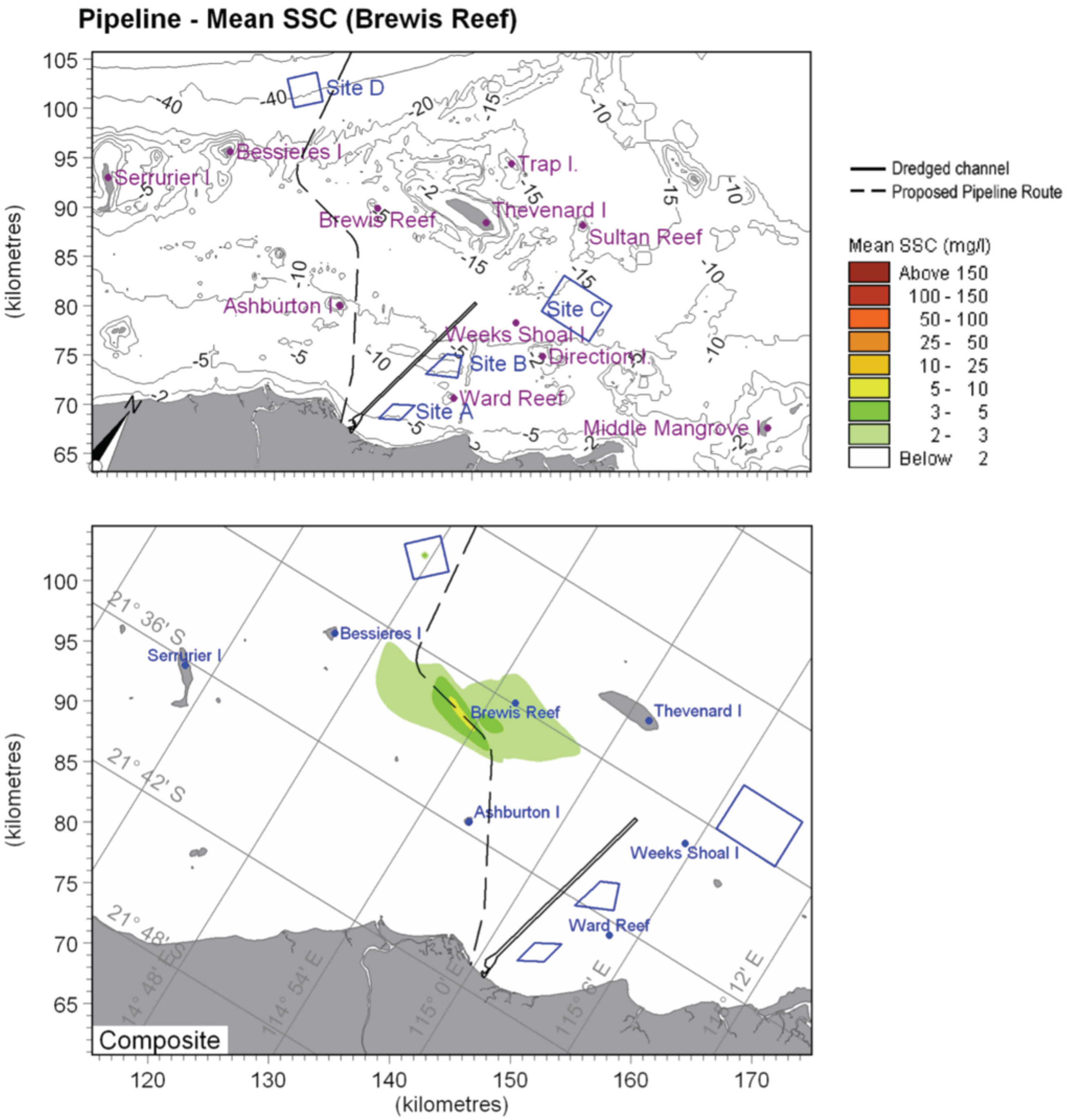


Figure 8.15: Mean SSC for Brewis Reef Trunkline Dredge Scenario based Contingency Plan Spill Rates – Climate Composite

3. Excavating a trench through the lagoon and barrier spit, then pulling the trunkline through the trench and backfilling the trench after the trunkline has been buried with lagoon and spit bathymetry re-instated
4. Bringing the trunkline to the PLF and across the beach.

Options 1 and 4 above have since been rejected. Option 1 is not considered feasible as the size of trunkline that needs to be brought ashore is beyond current technical capability of HDD. Option 4 is not considered feasible for safety reasons. Options 2 and 3 for the trunkline shore crossing are both considered feasible and have been investigated further. Option 2 (microtunnelling) is the preferred engineering and environmental solution because it is logistically much easier than trenching, it reduces the risk of disturbance of the lagoon and demonstrates application of "best practice" technology to manage potentially adverse impacts. However trenching remains an option in the event that microtunnelling proves technically unfeasible due to adverse geotechnical conditions (currently undefined) and the length of tunnelling required (1.2 to 1.4 km) which is close to the current technological limit for a tunnel of the diameter proposed (Chapter 2, *Project Description*).

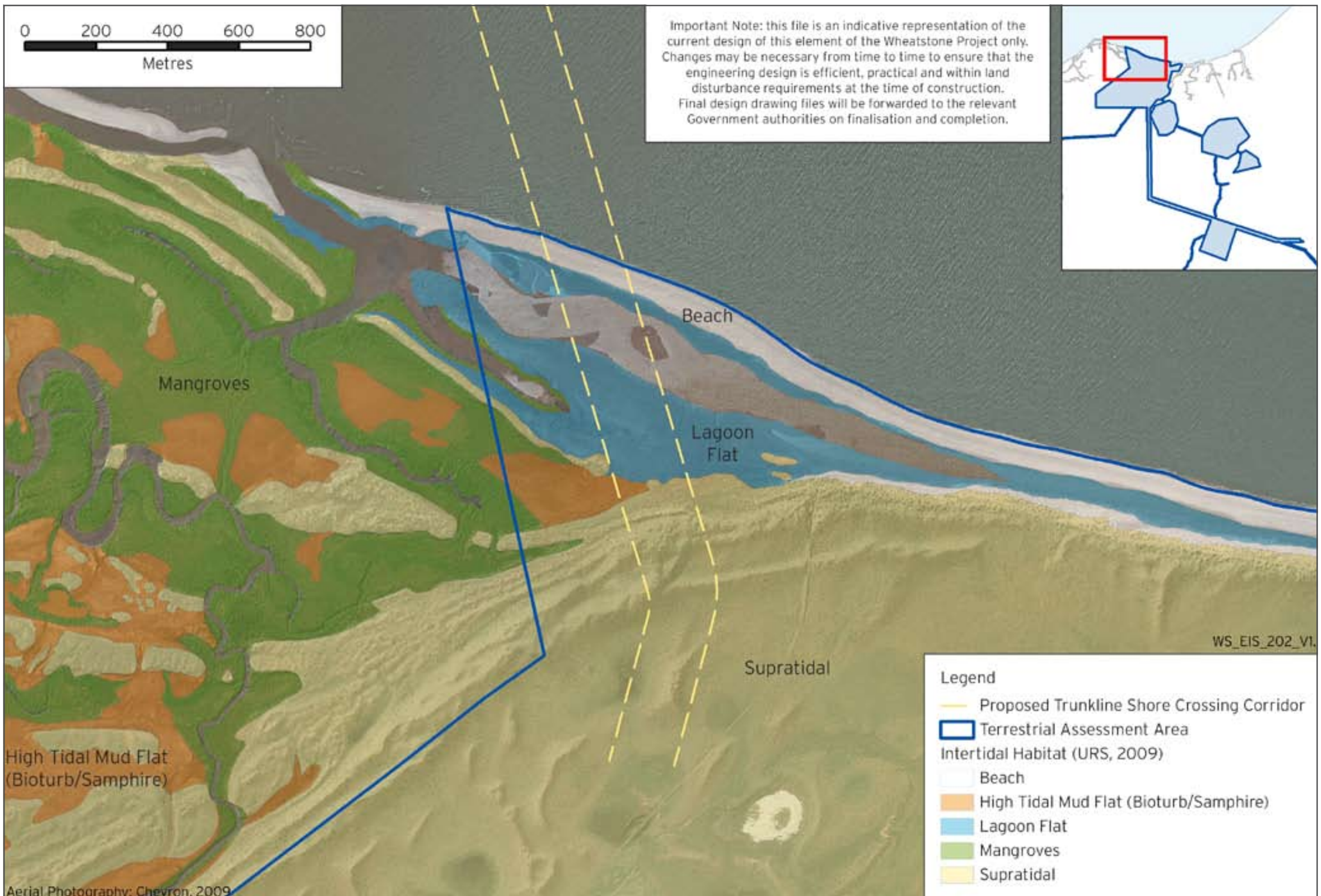


Figure 8.16: Habitat Types in the Vicinity of the Proposed Trunkline Shore Crossing

Trunkline Shore Crossing by Microtunnelling

Residual risk to marine water quality from construction of the trunkline shore crossing by microtunnelling is	**Low**

Microtunnelling is preferred because it results in very little disturbance to the surface environment. It involves the construction of a 3 m diameter tunnel beneath the dune system and lagoon, as described in Section 2.3.2. All drill cuttings from the tunnelling operation (approximately 200 000 m^3) will be, as far as practicable, placed onshore. The only disturbance to marine waters will occur for a short period by the backhoe excavation of a small pit into which the drill head can exit prior to recovery. All excavated material will be placed into a hopper barge and subsequently taken to an approved placement site (site C). Turbidity impacts will be localised and short term and barely measurable against the existing high background turbidity in these nearshore waters.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that construction of the trunkline shore crossing will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Low" – of "Negligible" consequence, as this method is not predicted to result in detectable changes to background water quality in the lagoon, and "Likely" to occur.

Trunkline Shore Crossing by Trenching

Residual risk to marine water quality from construction of the trunkline shore crossing by trenching is	**Medium**

The trenching option (Option 3) is the only option that risks potential direct impacts to Ashburton River Delta and directly affects lagoon circulation processes. This option may involve constructing two parallel rock berms across the lagoon and barrier spit to a location 200 m seaward of the spit. This will provide support for excavating, earthmoving and pile driving plant and equipment. These groynes may be 40 to 100 m apart depending on whether provision is required for future trunklines. The rock coffer dam created by the berms will allow excavation of seabed material to create the pull-in trench without risk of backfill due to coastal processes. Excavated material from this area will be stored onshore and may possibly be used to backfill the trench later after the trunkline is installed.

Once the pipelay trench is constructed, the trunkline can be pulled through the trench from onshore. Once the pull is completed, the trench will be backfilled to as close to the original bathymetry as can be achieved using appropriate engineered materials, excavated material or rock. The two rock groynes will be removed by excavators working from seaward back to the shore. It is anticipated this work will take up to 24 months to complete. This activity may be repeated another two to three times over the next 25 years as additional trunklines are brought ashore.

The potential physical environmental effects of the trenching option are as follows.

- Construction and removal of the berms will create localised and temporary turbidity in adjacent waters but is unlikely to create substantial turbidity within the lagoon. This is because of the large size of rock material that will be required to protect the trench over two cyclone seasons and because all excavated material from within the coffer dam trench could be stored onshore in holding ponds. Some of this material is likely to contain acid sulphate soils which may need to be neutralised during storage. Much of the stored material will be returned to the trench once the trunkline has been installed providing it is considered technically acceptable from an engineering standpoint.
- The berms will affect the overall morphology and water circulation patterns of the lagoon during the trunkline shore crossing construction program. Water flows east of the rock berms and coffer dam will be interrupted while the trench is in place thereby restricting tidal flushing, although this can be ameliorated by constructing a channel through the sand spit/beach to allow water to flow into and out of the lagoon to the east of the berms.
- Emplacement of the rock berms over 24 months will disrupt coastal processes (Damara WA 2010, Appendix P1) have shown that the sand spit is a dynamic feature that was substantially removed by Cyclone Vance in 1999 and subsequently re-built by prevailing easterly littoral drift. It is therefore likely that some sediment accretion will occur on the western side of the berms and erosion on the eastern side. Once the berms have been removed, the sand spit is considered likely to reform and the lagoon to recover to its previous character. Hence installation of the first trunkline is likely to result in a temporary impact from which the lagoon will recover.
- Trenching the trunkline through the eastern lagoon is not the preferred option. However, this option should still be environmentally assessed in case microtunnelling cannot be achieved.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that construction of the trunkline shore crossing by trenching will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Minor" consequence, arising from localised short-term exceedence of background and applicable ANZECC/ARMCANZ water quality guidelines during the installation of the rock berms to create the coffer dam, and an "Almost Certain" likelihood.

8.2.5.6 Discharges from Onshore Construction

The assessment of onshore discharges is preliminary as the effluent streams for both the construction and operational phases of the Project are not fully characterised at present. Modelling has been based on the Cornell Mixing Zone Expert System (CORMIX; URS 2010j, Appendix Q3) and a proprietary URS Dilution Model, developed specifically for the Project. The URS Dilution Model was used to extend short period 3D far-field model simulations of discharge impacts, to represent long-term conditions (URS 2010j, Appendix Q3). DHI Mike 21 and MIKE 3D software previously described was used to calibrate the URS Dilution Model. The URS Dilution Model is an extension of the steady state CORMIX that takes into account unsteady currents for year-long (or multiple-year) time periods and estimates the dilution of a conservative tracer within a homogenous marine environment The model requires relatively little computer processing to simulate a two year period, for example, and thus can provide long-term "worst-case" conditions for each discharge, not able to be produced using detailed 3D transport models.

URS Dilution Model approach that was undertaken provides an indication of the spatial extent of the mixing zone surrounding each of the specified outfall locations. The extent of the mixing zone is determined by the distance required to achieve applicable water quality criteria selected from ANZECC/ARMCANZ (2000) water quality guidelines. When presenting results of the modelling, a conservative approach has been adopted whereby predicted worst-case results for dilution are presented that correspond to when the spatial extent of the discharge plume is the largest. A refinement of the modelling methodology and optimisation of outfall diffuser design and/or location may be warranted once effluents are better characterised, in order to ensure that water quality objectives are achieved within a specified mixing zone.

The discharges arising from the onshore aspects of the Project at the Ashburton North SIA have been modelled using the two outfall locations shown in Figure 8.17. The nearshore Outlet 1 located at approximately five m CD will be used for discharges from both the construction and operation phases at the Ashburton North SIA. With the subsequent introduction of LNG trains 3 to 5, PW may be brought onshore and it is proposed that this will be discharged at Outlet 2 located at around -20 m CD and approximately 30 km offshore.

Discharges from the Accommodation Village, Stormwater Run-off and Reverse Osmosis Brine

Residual risk to marine water quality from accommodation village, stormwater run-off and reverse osmosis brine discharges is	Low

The onshore construction program for the Project has been described in Chapter 2, *Project Description*. Assessment of the potential impacts to surface water in the vicinity of the Ashburton North SIA suggests that localised increases in suspended sediment and salt may arise from disturbed soils and the large volumes of dredged materials that may be placed onshore (URS 2010f, Appendix G1). Measures to mitigate the impacts of discharges to the marine environment will be developed as part of the Construction Environmental Management Plan (CEMP, Appendix U1), which will be produced prior to commencement of construction activities. These mitigation measures are summarised in Table 8.18.

Nearshore discharge resulting from onshore construction may include treated domestic wastewater from the accommodation village, site stormwater run-off and RO brine from the reverse osmosis (RO) desalination unit. At the peak of construction up to 5000 workers will be accommodated at a purpose-built accommodation village located at the Ashburton North SIA. Construction wastewater volumes are based on desalination plant and the number of construction personnel to be employed. A maximum rate of 433 m^3/hr of RO brine is expected from the desalination plant. Maximum domestic wastewater production is estimated to be 76 m^3/hr, based on peak number of personnel during construction of the first two trains.

The potential impacts to marine water quality are related to the composition and methods of discharge of wastewater and RO brine from the accommodation village. The proposed treatment and disposal of wastewater from the accommodation village and operations is discussed in Chapter 4, *Emissions, Discharges and Wastes*.

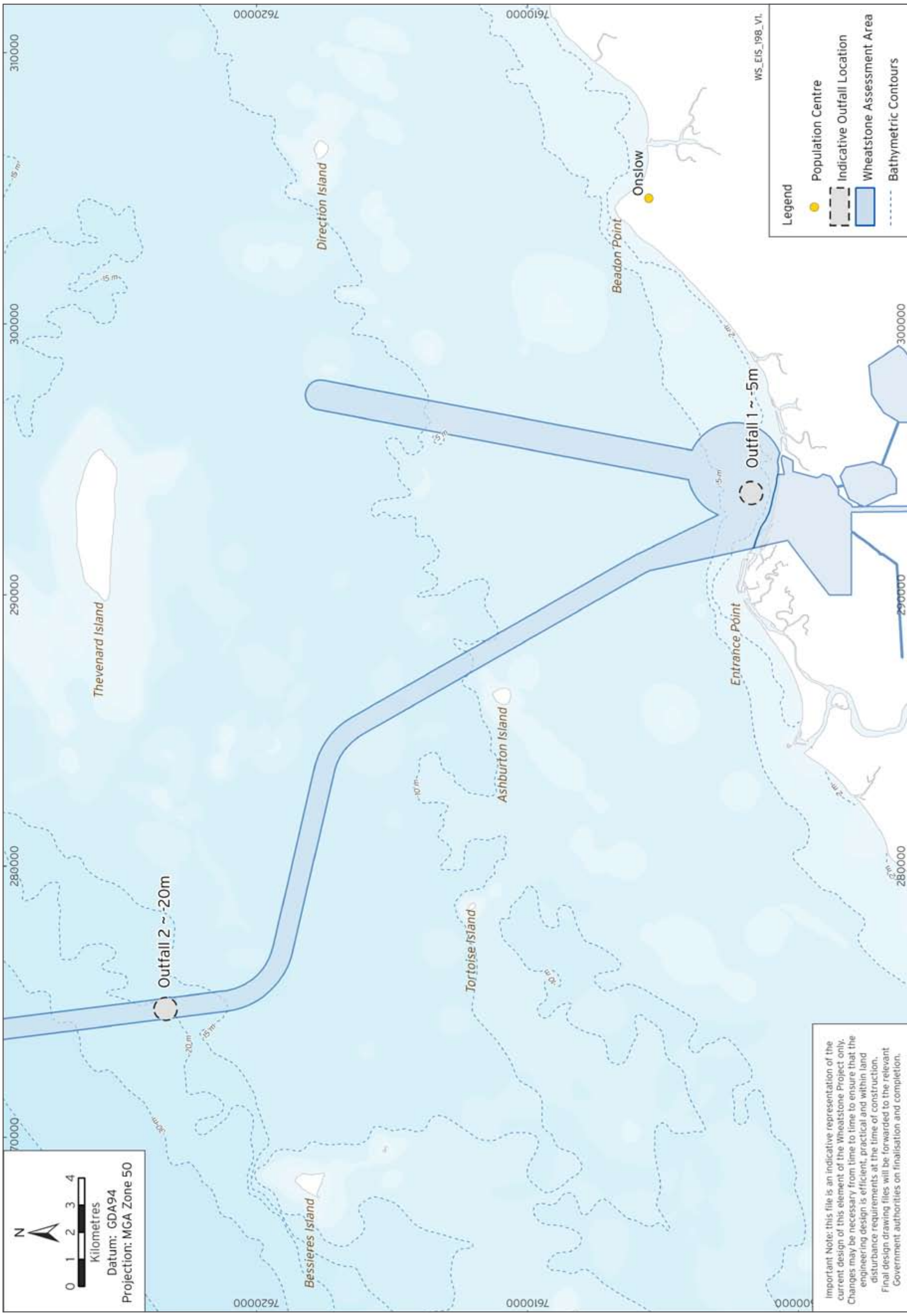


Figure 8.17: Location of Nearshore Discharge Outlets

The construction discharges to the marine environment include co-mingled RO brine, clean stormwater and some treated domestic waste water. These will be discharged directly to nearshore waters. The characteristics of the discharge used for scenario modelling are shown in Table 8.10 and the location of the outfall at -5 m CD is shown as Outlet 1 on Figure 8.17.

The discharge outlet is proposed to be fitted with a diffuser designed to dilute the discharge within the marine environment, as described in Table 8.11.

The worst-case mixing scenario dilution curve, as a function of distance from Outlet 1, is shown in Figure 8.18. This predicts dilution of >1:30 within 25 m of the discharge point and approximately 1:40 within 200 m.

On the basis of discharge concentrations of nitrogen and phosphorus, shown in Figure 8.18, and the ANZECC/ ARMCANZ (2000) guidelines applicable for slightly disturbed tropical marine waters for total nitrogen (100 µg/L) and total phosphorus (15 µg/L), the dilution requirement is approximately 1:60 for nitrogen and 1:70 for phosphorus at the edge of the mixing zone. This is likely to be met under all but worst-case scenarios and the mitigation and management measures summarised in Table 8.18 will decrease the likelihood of exceedence outside a proposed mixing zone of 200 m.

Table 8.10: Construction Discharge Scenario – Outlet 1

Parameter	Units	Construction discharge modelling scenario
Location		293,754 E; 7,601,736 N
Depth of water column	m	5
Description	-	Construction
Discharge streams and volumes	-	Sanitary wastewater, contact stormwater, RO brine
Duration	hours	Continuous
Depth	m	5
Temperature	°C	Ambient
Salinity	ppt	45.69
Total nitrogen	mg/L	6(2)
Total phosphorus	mg/L	1(2)
Density	kg/m^3	1 031.41(1)
Flow rate	m^3/hr	517

NB: Calculated based on an ambient temperature of 25°C, Estimates to be confirmed by analysis.

Table 8.11: Modelled Diffuser Design Characteristics – Outlet 1

Parameter	Units	Value
Design volume	m^3/hr	331(1)
Trunkline diameter	mm	254(1)
Port diameter	mm	76.2(1)
Number of ports	-	16(1)
Port arrangement	-	Alternating without fanning(1)
Port type	-	Sharp edge(1)
Diffuser length	m	15(1)
Diffuser type	-	Alternating perpendicular(1)
Length of port	m	0.5(2)
Angle of outlets	degrees	30(2)

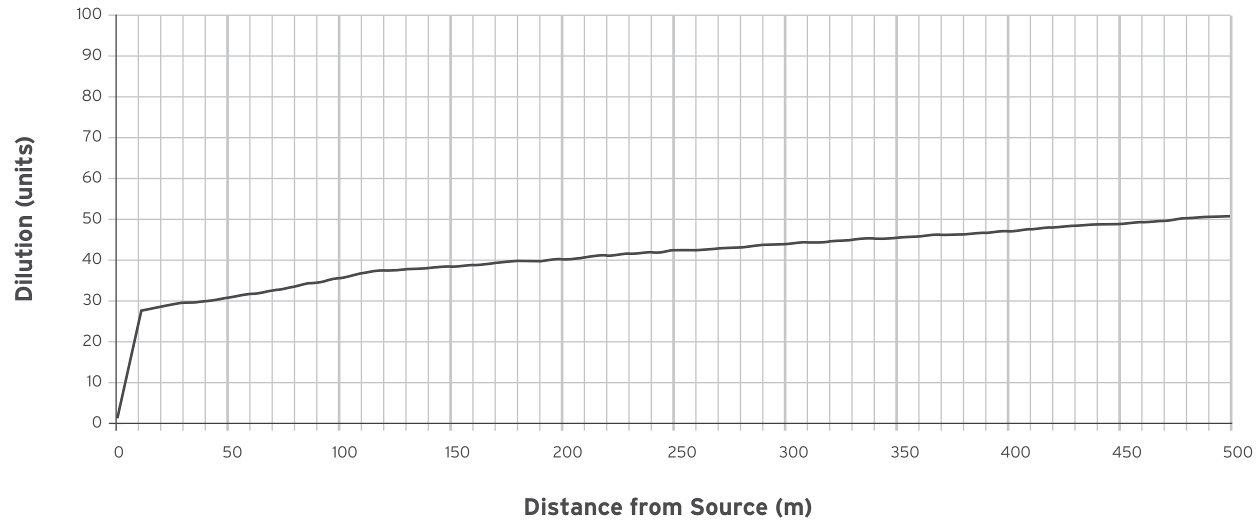


Figure 8.18: Worst Case Dilution of Construction Discharge with Distance from Outlet 1

Domestic wastewater discharges elsewhere (Turner 2008) have been shown to contain concentrations of zinc and copper (but not other metals) at 10 to 20 times the ANZECC/ARMCANZ (2000) guidelines. Dilution of Project domestic wastewater with RO brine and stormwater prior to discharge, followed by a further 1:30 dilution within 25 m of the outfall indicates exceedence of guideline values for these metals outside the mixing zone is unlikely.

Summary

The potential impacts on water quality from the discharge of construction wastewater include elevated nutrients, metals and microbial contamination. Microbial contamination will be addressed with sewage treatment, as described in Chapter 4, *Emissions, Discharges and Wastes*, concentrations of metals are expected to be low and nutrients will be diluted upon entry into the marine environment.

The residual environmental risk for this potential impact was assessed as being "Low" – of "Minor" consequence, arising from the localised long-term exceedence of background and applicable ANZECC/ARMCANZ water quality guidelines but within approved mixing zone, and of "Likely" occurrence.

8.2.5.7 Discharges from Onshore Operations

The onshore operational program for the Project is described in Chapter 2, *Project Description* and the discharges in Chapter 4, *Emissions, Discharges and Wastes*. This section considers two separate operational discharges: discharges of sanitary wastewater, process wastewater, contact stormwater and RO brine at Outlet 1; and the discharge of PW from the LNG plant at Outlet 2 (Figure 8.17). Each type of discharge has been modelled and the results are summarised in this section. The section concludes with a summary.

Discharge of Wastewater, Process Wastewater, Contact Stormwater and Reverse Osmosis Brine

Residual risk to marine water and sediment quality from wastewater, process wastewater, contact stormwater and reverse osmosis brine discharges is	**Low**

Several wastewater streams will be generated from the onshore infrastructure, co-mingled and discharged at -5 m CD at Outlet 1 (Figure 8.17). The waste water streams will include:

- Process water
- Treated sewage

- Grey water
- Treated stormwater
- RO brine

These waste streams, if not managed correctly, have the potential to result in contamination and nutrient enrichment of the surrounding waters. Characterisation of operational discharges and the proposed treatment and disposal of operational wastewater from the Ashburton North SIA is discussed in Chapter 4, *Emissions, Discharges and Wastes*.

Waste water discharge for the five-train case will consist of up to 435 kL/day of sewage, 3 120 kL/day of stormwater and process water and 5 600 kL/day of RO brine. RO brine will make up between 30 and 80 per cent of this discharge. RO brine is essentially seawater with an elevated salinity (approximately 60 per cent above ambient). It may also contain anti-scalant and low concentrations of biocides (typically chlorine) and by-products. The desalination discharge (3 500 to 5 600 kL/day) is small relative to other Projects of a comparable size (e.g. ten to 20 per cent of the Karratha desalination discharge). Low levels of heavy metals may be present in the RO brine discharge from corrosion or other sources. However, the discharge area will be well flushed and no accumulation of contaminants is expected. Sewage water will be treated as described in Chapter 4, *Emissions, Discharges and Wastes*.

Discharge modelling was undertaken for two scenarios, a maximum discharge scenario and a typical discharge scenario, using the Project-specific Dilution Model described above (URS 2010j, Appendix Q3). The volumes and expected composition of the two co-mingled discharge scenarios are shown in Table 8.12.

On the basis of discharge concentrations of nitrogen and phosphorus, shown in Table 8.12, and the ANZECC/ARMCANZ (2000) guidelines for total nitrogen (100 µg/L) and total phosphorus (15 µg/L), the dilution requirement is approximately 1:10 at the edge of the mixing zone (URS 2010j, Appendix Q3). This is likely to be met within 200 m of the discharge outfall even under worst case dilution for the typical discharge scenario (Figure 8.19).

Summary

The potential impacts of discharges from onshore operations on water and sediment quality include nutrient enrichment and potential contamination. Microbial contamination will be managed through sewage treatment, as described in Chapter 4, *Emissions, Discharges and Wastes*, concentrations of metals are expected to be low and nutrients will be diluted below the threshold limits of the ANZECC/ARMCANZ (2000) guidelines within a 200 m mixing zone.

Table 8.12: Operational Discharge Scenarios – Outlet 1

Parameter	Units	Operational discharge modelling scenarios	
Location		293,754 E; 7,601,736 N	
Depth of water column	m	5	
		Scenario 1A	**Scenario 1B**
Description	-	Operational – maximum	Operational – typical
Discharge streams	-	Sanitary wastewater, process wastewater, contact stormwater, RO brine	Sanitary wastewater, process wastewater, contact stormwater, RO brine
Duration	hrs	Continuous	Continuous
Depth	m	5	5
Temperature	°C	Ambient	Ambient
Salinity	ppt	22.4	60.16
Total nitrogen	mg/l	1.3	1.0
Total phosphorus	mg/l	0.12	0.15
Density	kg/m^3	1 013.88[1]	1 042.51[1]
Flow rate	m^3/hr	776	172

Note (1): Calculated based on an ambient temperature of 25°C

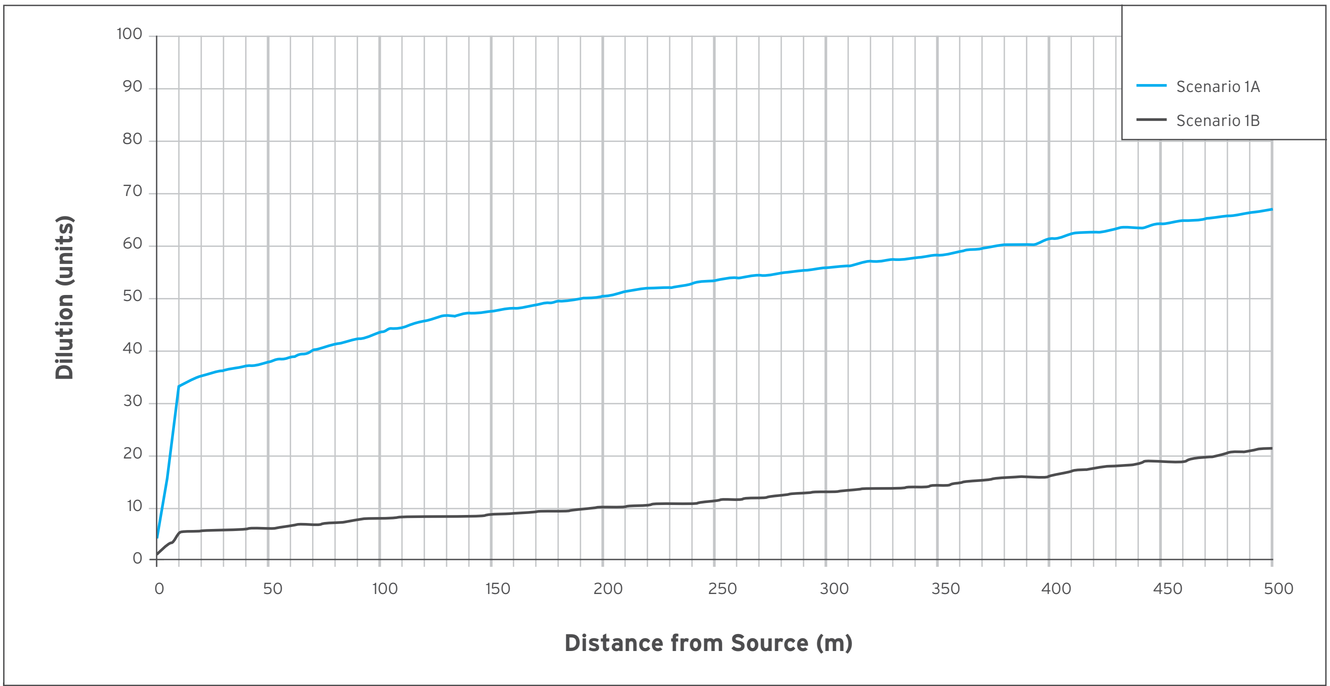


Figure 8.19: Worst Case Dilution of Maximum and Typical Operational Discharge with Distance from Outlet 1

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that discharges of sanitary wastewater, processes wastewater, contact stormwater and RO brine during the operations phase will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Low" – of "Minor" consequence, arising from the localised long-term exceedence of background and applicable ANZECC/ ARMCANZ water and sediment quality guidelines but within approved mixing zone, and of "Likely" occurrence.

Discharge of Produced Water from the LNG Plant

Residual risk to marine water and sediment quality from discharge of produced water from the LNG plant is	Medium

The initial operational stage for the Project will bring gas onshore from Petroleum Titles WA-253-P, WA-16-R, WA-17-R and WA-356-P after treatment at the offshore Wheatstone Platform (WP) to remove PW. With the introduction of LNG trains 3 to 5, PW may be brought onshore. If this occurs, it will be disposed of at outfall 2 (Figure 8.17).

Untreated and condensed PW contains some volatile hydrocarbons, such as BTEX, that have condensed from the gas as it is transported from the well to the platform.

Polycyclic Aromatic Hydrocarbons (PAHs) are the petroleum hydrocarbon of greatest environmental concern in untreated PW. They have a wide range of solubilities (Neff 2002). Biodegradation half lives of PAHs range from readily to poorly biodegradable and vary from 1.5 days for naphthalene, 17 days for two to three-ring PAHs and 350 days for more than four-ring PAHs (Johnsen *et al*. 2000). All PAHs (with the exception of naphthalenes, which are readily biodegradable) have a strong tendency to bioaccumulate in the tissues of marine organisms (Neff and Sauer 1996). Studies of PW discharge have shown that the highest PAH concentrations in marine sediments tend to occur in the finest grained sediments with high initial levels of total organic carbon, particularly in shallower waters (Neff *et al*. 1992). Solubility of PAHs decreases with increasing molecular weight, so the most common PAHs in PW are naphthalene, alkylnaphthalenes, fluorene and phenanthrene. These are predicted to be present in low initial concentrations and, on discharge, will be reduced further by rapid dilution with the receiving water and evaporation from the sea surface.

Heavy metals associated with PW are usually present at trace levels as dissolved mineral salts. Reservoir water is anoxic and the metal ions are typically in low oxidation states. However, they oxidise when brought to the surface and exposed to the atmosphere. The metal oxides then combine with anions such as sulfides, carbonates and chlorides and form insoluble precipitates. Once they form precipitates, there is the potential for build up in the sediments, however concentrations are typically very low and precipitates are widely spread across the seabed by currents.

Untreated PW also contains low levels of chemicals that have been added to the production process for purposes such as emulsion control, inhibition of scale formation, reduction of corrosion and prevention of growth of bacteria. The number of additives used in a particular production system is usually low and depends on the particular production problems encountered in the well. Additives may include biocides, corrosion inhibitors, scale inhibitors, oxygen scavengers, demulsifiers, emulsifiers, coagulant/de-oiler, flocculants, antifoam agent, dispersants, thinners, viscosifiers, surfactants/detergents and/or hydrate inhibitors.

The concentration of process chemicals in discharged PW is directly related to the initial dosage concentration, solubility of the chemical in water, and the level to which it decays or is neutralised during the production process. The initial dosage concentration range is specified by the chemical supplier and then fine-tuned by the operator to achieve optimum performance of the chemical in combination with other chemicals and the hydrocarbons.

Toxicity of PW to marine organisms depends on the chemical compounds present and the exposure duration (acute or chronic). For example, the toxicity of most hydrocarbons depends on attainment of a critical volume or concentration in the tissues of aquatic organisms (Neff 2002). The toxicity of hydrocarbons in mixtures is additive, and the toxicity of a complex mixture such as Project PW therefore depends on the total concentration of bio-available hydrocarbons and degradation products in the water to which aquatic organisms are exposed.

The internationally accepted "Predicted Environmental Concentration: Predicted No Effect Concentration" (PEC:PNEC) approach can be used to demonstrate the risk associated with the proposed Project PW discharge after management and mitigation. PEC was simulated using a dispersion model (URS 2010j, Appendix Q3). This provides an estimate of the expected dilutions of PW around the outfall and the concentrations of PW to which the environment will be exposed during discharge. The PNEC is derived from ecotoxicity data and is the concentration below which it is believed there will be no detrimental effect to the environment. PNEC relies on the assumption that a single value captures the concentration at which no toxic response (acute or chronic) is expected in the target population of marine biota. This concentration represents a toxicity value for the PW prior to discharge to the ocean and takes into consideration all chemicals in the PW and any synergy or antagonism between them. For the Pluto LNG Development, the PNEC value for PW was based on Whole Effluent Toxicity test results from PW at Goodwyn Alpha, a gas and condensate project on the NWS. It is anticipated that the Project will use process chemical types and quantities, similar to those used at the Goodwyn Alpha Project (Woodside Petroleum Ltd 2006).

For the PW from Goodwyn Alpha, the chronic algal growth inhibition endpoint was the most sensitive to the PW. The lowest chronic No Effect Concentration (NOEC) for this test was 3.13 per cent. Goodwyn Alpha PW was therefore conservatively estimated to require 32 dilutions to achieve NOEC in the marine environment (Woodside Petroleum Ltd 2006). This value was assumed to be representative of the toxicity of the PW to the most sensitive organism in the NWS tropical waters. It is expected that the PW from the Project will have a similar toxicity and that a similar dilution will be required, to reduce observable effects. A safety factor has then been applied to the NOEC in order to derive an estimated "safe" dilution for the PW in seawater (that is a PNEC).

The use of safety or "assessment factors" are described by ANZECC/ARMCANZ (2000) as a means of extrapolating from acute to potential chronic affects and for dealing with uncertainty in the available data. These are recommended to derive interim environmental concern levels in the absence of an adequate dataset for a statistical approach. International practice requires additional safety factors of 10 to 1000 to be applied to NOECs in order to derive a PNEC, depending on the amount and type of toxicity testing data available. A review of the limitations of safety factors by Chapman *et al.* (1998) suggests that safety factors for laboratory-to-field extrapolations should not exceed 10 and may be much less. Based on these recommendations and the possibility of differences between Goodwyn Alpha and the Project, a nominal conservative safety factor of 40 was applied to derive a safe dilution rate for untreated PW of approximately 1 300 dilutions. Treatment of PW will result in a further reduction in potentially toxic substances and a reduced PNEC.

The detailed characteristics and volumes of PW that may be brought onshore for treatment at the Ashburton North SIA are currently unknown as the reservoirs that may provide the hydrocarbons for trains 3 to 5 have not been identified as yet.

Discharge Modelling Results for Produced Water from the LNG Plant

Discharge modelling was undertaken using the Project-specific Dilution Model described above (URS 2010j, Appendix Q3). The discharge outlet located at -20 m CD and depicted in Figure 8.17 (Outlet 2) is associated with the discharge of PW from the onshore infrastructure. The discharge scenario is summarised in Table 8.13. Details of the diffuser design are yet to be finalised for this outfall, so a diffuser similar to that described for the shallower outfall (Table 8.11) but with a length of 20 m has been assumed.

Results indicate that initial mixing of the discharge at -20 m CD occurs rapidly throughout the water column. However, the density of the combined discharge with the ambient environment results in a mixture that is less dense than the far-field ambient environment and the plume is predicted to begin to rise to the surface approximately 100 m downcurrent of the diffuser.

Under this worst case scenario (Figure 8.20), a dilution of approximately 1:450 is reached within 200 m of the outfall. While this is insufficient to reach the PNEC dilution for untreated PW of 1:1300, the PW will be further treated and managed as described in Table 8.18 so that the dilution required to meet the PNEC is achieved within 200 m of discharge. In addition, toxicity risk is decreased because the plume is predicted to form a shallow layer near the surface, its length depending on its density and temperature as well as environmental conditions. Hydrocarbons will be more exposed to volatilisation at the surface (not included in the model) and will not be in contact with biota on the ocean floor. With the dilutions predicted from the model, it is expected that salinity, temperature and TSS will be within the normal range at the edge of a 200 m mixing zone for all scenarios.

Nutrient load in the Project area will be markedly increased from the discharge. PW is expected to contain 20 and 23 mg/L of nitrogen and phosphorus respectively (Section 4.6.3.4). A dilution of 1:400 indicates that the ANZECC/ARMCANZ (2000) guideline concentrations for nitrogen and phosphorus should not be exceeded, outside the mixing zone, but PW discharge will add approximately 100 t/yr of both nitrogen and phosphorus to the region. This represents an increase of 25 and 75 per cent of the average annual discharge from the Ashburton River for nitrogen and phosphorus respectively (URS 2009, Appendix Q6).

At the time of preparing this ESI/ERMP the gas and condensate fields to supply LNG trains 3, 4 and 5 had not been identified. Therefore it was not possible to present the characteristics of the PW, in terms of properties, volumes, and productions rates to be brought onshore for treatment and disposal to the marine environment at the 20 m contour in State Waters. In the absence of specific details characterising the PW, and to support the impact assessment process, a draft Outcomes Based Condition has been prepared and is included in the Draft EIS/ERMP (Table 12.10 Chapter 12). This draft Outcomes Based Condition commits the proponent to achieving appropriate standards for discharges to the marine environment. Specific discharge standards and treatment protocols for PW discharges from the onshore facility will be developed further and presented in the Supplementary EIS. The discharge standards and treatment protocols will be developed to achieve appropriate discharge standards across the full range of potential PW volumes and to be consistent with legislative requirements.

Table 8.13: Produced Water Discharge Scenario – Outlet 2

Parameter	Units	Onshore operations PW discharge
Location		274,621 E; 7,623,332 N
Depth of water column	m	20
Description	-	Operational
Discharge streams	-	PW
Duration	hrs	Continuous
Depth	m	20
Temperature	°C	Ambient + 30
Salinity	ppt	17(1)
Density	kg/m^3	998.19(2)
Flow rate	m^3/hr	552

NB: (1): Assumed based on salinity characteristics of Iago (conservative). (2): Calculated based on an ambient temperature of 25°C

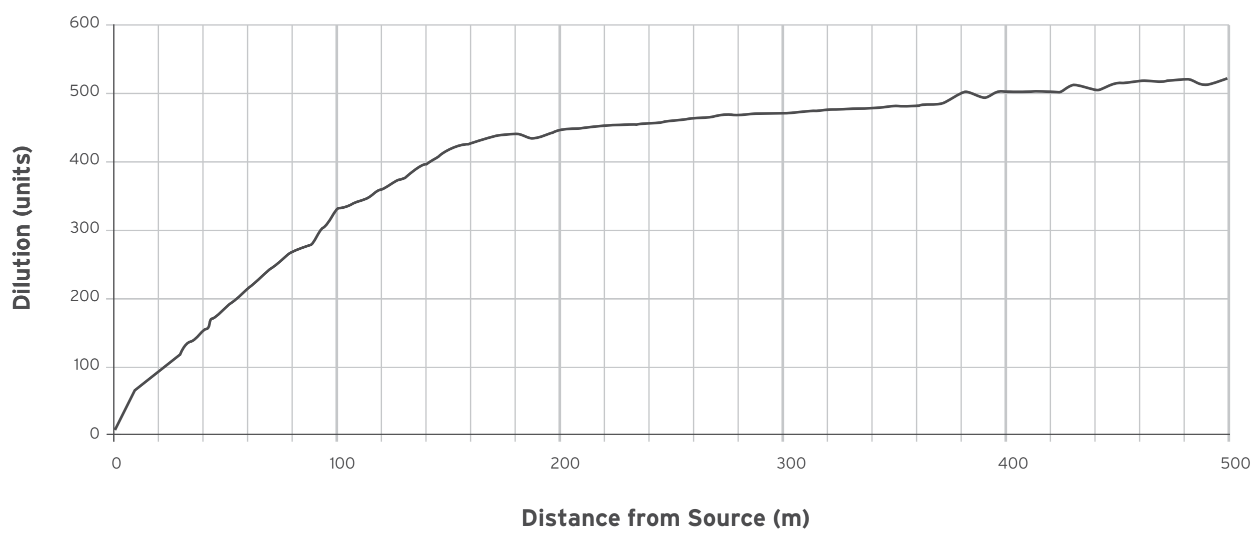


Figure 8.20: Worst Case Dilution or Produced Water Discharge with Distance from Outlet 2

Summary

The potential impacts of the discharge of PW from the LNG plant on water quality include increased nutrients and hydrocarbon contamination.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that the discharge of PW from the LNG plant will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Moderate" consequence, arising from the localised short-term exceedence of background and applicable ANZECC/ARMCANZ water quality guidelines, and of "Likely" occurrence.

8.2.5.8 Discharges from Offshore Construction

This section considers offshore discharges from construction of offshore infrastructure, including the WP, development wells and flow lines in Commonwealth waters, approximately 145 km off of the WA coast.

Discharges of Drill Cuttings and Muds, Sewage from Vessels, Hydrotest Water

Residual risk to marine water and sediment quality from offshore construction discharge is	**Low**

There are two basic types of drilling fluids or muds, water-based muds (WBM) and synthetic-based muds (SBM). WBMs have either fresh water or salt water as the primary fluid phase, while SBMs have either refined oil or synthetic materials as the primary fluid phase. WBM will be used as a preference. However, an SBM will be used where this is not technically feasible, for example where they cannot provide the required lubrication, borehole stability or other properties. Drill cuttings are crushed rock generated by the drill bit as it penetrates the seafloor. These are interspersed with low levels of hydrocarbons and heavy metals from components of the drilling fluids. These concentrations have been described as insignificant in comparison to background levels (Hinwood *et al*. 1994). However, recent studies of SBM cuttings piles on the seabed offshore of WA indicate that the piles are more persistent than expected.

Persistent cuttings piles represent a medium to long-term potential effect on the environment (Department of Industry and Resources [DoIR] 2006). The Petroleum Guidelines – Drilling Fluids Management (DoIR, 2006) provide guidance on the permitted use of drilling fluids.

Cuttings discharged during drilling using WBMs usually contain five to 25 per cent drilling fluids, whereas cleaned SBM cuttings normally contain less than ten per cent synthetic chemical. Cuttings may also contain small amounts of hydrocarbons from the geologic strata being penetrated. The target residual amount of drilling fluids on cuttings will be <ten per cent dry weight in accordance with Drilling Fluids Management Guidelines (DoIR 2006). The volume of drill cuttings anticipated to be produced may range from 500 to 700 m^3 per well.

During drilling, the drill fluids are recirculated, as discussed in Chapter 4, *Emissions, Discharges and Wastes*. Sludges and sand that are separated from the drilling muds may contain residual contamination from the drilling mud. Sand and silt recovered from the desanders and desilters may contain hydrocarbons and, potentially, minor quantities of NORM and heavy metals. At the end of the drilling operation, or occasionally during a drilling campaign, a large portion of the mud is discharged or disposed of. Excess WBMs are discharged overboard; whereas, SBMs are returned for onshore treatment for re-use and/or disposal.

Drill cuttings discharged overboard from the mobile offshore drilling unit (MODU) may result in an increase in the turbidity of the water column below the MODU during well development campaigns. Cutting piles may develop on the ocean floor as a result of drill cutting disposal. Impacts to water and sediment quality are predicted to be temporary and localised in the vicinity of the WP.

Construction discharges of PW (among other discharges) are discussed in Chapter 2, *Project Description* and Chapter 4, *Emissions, Discharges and Wastes*. Hydrotest water, used in commissioning of the trunkline, flow lines and offshore/nearshore trunklines, will be disposed of into offshore waters most likely at the platform as described in Chapter 4, *Emissions, Discharges and Wastes;* with the exception of limited volumes of water in front and between the pigs which could be discharged through the microtunnel. However, in the unlikely event of an emergency during the commissioning procedure, a release may occur nearshore. Potential impacts to biological communities from hydrotest water are discussed in Section 8.4. Impacts to water and sediment quality are predicted to be localised and temporary. Sewage from construction vessels will be treated on board in accordance with International Maritime Organization (IMO) requirements prior to discharge.

Summary

The potential impacts of discharges from offshore construction on water and sediment quality include temporary and localised elevation of contaminant concentrations in water and sediments.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that the discharge of drill cuttings and muds, vessel sewage and hydrotest water will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Low" – of "Moderate" consequence, arising from the localised contamination of water and sediment, and "Possible" likelihood.

8.2.5.9 Discharges from Offshore Operations

This section describes the various discharges from operation of the offshore infrastructure, located at the WP. The offshore operational program for the Project is described in Chapter 2, *Project Description,* and the discharges in Chapter 4, *Emissions, Discharges and Wastes*. The offshore operations are located on the WP in deep water (approximately 73 m) where the benthic zone does not receive light and metocean conditions facilitate rapid dilution of the discharge. It is unlikely that sensitive receptors will exist in the immediate vicinity of the WP, with the nearest shallow water located at the Montebello Islands, 45 km to the south.

This section considers discharges of PW, monoethylene glycol (MEG), CW and discharges from offshore accommodation on the WP, including as sewage, greywater and RO brine. Further discussion is found in Chapter 4, *Emissions, Discharges and Wastes*. Sources and indicative volumes are listed in Table 8.14. Some volumes and quality may vary during commissioning, shutdowns and start-ups, changes in well fluids and seasons.

Discharge of Produced Water Discharge at WP

Residual risk to marine water and sediment quality from produced water discharge is	**Medium**

Characterisation of PW discharges is discussed in Section 8.2.5.7. By determining the likely components, the environmental hazard can be forecast for each chemical by comparing the measured concentrations with the marine water trigger values (such as ANZECC/ARMCANZ 2000 and international literature) for a specific level of protection. As described previously, a conservative dilution of 1:1300 of untreated PW has been targeted as the dilution to meet the estimated PNEC close to the edge of the mixing zone.

Table 8.14: Preliminary Operations Discharge Scenario from WP

Discharge from Platform	Indicative Maximum Volume/Rate	Discharge Temperature (° C)	Comment
PW	6 530 m^3/day	75	Represents peak anticipated water production.
MEG injection during start-ups	1 200 - 2 700 m^3 MEG per event	20 - 75 over start-up duration	The range 1200 to 2700 m^3 represents the current bounding of the anticipated "worst-case" MEG discharge event; i.e. a full start-up of the entire gathering system, late in field life and at low seabed temperatures. MEG discharge events will vary in magnitude from close to zero to this upper bound (i.e. between 1200 and 2700 m^3). During a discharge event MEG would generally be discharged at varying rates over a period of around 4-24 hours following restart of a flow line(s).
CW	182 000 m^3/day	45	Assumes gas compression is operational.
Sewage and putrescible organic waste	14 (typical) - 29 (peak) m^3/day	Ambient	Initial estimates are around 0.3 m^3 per person per day. Persons on board range from 47 (typical) to 95 (peak). Treated in compliance with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78, Annex IV).
RO Brine	57 (typical) - 114 (peak) m^3/day	Ambient	Assumes manning and per capita consumption the same as for the sewage discharge calculation. Discharged overboard.

Options are being assessed for secondary treatment of PW that could result in a further reduction in potentially toxic substances and hence a reduced PNEC. In addition, likely PW composition and contaminant ranges are being developed in the ongoing Front End Engineering and Design (FEED) phase.

The dispersion of PW from the WP was modelled using a similar procedure to that described previously for nearshore discharges Section 8.2.5.7. The PW was initially simulated as a continuous discharge in isolation with the characteristics listed in Table 8.15, separated from the CW discharge horizontally by 124 m (i.e. from opposite legs of the platform). A scenario was also run co-mingling the PW with the CW but as results showed less near-field dilution, this case has not been discussed further here.

The plume is predicted to form a shallow layer near the surface. This means hydrocarbons will be more exposed to volatilisation (not included in the model) and will not be in contact with biota on the ocean floor. Hence the consequence of the PW discharge to marine sediment quality is considered to be minor.

Based on preliminary modelling (Figure 8.21), a dilution of approximately 1:1300 is reached within 100 m of the outfall (URS 2010j, Appendix Q3). Planned optimisations will further reduce the distance to achieve the PNEC required for the appropriate level of protection recommended by the ANZECC/ARMCANZ (2000) trigger values for toxicants. This will ensure determination of appropriate key performance indicators for inclusion in management plans. Likewise, it is expected that salinity, temperature and TSS will be close to ambient conditions local to the discharge.

The feasibility of the optimised discharge design, and the potential for the PW stream to impact the CW stream in the far-field, will be further assessed in FEED.

As FEED progresses, the following optimisations will be assessed:

- Refinement of the volumes and characteristics of the modelled PW as information around likely wellstream composition becomes available
- Options for further PW treatment that would reduce the distance required to obtain the PNEC
- Assessment of the impacts and feasibility of mixing of the CW and PW discharges, or keeping the discharge caissons horizontally separate
- Optimisation of the diffuser design such as depth of discharge, number of ports, orientation of ports, discharge temperatures and pipe diameters
- Investigation of potential impacts of MEG at start-ups on the dissolved BTEX concentrations
- Ecotoxicity testing prior to operational discharge to re-assess the PNEC if practical, or benchmarking with similar NWS PW discharges if not.

Table 8.15: Produced Water Characteristics Modelled - Operational Phase (Offshore) - Isolated Discharge Parameter

Parameter	Units	Modelled	Comment
Water depth	m	73	Overboard WP
Discharge depth	m	20-40	Potential for optimisation
Temperature	˚C	75	50-80. Potential for optimisation
Density	kg/m^3	963	Variable, depending on temperature (and wellstream characteristics).
PW flow rate	m^3/hour	272	Rate depends on which wells are operating, phase of field life, water management strategy etc.
Discharge pipe	m diameter	0.305	(1) Down facing and (2) Down- angled at 45°. Potential for optimisation
Oil in water	mg/L dispersed oil	30	Legislative minimum (24 hr average).
Project Temperature Criteria	˚C	<3 ˚C temperature difference between discharge and ambient	
Project PNEC		Preliminary target of 1300 dilutions	

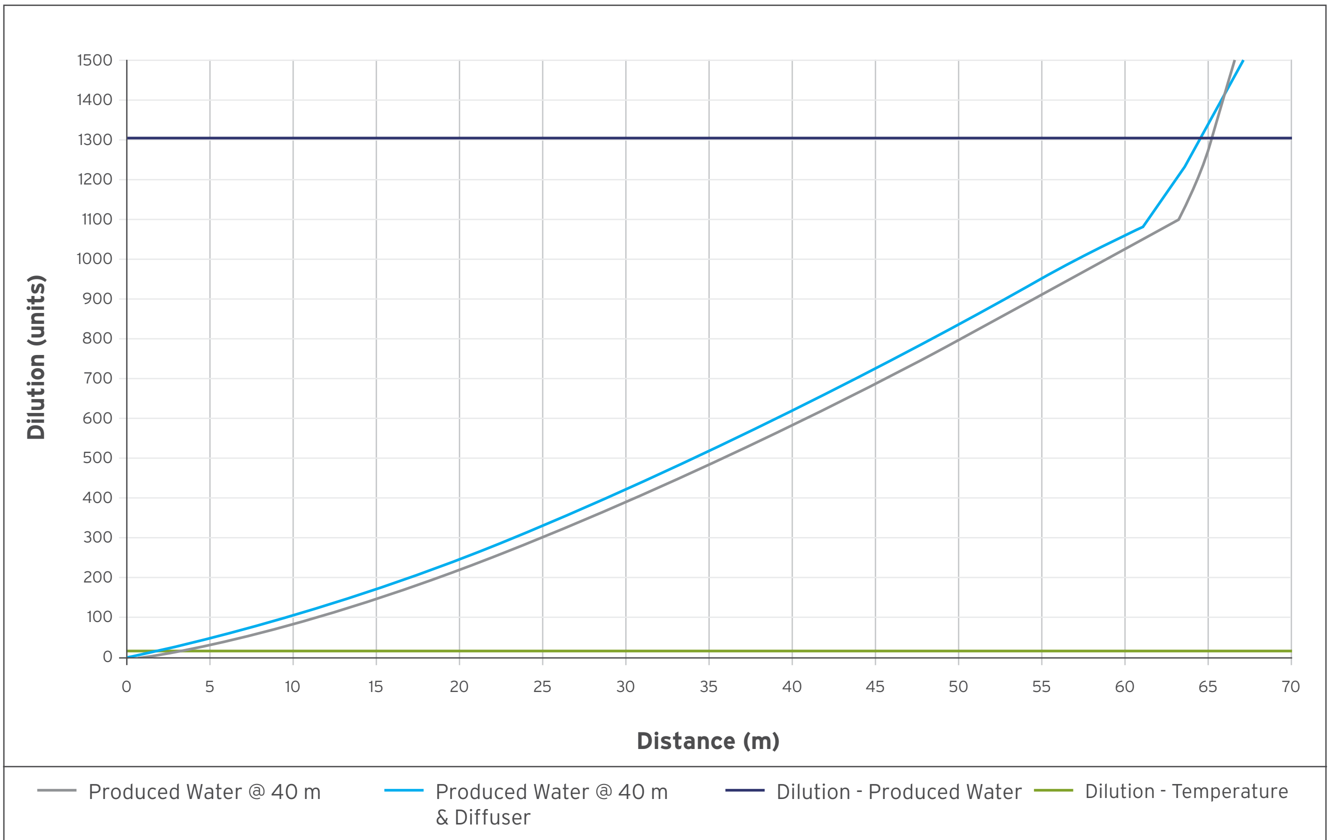


Figure 8.21: Worst Case Dilution of PW with Distance from WP Outlet (20-40 m depth)

PW management will be agreed with the Regulator through the development of the platform construction and operating Environment Plan in compliance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009. This Plan will include the following details:

- Proposed PW discharge oil-in-water analyses and method of analysis
- Monitoring and reporting of quality and quantity of discharge
- Targets and performance criteria
- Routine ecotoxicity testing and modelling
- Modelling prior to expected changes in composition;
- The consideration of process chemical ecotoxicity in the selection process
- Periodic discharge testing with full chemical characterisation and dispersion modelling
- An environmental assessment of future discharge rates and potential changes to the design
- A response strategy.

Summary

The potential impact of PW discharges from offshore operations on water and sediment quality are an increase nutrients and contaminants. The potential for acute and chronic impacts, as well as bioaccumulation, is reduced because the location (at approximately 75 m water depth) is remote from shallow-water habitats and does not support nearby sensitive receptors. The discharge plume is unlikely to contact biota on the ocean floor prior to extensive dilution. Temperature plumes, total dissolved solids (TDS) and salinity is likely to be close to ambient conditions local to the discharge.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that the discharge of PW from the WP will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Moderate" consequence, arising from the localised short-term exceedence of applicable ANZECC/ARMCANZ water and sediment quality guidelines, and of "Likely" occurrence.

Discharge of Monoethylene Glycol and BTEX in PW during Start-ups at WP

Residual risk to marine water and sediment quality from MEG and BTEX discharges is	**High**

MEG discharges will occur for a variety of reasons as part of the hydrate prevention strategy. Discharges will vary in magnitude between small events that might occur a number of times throughout the year, and more significant events that should only occur a few times a year. Small events would be associated with activities such as start up of individual wells or flow-lines. These small events could result in a MEG discharge volume of approximately 10 m^3/event.

Major events such as a full start-up of the gathering system could result in a MEG discharge of around 1200 m^3 to 2700 m^3/event. These upper ranges represent the current bounding of the anticipated "worst-case" MEG discharge event; i.e. a full start-up of the entire gathering system, late in field life and at low seabed temperatures. The figure of 1200 m^3 comprises 800 m^3 from Petroleum Titles WA-253-P and WA-17-R, plus 400 m^3 from Petroleum Title WA-356-P. The figure of 2700 m^3 is currently considered conservative but accounts for unknowns, including uncertainties around WA-356-P operations. MEG would generally be discharged at varying rates over a period of around 4-24 hours following restart of a flow-line(s). Characteristics of discharges during these start-up events are listed in Table 8.16.

The PW and CW modelling studied two distinct discharge options; a common discharge caisson and separate PW/CW discharge caissons. Similarly, initial modelling of the MEG discharge considered two distinct discharge options; PW/MEG discharged either separately or in combination with the CW. The characteristics of the combined MEG/PW/CW discharge scenario are shown as the base case with additional cases discussed in later sections.

The results of modelling a combined 50°C MEG/PW (422 m^3/hour) and 8000 m^3/hour of 45°C CW discharged at a depth of 20 m, suggest that the plume will reach the surface of the water column approximately 25 m downcurrent of the discharge point. A dilution of 18-fold is predicted at this point on the surface. Once the surface of the water column is reached, the potential for dilution will be reduced when compared with the dilution over the first 20 m. Results suggest that the MEG would disperse within 24 hours, once the MEG ceases being discharged overboard.

Table 8.16: WP Discharge Characteristics during Start Ups

Parameter	Units	Base Case Modelled	Comment
Description • Major MEG discharge event (full system start, at low temperature with 6530 m³/day PW), • Combined MEG, PW and CW discharge line			
Water depth	m	73	
Depth of discharge	m	20	Potential for optimisation.
Discharge	1 port 1.5 m diameter		Down facing. Potential for optimisation.
Duration	hour	18	4-18 hours depending on scope and duration of shutdown, sea bed temperature and well ramp-up profile.
MEG and PW Discharge			
Temperature of MEG/PW	°C	50	30°C (ambient seawater) to 80°C (PW).
Density	kg/m^3	Variable	Dependent on temperature and ratio of PW to MEG in solution.
MEG flow rate (Note [1])	m^3/hour	100	High anticipated MEG volumes for full system start-up at low temperatures.
PW flow rate	m^3/hour	Ramping from 0 to 272	Depends on which wells are being brought on line, the season (summer/winter) and the number of wells. For the purposes of modelling a linear ramp-up has been assumed.
CW Discharge			
CW flow rate	m^3/hour	8000	7000 to 8000 depending on compression requirements at the time.
CW Temperature	°C	45	

Note 1: Wellhead MEG injection rates do not necessarily correspond to the platform discharge rates due to the hold-up behaviour of the gathering system.

To reach the ANZECC/ARMCANZ (2000) low reliability trigger value for MEG of 50 mg/L would require a dilution of the co-mingled discharge of approximately 1:270. The dilution required to meet this criteria is not reached under the scenario described in Figure 8.22 for 5 km from the platform. No biodegradation or volatilisation of the MEG is assumed.

Preliminary optimisation shows a significant reduction in size of mixing zone by extending the discharge depth, narrowing the diameter, and changing the diffuser to downward facing multiple ports. For example, using two downward facing ports (-45°C) of reduced diameter reduces the distance to reach the required dilution of 1:270 from 5 km to 900 m. Further optimisation is being assessed for feasibility.

In addition, separate discharges for PW/MEG and CW have been assessed using CORMIX and short-term three-dimensional numerical simulations. In isolation of CW, the MEG discharge is negatively buoyant with respect to the ambient environment and will descend through the water column to the seafloor.

To reach the ANZECC/ARMCANZ (2000) low reliability trigger value for MEG of 50 mg/L would require a dilution of the MEG discharge of approximately 1:20 000 for Hour 0 when the MEG discharge is most concentrated. Steady-state results from CORMIX suggest that the dilution is not reached under the scenario described in Figure 8.23 until the plume reaches 7.5 km from the platform. Results of the three-dimensional modelling suggest that the MEG would disperse within 24 hours once the MEG ceases being discharged overboard (URS 2010j, Appendix Q3). No biodegradation or volatilisation of the MEG is assumed.

Although the MEG discharge modelled scenario indicates an exceedence of the low reliability trigger over a relatively broad area, the large volume discharge of MEG (in isolation or co-mingled with CW) only occurs for approximately four one-day periods per year, so exceedence will be short term and the impact localised. The MEG is expected to disperse within 24 hours once the MEG ceases being discharged.

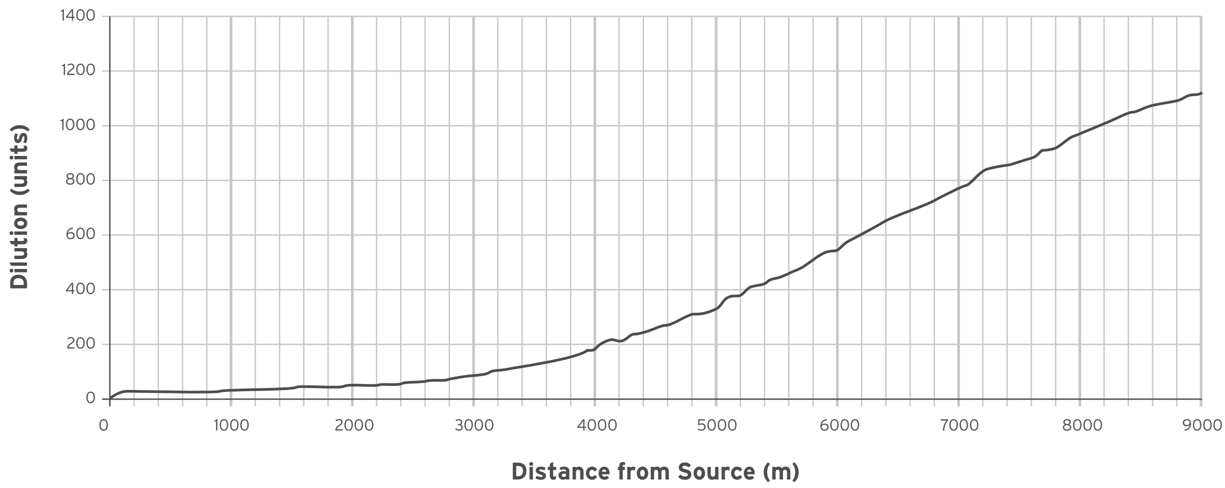


Figure 8.22: Worst Case MEG Dilution with Distance from the Discharge – PW/MEG and CW Combined in Single Caisson

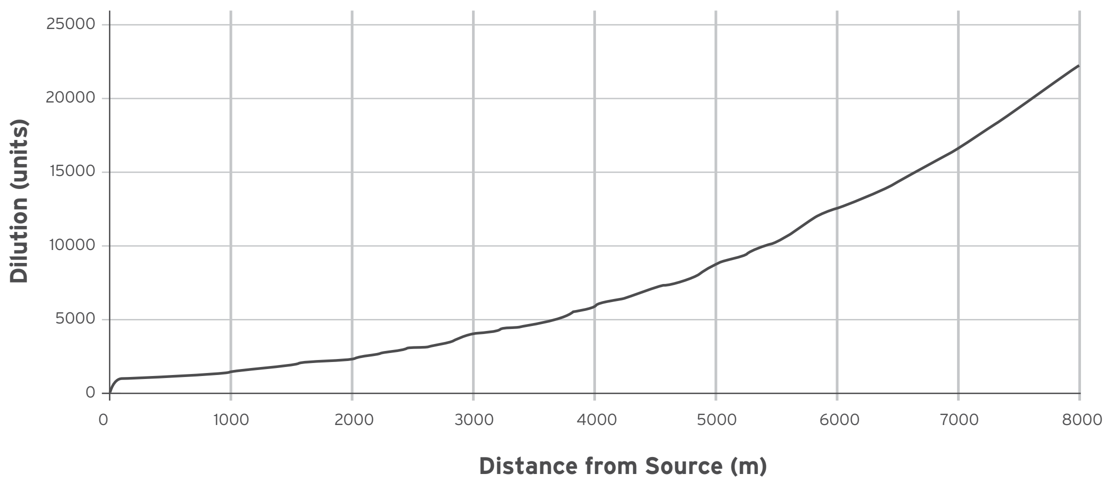


Figure 8.23: Worst Case MEG Dilution with Distance from the Discharge (CORMIX for Hour 0) – PW/MEG in Isolation and CW Combined in Single Caisson

MEG toxicity is very low (ANZECC/ARMCANZ 2000) and is described as a chemical Posing Little Or No Risk to the environment (PLONOR) under the Oslo and Paris Commissions Recommendation 2000/4 on Harmonized Pre-screening Scheme for Offshore Chemicals. MEG is also readily biodegradable in water with degradation likely to occur through aerobic bacterial activity (Price *et al*. 1974).

MEG raises the levels of BTEX in the PW, thus increasing the dissolved hydrocarbon component and hence toxicity. Studies are underway to quantify the impact and review options for minimisation.

During ongoing FEED, the following issues will be reviewed:

- The impact of MEG on raising the BTEX levels in the PW during start-up, and options to ensure compliance with legislation during start-up
- Options for possible PW/MEG treatment that could reduce the required PNEC
- Refining the volumes and characteristics of the PW discharges as information around likely wellstream compositions mature
- Refining the volumes and characteristics of MEG discharges as operational strategies are developed
- Separating the CW and PW discharges and/or optimising the mixing of CW and PW discharges
- Minimising thermal impacts and impact area through diffuser design (e.g. depth, number of ports, and orientation of ports) discharge temperatures and pipe diameter.

The potential for acute and chronic impacts, as well as bioaccumulation, is reduced because the location is in about 75 m water depth which is remote from shallow water habitats with sensitive receptors. The MEG/PW/CW co-mingled discharge plume is buoyant and will not be in contact with biota on the ocean floor prior to extensive dilution. The isolated MEG/PW discharge is negatively buoyant and will descend through the water column to the seafloor. The temperature plume, TDS and salinity levels are likely to be close to ambient conditions local to the discharge. MEG is expected to disperse within 24 hrs of the MEG discharge ceasing, is considered PLONOR, and no long-term impacts on marine organisms are expected. The BTEX levels will be raised for the duration of the MEG discharge (up to 24 hours). The large MEG volume discharges may occur around four times per annum.

Summary

The potential impact of discharges from offshore operations is the exceedence of targets for MEG and BTEX in PW during start-ups. MEG in the marine environment, particularly sediments, has not shown to be a chemical of concern in the available literature due to its low inherent toxicity, rapid biodegradability and inability to bioaccumulate. MEG is also on the "Preparations Used and Discharged Offshore which Are Considered to Pose Little or No Risk to the Environment" (PLONOR) list. Modelling predicts that MEG will disperse within 24 hours after the cessation of the discharge. The anticipated life of the Project is 30 years and large MEG volume discharges may occur around four times per annum.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that the discharge of MEG in PW from the WP will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "High" – of "Moderate" consequence, arising from the localised short-term exceedence of applicable ANZECC/ARMCANZ water and sediment quality guidelines, and an "Almost Certain" likelihood. To restrict, and potentially further reduce, the risk ranking to "High", the implementation of the management and mitigation measures outlined in Table 8.18 will be required.

BTEX levels will be raised for the duration of the MEG discharge (up to 24 hours). The concentrations, frequencies and durations of the BTEX spikes are yet to be confirmed under various operating scenarios. As the worst-case consequence there may be localised short-term exceedences of background and applicable ANZECC/ARMCANZ WQ and SQ Guidelines under certain environmental conditions. Additionally, under worst-case scenarios, the petroleum in water limit may also be exceeded for short periods.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that the discharge of BTEX in PW from the WP will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "High" – of "Moderate" consequence, arising from the anticipated exceedence of targets for BTEX in PW during start-ups, and "Almost Certain" likelihood. To restrict, and potentially further reduce, the risk ranking to "High", the implementation of the management and mitigation measures outlined in Table 8.18 will be required.

The above rankings do not reflect a high level of risk to the environment for criteria other than water and sediment quality. The consequences of high MEG and BTEX in water

Table 8.17: Offshore Cooling Water Discharge Characteristics

Parameter		Units	Comment
Depth of water column		m	73
Depth below sea level of discharge		m	20 -40 Potential for optimisation.
Diameter of discharge line(s)		m	1.5 (CW Caisson) Potential for optimisation.
Number of diffusers		-	Open and face downwards. Potential for optimisation.
CW Stream	Duration	hours	Continuous
	Temperature of CW discharge	˚C	45
	Salinity	ppt	Surrounding seawater
	Density	kg/m^3	1013
	CW Flow Rate	m^3/hour	7580
	Residual chlorine at exit	ppm	0.2

and sediment are likely to be "Minor" due largely to short durations of discharge and rapid dilution. The combined residual risk for MEG and BTEX is "High", however this is expected to fall to a "Medium" as FEED progresses.

Discharge of Cooling Water at WP

Residual risk to marine water and sediment quality from CW discharges is	Medium

The open loop seawater system on WP will provide the cooling medium for the closed loop Tempered Water System. In addition, the seawater system provides source water for potable water generation, make-up firewater and provides source water for anti-foulant generation (such as hypochlorite) as described in Chapter 2, *Project Description*, and Chapter 4, *Emissions, Discharges and Wastes*. A biocide (typically the generated sodium hypochlorite) will be injected continuously at a low dose (around 1 ppm) to ensure biofouling is managed. Shock dosing (nominally 3 ppm free chlorine) is provided intermittently – typically for 15 minutes every 12 hours. Dosing rates will be designed to manage the free chlorine in the outlet which rapidly degrades to a salt in the ocean.

Potential impacts from the CW discharge include the temperature plume, residual biocide levels and changes in oxygen levels.

The seawater system is designed to be fully segregated from the hydrocarbon system so there is no risk of hydrocarbon contamination in CW discharges.

The heated seawater is discharged back to the ocean at a maximum temperature 45°C via a caisson. Two scenarios have been considered; CW and PW as separate single discharges, or the two streams discharged into the same caisson. In both cases the discharged streams will be released at a point above the seawater inlet caisson in order to reduce the risk of CW recirculation or MEG contamination of the seawater supply to the platform. The modelled characteristics of the separate CW discharge are shown in Table 8.17.

Figure 8.24 shows:

- The number of dilutions required (< 10) to meet the target temperature of less than 3°C above ambient
- The number of dilutions required (approximately 70) to return chlorine levels to background concentrations
- The downcurrent distance required to meet the above target temperature and chlorine concentrations from CW discharges located at 20 and 40 m depth.

The modelling results presented in Figure 8.24 show that only the CW discharge at 40 m depth provides the required dilutions close to the discharge point (within 50 m). Further optimisation of the CW discharge will focus on selecting the most appropriate depth and diameter of discharge outfall to achieve the required mixing zone.

Summary

It is possible that the discharge of CW at the WP may impact marine water and sediment quality, however the discharge location is remote from shallow water habitats, has no nearby sensitive receptors, will be discharged at about -75 m CD and is exposed to the open ocean currents. The plume is buoyant and will not be in contact with biota on the ocean floor prior to extensive dilution. The temperature plume, TDS and salinity levels are likely to be close to ambient conditions local to the discharge.

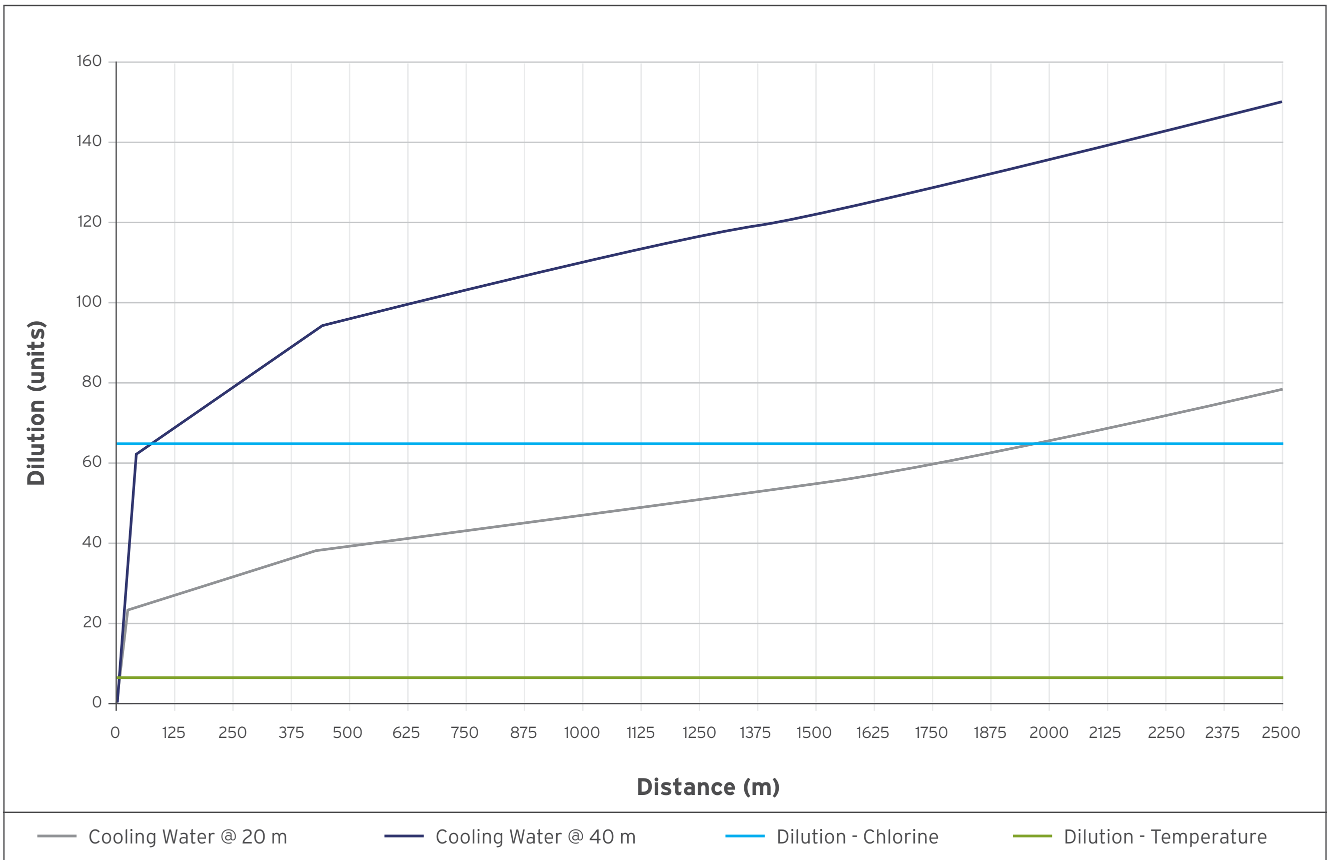


Figure 8.24: Cooling Water Discharge: Near-Field Worst-case Dilution with Distance from the Wheatstone Platform (Ambient Current Velocity 20 cm/s)

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that the discharge of cooling water from the WP will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Moderate" consequence, arising from the localised short-term exceedence of applicable ANZECC/ARMCANZ water and sediment quality guidelines, and of "Likely" occurrence.

Discharge of Sewage, Grey Water, and Reverse Osmosis Brine at WP

Residual risk to marine water and sediment quality from sewage, grey water, and reverse osmosis brine discharges is	**Very Low**

The discharges of sewage, putrescible organic waste and RO brine will be treated in compliance with legislation (*Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and MARPOL 73/78). RO brine discharge is predicted to have a salinity indicatively 25 per cent higher than seawater. Sewage and grey water will be macerated to less than 25 mm prior to overboard discharge where, like the RO brine, they will be rapidly diluted and dispersed by ambient currents.

These routine discharges may cause localised temporary increases in nutrients in the water column. Total phosphorous and nitrogen levels are expected to be low compared with the background turnover of nutrients. Toxicity effects of sewage discharged to the sea are well understood and any effects will be highly localised given the forecast small volumes (Chapter 4, *Emissions, Discharges and Wastes*).

Summary

It is unlikely that discharges of sewage, grey water, and RO brine at the WP will result in detectable changes to background water and sediment quality, due to water depth of discharge, the lack of sensitive environments, the exposure of discharges to open ocean currents and forecast biodegradability. No detectable impacts to marine sediment quality are forecast.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that the discharge of sewage, grey water and RO brine from the WP will result in impacts to marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Very Low" – of "Negligible" consequence and "Possible" likelihood.

8.2.5.10 Release of NORM During Descaling

This subsection discusses the potential presence of NORM and their disposal.

Residual risk to marine sediment quality from the release of NORM is	**Very Low**

PW may contain minimal quantities of NORM. Under certain conditions (high salinity, together with the presence of sulfates and/or carbonates, calcium, barium and strontium) NORM can become bound to scale deposits which form in piping (including the gas trunkline) and process vessels.

Maintenance of vessels during production phase and clean-up tasks during decommissioning may require the disposal of scale if it has built up as a solid in the flow-lines and pipework over the life of the Project. Potential environmental effects associated with the disposal of NORM to the marine environment include toxicity effects on marine flora and fauna.

Fluid property reports for Petroleum Titles WA-253-P, WA-17-R and WA-356-P indicate that NORM are minimal and of low concentration. As the production of NORM is anticipated to be minimal, there is no expected impact to the marine environment as a result of offshore discharges.

Should NORM be found at a later stage of production it will be stored, handled and disposed of in compliance with legislation through approved processes and by appropriately licensed entities.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that the release of NORM will result in impacts to marine sediment quality. The residual environmental risk for this potential impact was assessed as being "Very Low" – of "Moderate" consequence, arising from localised contamination of marine sediments, and "Remote" likelihood.

8.2.5.11 Shipping

This subsection discusses the potential impacts from shipping activity in the Project area.

Ship Movements During Construction and Operations

Residual risk to marine water and sediment quality from shipping is	**Low**

A description of the nearshore infrastructure and anticipated vessel movements during the operation of the Project at 25 MTPA LNG capacity is provided in Chapter 2, *Project Description*. It is not anticipated that export vessels will refuel within the MOF/PLF. However, dedicated support vessels (tugs and work boats) will be refuelled at the MOF. Shipping and tug movements create propeller wash that may lead to increased turbidity, TSS and light attenuation. Vessels will also introduce streams of ballast water, CW, grey water and other wastewater. These discharges will be treated in compliance with legislation (*Pollution of Waters by Oil and Noxious Substances Act 1987* [WA] [vessels in State waters], and *Protection of the Sea [Prevention of Pollution from Ships] Act 1983* and MARPOL 73/78 [vessels in Commonwealth waters]) as well as Australian Quarantine and Inspection Service (AQIS) requirements regarding management of ballast water from international origins (URS 2009j, Appendix R1).

Increased shipping may introduce contaminants to the marine environment by leaching from anti-fouling systems. Application of anti-fouling paint on the bottom of ships is used to prevent the attachment of marine organisms such as molluscs and algae (biofouling). Historically TBT was commonly used for this purpose; however, under the International Convention on the Control of Harmful Anti-fouling Systems on Ships (2001), TBT was deemed a harmful anti-fouling system.

As Australia is a signatory to this Convention, AQIS will require compliance from any ships that are involved in the Project, therefore reducing the risk of harmful substances leaching from their anti-fouling systems into the marine environment.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that the movement of vessels during construction and operations will result in impacts to marine sediment quality. The residual environmental risk for this potential impact was assessed as being "Low" – of "Moderate" consequence, arising from short-term exceedence of background and applicable ANZECC/ARMCANZ water and sediment quality guidelines and localised contamination of sediment, and "Possible" likelihood.

8.2.5.12 Hydrocarbon Leaks and Spills

This section discusses the risk of leaks and spills occurring and examines their potential impacts.

Residual risk to marine water and sediment quality from leaks and spills entering the nearshore marine environment is	**Medium**
Residual risk to marine water and sediment quality from leaks and spills entering the offshore marine environment is	**Low**

Assessment of Leaks and Spills

Hydrocarbon spill modelling was conducted for the Project (DHI 2010, Appendix Q2). Although leaks and spills have the potential to impact on water and sediment quality, the receptors most at risk are the associated BPPH (Section 8.3) and marine fauna (Section 8.4). The full assessment of leaks and spills entering the marine environment is given in those sections.

Leaks and spills of hydrocarbons may occur during any of the construction, operations or decommissioning phases of the Project. The main substances of concern are condensate (leaks and spills may occur during the drilling, extraction, processing or transportation phases) and diesel (leaks and spills may occur during regular vessel movements i.e. accidental discharge or collision, deck drain discharge and during refuelling). Hydrodynamic modelling has been used to determine the probability of spilt hydrocarbons reaching particular receptors. Results of the modelling (DHI 2010e, Appendix Q2) are presented in Section 8.3.

It is expected that the majority of any spilt condensate or diesel would evaporate within approximately 48 hours (International Tanker Owners Pollution Federation 2002). However, a spill of condensate or diesel may cause nutrient loading of the water column and limit the penetration of light to surface waters. Water quality may also be impacted by the introduction of toxic aromatic components such as toluene, benzene and xylene. These toxic components tend to be very light and are expected to evaporate rapidly.

As diesel contains heavier particles than condensate, a large spill of diesel would have a greater chance of combining with marine sediments. However, sedimentation of spilt hydrocarbons usually only occurs when the spilt hydrocarbons contain a high proportion of particles with "heavier" molecular weights (such as crude oil) and where the sediments have a high organic content, such as silts and clays (Volkman *et al*. 1994, Basheer *et al*. 2003).

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that accidental leaks and spills of hydrocarbons will result in impacts to nearshore marine sediment quality. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Massive" consequence, arising from short-term exceedence of background and applicable ANZECC/ARMCANZ water and sediment quality guidelines and localised contamination of sediment, and of "Unlikely" occurrence.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.18, it is possible that accidental leaks and spills of hydrocarbons will result in impacts to offshore marine water quality. The residual environmental risk for this potential impact was assessed as being "Low" – of "Major" consequence, arising from the localised short-term exceedence of background and applicable ANZECC/ARMCANZ water quality guidelines, and of "Unlikely" occurrence.

8.2.6 Implications for Matters of National Environmental Significance

There are no matters of NES directly attributable to marine water and sediment quality.

However, other aspects with matters of NES are dependent on marine water and sediment quality, including marine fauna. These potential impacts are addressed in Section 8.4.

8.2.7 Residual Risk Summary

The following table (Table 8.18) provides a summary of the aspects, activities and potential impacts to marine water and sediment quality as a result of Project activities. Indicative management and mitigations measures are also listed, along with the residual risk following the implementation of the proposed management and mitigations measures.

Where applicable, reference has been made to the Proposed Operational Marine Water and Sediment Quality Management Outcome-based Conditions (OBCs; Chapter 12, *Environmental Management Program*). These OBCs have been developed in alignment with the EPA's Draft *Environmental Assessment Guidelines. No. 4: Towards Outcome-based Conditions.* (EAG 4; EPA 2009f).

Table 8.18: Summary of Management Measures and Residual Risk for Marine Water and Sediment Quality

("C" = consequence, "L" - likelihood, "RR" = residual risk rating)

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Dredging Program							
Construction dredging of the channel and berthing area.							
	Increased turbidity and light attenuation exceeds agreed water quality targets.	Refer to DSDMP for complete list of mitigation measures. Design: Nearshore infrastructure location has been selected to reduce risks to sensitive water quality receptors where practicable. Mitigate: During sediment transport by the TSHD and barges, the level of the overflow pipe will be raised to its highest point to reduce the potential for spillage. Mitigate: Hopper doors on the TSHD will be well maintained to reduce the potential for sediment loss during transport. Mitigate: Well maintained and properly calibrated dredging equipment will be utilised. Mitigate: Hopper dewatering will be confined to areas away from sensitive receptors, where reasonably practicable. Mitigate: TSHDs will be fitted with a turbidity reducing valve within the overflow pipe. Mitigate: Where sensitive receptors are at risk from TSHD dredging operations, restricted overflow may occur. Monitor: Monitor water quality to quantify temporal and spatial scale of impact associated with dredging in relation to baseline data.	4	1	**High**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	Not Applicable

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Maintenance dredging							
	Increased turbidity and light attenuation exceeds water quality targets Mobilisation of contaminants during dredging leads to an exceedence of standards	Surveys will be undertaken to confirm natural turbidity, sedimentation rates and contamination levels.	5	3	**Low**	**Low** No survey data. No model verification possible	Not Applicable
Placement of dredge material nearshore and offshore							
	Increased turbidity and light attenuation exceeds agreed water quality targets	Design: Dredge material placement sites selected to reduce risks to sensitive water quality receptors Mitigate: Diffusers will be utilised during offshore dredge material placement via the CSD. Mitigate: Fine material will be managed appropriately based on experience during the construction dredging program and will include selection of placement locations accordingly. When practicable, material with high fines content will be placed at placement sites in deeper waters.	4	2	**Medium**	**High** Modelling conducted and calibration shows good adherence to real occurrences.	Not Applicable

Placement of dredge material onshore							
	Increased turbidity and light attenuation due to decant water discharge exceeding applicable water quality targets.	Design: The onshore dredged material will be contained in a bunded area to reduce the risk of an unconfined release of seawater and sediments. Design: A drainage ditch (with sump and pump system) will be installed to collect and divert seepage away from the Ashburton Delta system. Design: Discharge of decant water from the onshore dredge material placement site will be via a controlled point which will include the use of a weir box to manage water height. Monitor: Discharge water will be monitored, with the objective of maintaining the discharge water quality into the nearshore area at a level not in excess of 250 mg/L TSS. Mitigate: Discharge of decant water from the onshore placement area will be via a controlled point which will include the use of a weir box to control water height. Discharge water into the nearshore water will not exceed 250 mg/L TSS. However, this may be refined based on feedback information from monitoring programs. Monitor: Monitoring of decant water discharge will be undertaken with the objective of complying with the maximum turbidity limit of 250 mg/L for TSS.	4	2	**Medium**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences. Available information is adequate.	Not Applicable
Nearshore Construction Activities							
Construction of PLF and rock placement for MOF breakwater walls							
	Turbidity and light attenuation.	Refer to DSDMP for complete list of mitigation measures. Design: Nearshore infrastructure location has been selected to reduce risks to sensitive water quality receptors where practicable, Mitigate: Activity will be undertaken in accordance with the CEMP which will be finalised prior to commencement of construction activities.	6	1	**Low**	**Reasonable** Available information is adequate.	Not Applicable

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk C	L	RR	Confidence Level	Matters of NES
Nearshore trunkline trenching and stabilisation							
	Turbidity and light attenuation.	Design: Trunkline route location has been selected to reduce risks to sensitive water quality receptors where practicable Mitigate: Use graded rock material with reduced fines content. Mitigate: A DSDMP specific to trunkline trenching activities will be developed.	4	2	**Medium**	**Reasonable** Available information is adequate.	Not Applicable
Trunkline shore crossing by trenching							
	Changes to turbidity and light attenuation due to rock placement.	Mitigate: Activity will be undertaken in accordance with the CEMP which will be finalised prior to commencement of construction activities. Mitigate: Use graded rock material with low fines content.	5	1	**Medium**	**Reasonable** Available information is adequate.	Not Applicable
Trunkline shore crossing by microtunnelling							
	Turbidity and light attenuation.	Design: Trunkline shore crossing to be installed through microtunnelling. Mitigate: Activity will be undertaken in accordance with the CEMP which will be finalised prior to commencement of construction activities.	6	2	**Low**	**Reasonable** Available information is adequate.	Not Applicable
Discharges from Onshore Construction							
Nearshore discharge from the accommodation village, stormwater run-off and reverse osmosis brine							
	Exceed applicable water quality targets outside the mixing zone.	Mitigate: Activity will be undertaken in accordance with the CEMP which will be finalised prior to commencement of construction activities. Design: Nearshore discharge locations have been selected to reduce risks to sensitive water quality receptors Mitigate: Manage discharges by taking into account the threshold limits of the ANZECC/ARMCANZ guidelines. Mitigate: Diffuser designed to optimise the dilution of the discharge within the marine environment. Monitor: Mixing zone boundaries to be established and monitoring to achieve applicable water quality targets at mixing zone boundary.	5	2	**Low**	**Low to Reasonable** Available information is inadequate to adequate.	Not Applicable

Discharges from Onshore Operations							
Nearshore discharge of wastewater, process wastewater, contact stormwater and reverse osmosis brine							
	Exceed applicable water quality targets outside the mixing zone.	Refer to Chapter 12, *Environmental Management Program* for Proposed Operational Marine Water and Sediment Quality Management OBCs. Design: End of pipe diffuser located at the PLF in an appropriate water depth. Mitigate: Manage discharges by taking into account the threshold limits of the ANZECC/ARMCANZ guidelines. Monitor: Mixing zone boundaries to be established and monitoring to achieve applicable water quality targets at mixing zone boundary.	5	2	**Low**	**Low to Reasonable** Available information is inadequate to adequate.	Not Applicable
Discharge of PW from the LNG plant							
	Exceedence of the agreed targets for PNEC concentration outside the mixing zone.	Refer to Chapter 12, *Environmental Management Program* for Proposed Operational Marine Water and Sediment Quality Management OBCs. Design: Selection of outfall location and diffuser design for adequate dilution and dispersion of PW. Mitigate: The Proponent will characterise PW, prior to the PW being brought onshore to determine appropriate dilution rates to achieve PNEC, to determine a discharge location and to determine a mixing zone area that is acceptable to the regulatory agencies EPA and DEWHA. Mitigate: Diffuser design and size of mixing zone shall take into consideration the agreed target for PNEC. Monitor: Monitor PW concentrations prior to discharge.	4	2	**Medium**	**Low** Available information is inadequate.	Not Applicable

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Discharges from Offshore Construction							
Discharges from offshore production (includes drill cuttings and muds, sewage from vessels, hydrotest water)							
	Exceed applicable ANZECC/ARMCANZ guidelines.	Mitigate: Compliance with Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 as they apply from time to time. Mitigate: Treatment in compliance with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78, Annex IV). Mitigate: Controlled release of hydrotest water to reduce the risk of toxicity impacts.	4	3	**Low**	**High** Long-term monitoring results available (from similar projects).	Not Applicable
Discharges from Offshore Operations							
Discharges from offshore production							
	Exceedence of targets for PNEC of PW.	Mitigate: Compliance with Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009. Mitigate: The Proponent will determine PNEC for PW discharge through ecotoxicity testing and or benchmarking with similar NWS PW. Mitigate: Periodic PW discharge testing with full chemical characterisation during operations. Monitor: Monitor PW concentrations prior to discharge.	4	2	**Medium**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	Not Applicable
	Exceedence of targets for MEG and BTEX in PW during start-ups.	Design: Diffuser design and size of mixing zone shall take into consideration the target for PNEC. Mitigate: Control rate, timing and characteristics of discharge of MEG with the objective of maintaining discharge water quality at a level not in excess of 50 mg/L local to the platform (or an agreed distance from the platform).	4	1	**High**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	Not Applicable

	Exceedence of targets for CW.	Design: Diffuser design and size of mixing zone shall take into consideration the agreed target for CW plume.	4	2	**Medium**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	Not Applicable
	Discharge of sewage and putrescible organic waste and RO brine.	Mitigate: Treatment in compliance with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78, Annex IV).	6	3	**Very Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	Not Applicable
Release of NORM							
Descaling of strontium.							
	Accumulated NORM in onshore process filters which may cause contamination.	Design: Use of a scale inhibitor to manage build-up of scale (and therefore NORM). Mitigate: An approved NORM Management Plan will be developed on identification of NORM. Mitigate: Management and disposal of NORM in accordance with the Guidelines for the management of Naturally Occurring Radioactive Material (NORM) in the oil & gas industry (International Association of Oil and Gas Producers 2008).	4	5	**Very Low**	**Reasonable** Available information is adequate.	Not Applicable
Shipping							
Ship Movements during construction and operations							
	Accumulation of anti-fouling paints in marine sediments.	Monitor: All vessels under the control of the Proponent will comply with the International Convention on the Control of Harmful Anti-fouling Systems on Ships as monitored by AQIS.	4	3	**Low**	**Reasonable** Available information is adequate.	Not Applicable

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk C	Residual Risk L	Residual Risk RR	Confidence Level	Matters of NES
Leaks and Spills							
Nearshore leaks and spills							
	Degradation of marine water and sediment quality.	Design: A DMP approved MOPP will be implemented and relevant personnel will be trained in accordance with the MOPP. Design: The following measures will be used during drilling activities to reduce the risk of a subsea blowout: • Provision of numerous primary and secondary barriers (subsea safety valves, Production Master Valve, Swab Valve, Tree Cup, Production Shutdown Valve, Production Wing Valve, etc) • Well bore stability modelling for reservoir and overburden formations • Specific and approved controls for work-over or re-entry operations.	2	4	**Medium**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	Not Applicable
Offshore leaks and spills.							
	Degradation of marine water and sediment quality.	Design: A DMP approved MOPP will be implemented and relevant personnel will be trained in accordance with the MOPP. Design: The following measures will be used during drilling activities to reduce the risk of a subsea blowout: • Provision of numerous primary and secondary barriers (subsea safety valves, Production Master Valve, Swab Valve, Tree Cup, Production Shutdown Valve, Production Wing Valve, etc) • Well bore stability modelling for reservoir and overburden formations • Specific and approved controls for work-over or re-entry operations.	3	4	**Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	Not Applicable
Additive Effects							
All construction and production activities							
	The sum of all potential Project-attributable impacts from all Project phases and aspects.	See above for proposed management/mitigation measures. *NB: The risk ranking for Additive Effects is determined by the highest risk ranking for the water and sediment quality section.*	4	1	**High**	**Low** No modelling conducted on additive effects.	Not Applicable

8.2.8 Predicted Environmental Outcome

Short-term exceedences of the ANZECC/ARMCANZ (2000) guidelines for nearshore water quality during dredging and construction are expected. Short-term exceedences of turbidity will occur while dredge equipment is in operation, with the dredger acting as a point source of turbidity as it works across the dredge area. The dredgers will generate a variable spatial degree of turbidity in the water column that will persist during, and for a short period (at most days) after, dredging activities at a particular section of the dredge area. Construction-related exceedences of turbidity may persist during, and possibly for a few hours after, dredging activity. No long-term exceedences of the ANZECC/ARMCANZ (2000) guidelines are anticipated.

An increase in the amount of nitrogen and phosphorus in the water, resulting from the discharge of various streams of waste water at a nearshore outfall is anticipated. However, the anticipated increase offshore should be minimal given the high natural background cycling of nutrients in the open ocean (Holloway *et al*. 1985). The nearshore discharge outfall pipe is proposed to be located in 5 m of water on the PLF. These waters are flushed regularly and it is unlikely that significant eutrophication will occur in the coastal waters.

Remaining water and sediment quality parameters are anticipated to remain close to background levels, outside of the designated mixing zones, and in accordance with the proposed LEPs (Figure 8.25).

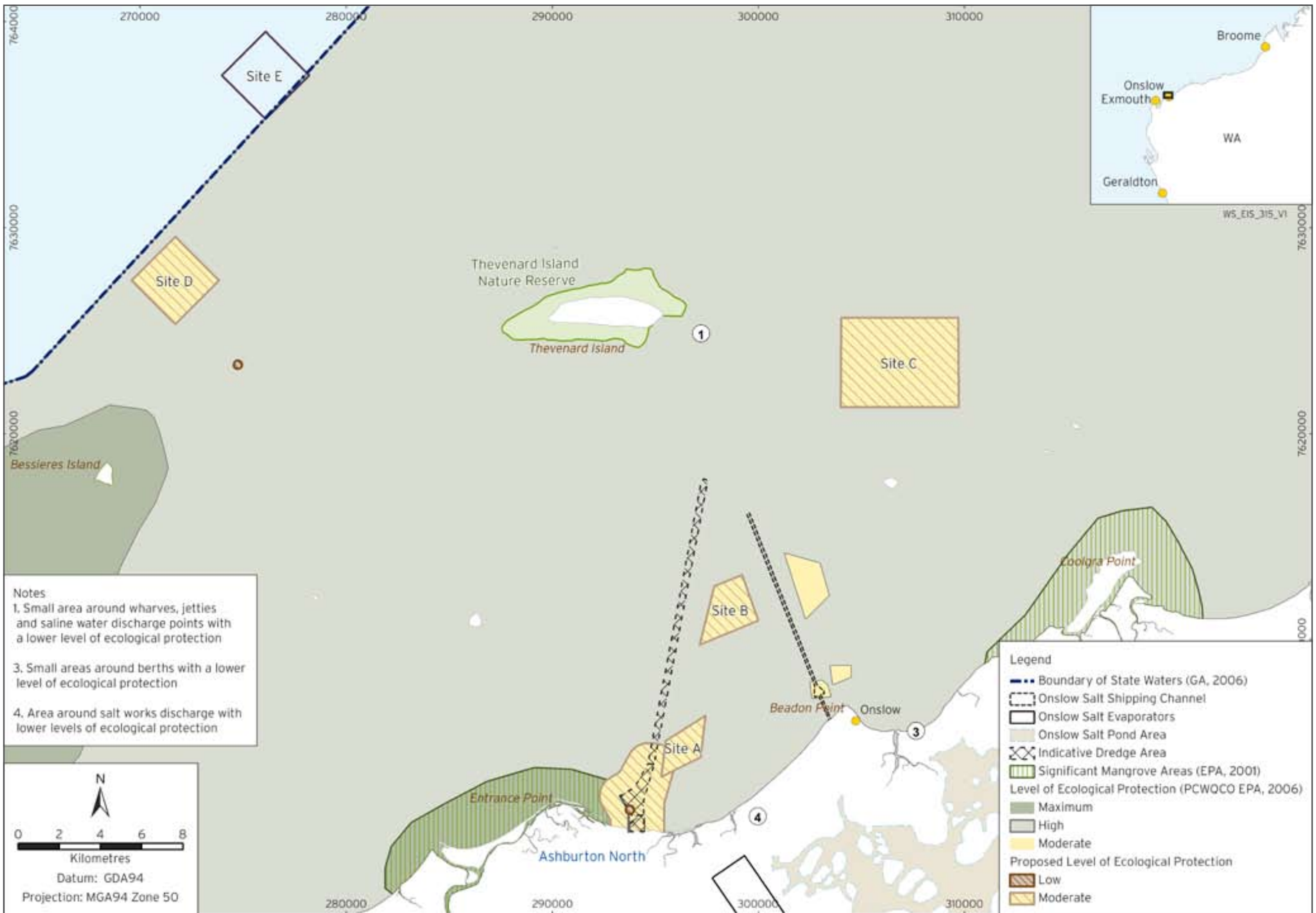


Figure 8.25: Proposed LEP Boundaries

Areas around the PLF and the MOF will be subject to ongoing disturbance and may be unable retain the requirements necessary to sustain a high LEP. Similar areas around the Onslow Salt jetty and berth, and the Woodside LNG and condensate jetties in Mermaid Sound, have been allocated a moderate LEP by the PCWQCO (DEC 2006) and it is anticipated that similar adjustments to LEP at spatially designated areas will result from the Project. It is proposed that a Moderate LEP be assigned to four of the five proposed marine dredge material placement sites (A to D), which are located in State Waters (Site E is located on the boundary, outside of State Waters). It is proposed that a Moderate LEP be assigned to the waters within a 1 km radius of nearshore infrastructure of the Project. It is proposed that a Low LEP be assigned to the waters within a 200 m radius of the two discharge outfall locations (Figure 8.17), within which the mixing zone will occur. It should be noted that the outfall locations are indicative at present.

The aspects described above have the potential to impact marine water and sediment quality in an additive manner. The conservative additive residual environmental risk to marine water and sediment quality as a result of Project-attributable impacts was assessed as being "High" – of "Moderate" consequence, arising from the combined effects of construction dredging, dredge material placement, installation of the trunkline, discharges to the marine environment and potential leaks or spills of hydrocarbons, and "Almost Certain" likelihood.

A CEMP (Appendix U1) and a DSDMP (Appendix S1) will be developed and finalised prior to the commencement of Project construction. These Plans will, in part, provide a high level indication of how impacts to water and sediment quality will be managed. Additionally, they will specify the management and mitigation measures which will be implemented to limit Project-attributable impacts to marine water and sediment quality. A DSDMP for the installation of the trunkline may also be developed, prior to construction occurring.

Proposed Operational Marine Water and Sediment Quality Management OBCs have been developed for water and sediment quality, and are presented in Chapter 12, *Environmental Management Program*.

The CEMP (Appendix U1), the DSDMP (Appendix S1) and the OBCs should be read in conjunction with the summary management measures and residual risk table above (Table 8.18) for a complete understanding of potential management and mitigation measures under consideration for the Project.

8.3 Benthic Habitats

The following sections present an assessment of potential direct and indirect impacts on marine benthic habitats, and in particular Benthic Primary Producer Habitat (BPPH) arising from construction and operation of the Project, taking into account mitigation and management methods applied to reduce the scale of impacts.

8.3.1 Management Objective

The management objectives, established by the EPA and the Commonwealth Government, for the protection of benthic habitats are to maintain:

- The integrity, ecological functions, and environmental values of the seabed and coast
- The abundance, biodiversity, geographic distribution and productivity of marine fauna and flora at species and ecosystem levels through the avoidance of adverse impacts and improvement in knowledge.

8.3.2 Description of Factor

The baseline characteristics of the receiving marine environment that describe the marine benthic habitats which occur within the Project area were assessed through the studies described in Chapter 6, *Overview of Existing Environment*. Sources of data included:

- Intertidal Habitats of the Onslow Coastline (URS 2009f, Appendix N11)
- Survey of Intertidal Fauna on the Islands off Onslow, Western Australia (URS 2009g, Appendix N10)
- Survey of Subtidal Habitat Off Onslow, WA (URS 2009e, Appendix N12)
- Wheatstone Project 20-70m Contour Habitat Survey Field Report WA (URS 2010m, Appendix N6)
- Deepwater Habitat Survey (URS 2009d, Appendix N9)
- Baseline Coral Community Descriptions (URS 2010n, Appendix N7).

Marine benthic habitats are defined as areas on the seabed, below the highest astronomical tide (HAT), that support living organisms and are key determinates that affect the distribution and abundance of BPP and associated marine fauna. Marine benthic habitats are generally regarded as key functional drivers of biodiversity and productivity at an ecosystem level. The EPA categorise BPPH as "*functional ecological communities that inhabit the seabed within which algae (e.g. macroalgae, turf and benthic microalgae),*

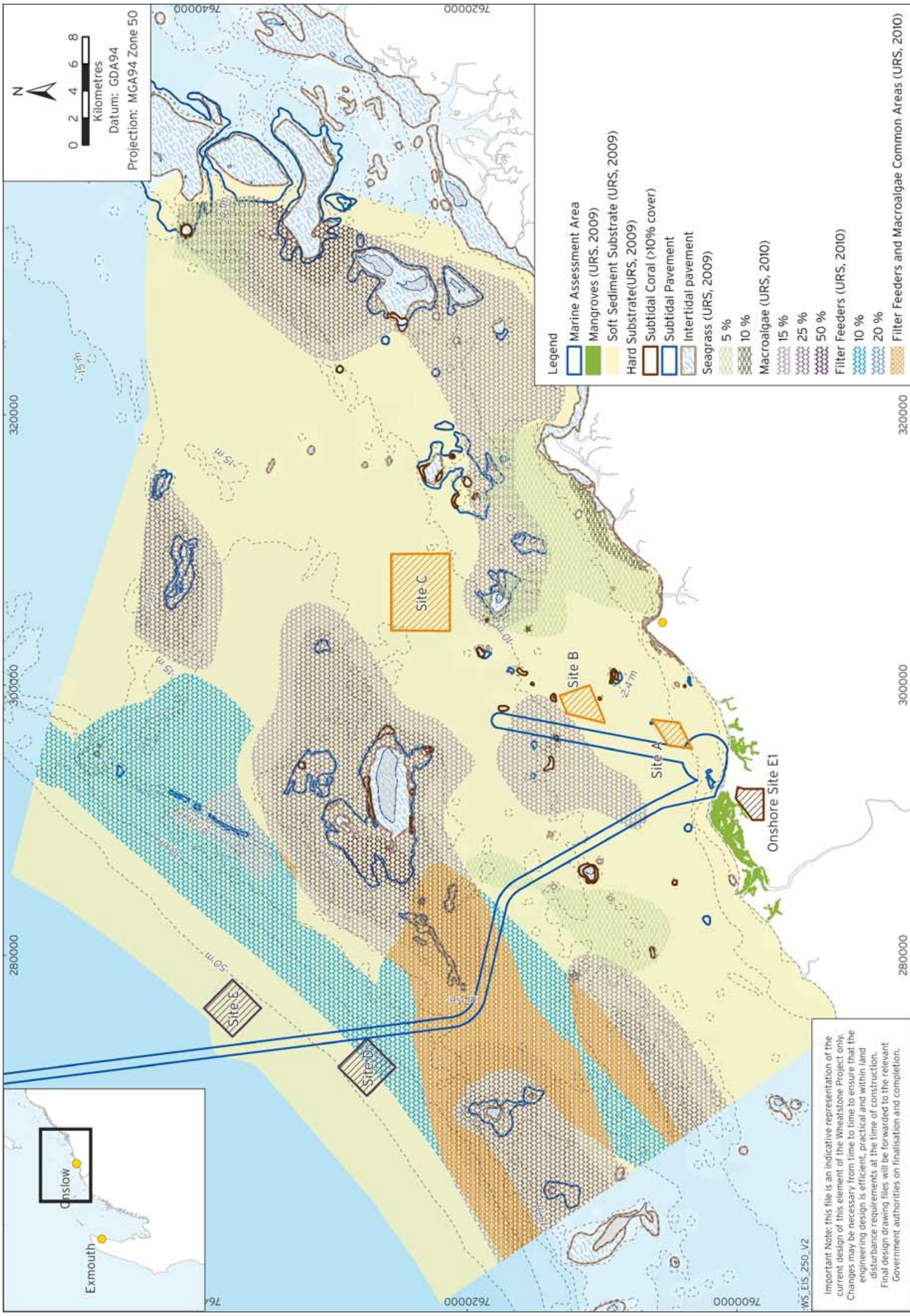


Figure 8.26: BPPH Distribution Map

seagrass, mangroves, corals or mixtures of these groups are prominent components. BPPH also include areas of seabed that can support these communities" (EPA 2009).

The distribution of marine benthic habitats in the Project area is illustrated in Chapter 6, *Overview of Existing Environment*. Figure 8.26 presents a map which shows the distribution of key BPPH types within the Project area.

8.3.3 Assessment Framework

The key environmental guidance document for assessing the acceptability of impact, and its ecological significance, to marine benthic environments in WA State waters is the EAG 3 (EPA 2009d). Guidance may also be provided by the EPA's *Guidance for the Assessment of Environmental Factors. Guidance Statement for protection of tropical arid zone mangroves along the Pilbara coastline. No. 1.* (GS 1; EPA 2001). A summary of these guidelines and their application is provided in the following sections.

8.3.3.1 Environmental Assessment Guideline No. 3

EAG 3 sets out "*a framework to impart clarity and consistency to the environmental impact of proposals that have potential to result in irreversible loss of, or serious damage to, BPPH in WA's marine environment*". Loss refers to "*direct removal or destruction of BPPH. It is considered to be irreversible and the term is intended to apply to BPPH which have been so severely modified that they are most unlikely to recover to pre-impact state*". Damage is defined as "*Significant alteration to the structure or function of a community or habitat. Damage is considered serious if the timeframe for full recovery is expected to be longer than five years.*"

"*The framework is underpinned by a set of overarching environmental protection principles, which are set out below. The EPA expects all proponents of proposals for which loss of and/or serious damage to BPPH is a relevant factor to demonstrate application of the impact avoidance and minimisation principles as well as how best practice has been incorporated into Project formulation and management before any quantitative appraisal of cumulative residual losses are made.*"

The EPA has provided a risk-based spatial assessment framework in Section 5 of EAG 3 for evaluating cumulative irreversible loss of and/or serious damage to BPPH. The cumulative loss value for the EIA of a proposal is the sum of proposed and historic loss/serious damage for each different BPPH within a defined sub-ecosystem scale area termed a "local assessment unit" (LAU).

Application of this spatial framework is based around six categories of marine ecological protection and corresponding quantitative Cumulative Loss Guidelines (CLGs) for BPPH that apply to each category (Table 8.19). CLGs are percentage values against which the calculated cumulative loss for each different BPPH is evaluated. These will be applied only after proponents can demonstrate to the EPA that all practicable options to reduce damage/loss of BPPH have been considered.

The EPA has developed the following overarching environmental protection principles aimed at protecting BPPH:

1) *All proponents should demonstrate consideration of options to avoid damage/loss of BPPH, by providing the rationale for selection of the preferred site and broad Project design for example.*
2) *Where avoidance of BPPH is not possible, then design should aim to minimise damage/loss of BPPH (e.g. through iterative design and demonstrable application of Principle 3 below). Proponents will be required to justify that design in terms of operational needs and environmental constraints of the site.*

Table 8.19: CLGs for Benthic Primary Producer Habitat within Defined Local Assessment Unit Area

Category	Description	CLG (% of original BPPH within a defined Loss Assessment Unit area)
A	Extremely special areas	0 per cent
B	High protection areas other than above	1 per cent
C	Other designated areas	2 per cent
D	Non-designated areas	5 per cent
E	Development areas	10 per cent
F	Areas where cumulative loss thresholds have been significantly exceeded	0 net damage/loss (+Offsets)

3) *Proponents will need to demonstrate "best practicable" design, construction methods and environmental management aimed at minimising further damage/ loss of BPPH through indirect impacts and maximising potential for recovery.*
4) *The EPA's judgement on environmental acceptability with respect to damage/loss of BPPH and the risk to ecological integrity will be based primarily on its consideration of the proponent's application of Principles 1 to 3 and calculations of cumulative loss of each BPPH type within a defined local assessment unit, together with supporting ecological information, and expert advice, as required.*

In addition to this assessment framework, the EPA will judge a proposal based on the Proponents' adherence to the overarching assessment principles and the overall risk to the ecological integrity of the local assessment units.

The risk-based framework presented in EAG 3 for assessing any implication for BPPH ecosystem integrity sets out several steps. The first step is the definition of LAUs for the purposes of applying EAG 3. As set out by the EPA, the LAU needs to be a geographical area which provides the most effective boundaries for the management of cumulative environmental impacts on ecological values and functions. The second step is to demonstrate how impacts have been reduced, and how they will be managed. The third step is to determine the cumulative loss of each BPPH within the LAU, and the final step is to seek a judgement on the acceptability of the proposal from the EPA.

BPPH Ecosystem Boundaries and LAUs

BPPH is restricted in distribution to the photic zone which in this region is mostly the nearshore waters <40 m CD. The aspect of the Project with the greatest potential for causing loss or damage to BPPH is the dredging impact associated with construction of the PLF, navigation channel and MOF, including associated dredge material placement activities; and trenching and stabilisation of the trunkline. Section 8.2.5.1 provides a high level description of the dredging program, dredge area, dredge material placement sites and trunkline construction options. Results of modelling of potential dredge plumes are also presented in Section 8.2.5.1. The potential impact on BPPH in the Project area occurs in the shallow shelf waters and covers an area which extends approximately 70 km along the coast and about 50 km offshore.

The CSIRO's hierarchical ecosystem classification framework as used by IMCRA (2006) and further developed by Lyne *et al*. (2006) for the NWS, has been applied to the Project area to derive four mesoscale Ecosystem Units (ECU) each with common characteristics of water quality and depth and distance offshore. The ECUs encompass a total area of 3500 km^2 (Figure 8.27) and are defined as follows:

- ECU0—Onslow onshore encompassing intertidal habitats between Highest Astronomical Tide (HAT) and LAT.
- ECU1—Onslow nearshore encompassing waters between LAT and down to 10 m below CD in relatively complex bathymetry covering mainly soft substrates, supporting seagrasses in some areas, and a ridge of scattered patch shoals which support corals and sponges.
- ECU2—Onslow offshore encompassing waters between 10–20 m CD 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 m to 70 m CD.

A number of smaller LAUs based on definable bio-geomorphic attributes and the distribution of various types of BPPH have been nested within each of the larger ECUs. Figure 8.28 presents each LAU used to assess BPPH losses of the proposed Project. A detailed justification of the boundaries proposed for the LAUs is presented in (URS 2009h, Appendix N5) together with a third-party review of the methodology and framework by Prof Sheppard. Each LAU that occurs within the mesoscale ECUs shown in Figure 8.27 is defined below in terms of the principal BPPH they contain and the boundary area for assessment.

Onslow Onshore (ECU 0)

- LAU0A Onslow Salt: the mangroves and associated samphire flats and algal mats which occur between Coolgra Point and Beadon Creek - (the intertidal region extensively modified by the Onslow solar salt field).
- LAU0B Hooley Creek: the mangroves and associated samphire flats and algal mats which occur between Four Mile Creek and Hooley Creek (the intertidal area immediately to the east of the Project area and containing some of the onshore infrastructure).
- LAU0C Ashburton River: the mangroves and associated samphire flats of the Ashburton River Delta (adjacent the Project area to the west).

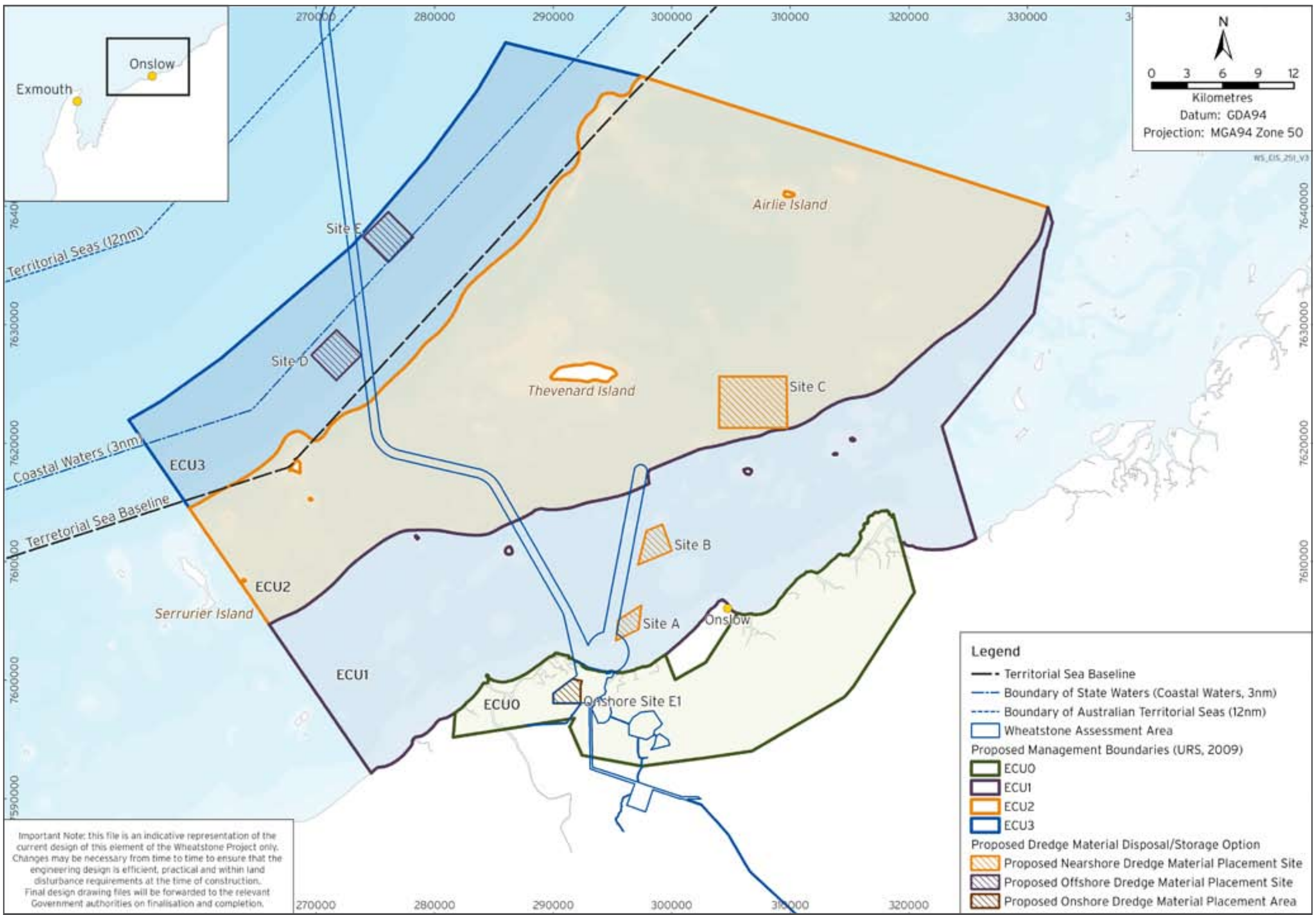


Figure 8.27: Proposed Ecosystem Unit Boundaries For BPPH Loss Assessment

Onslow Nearshore (ECU1)

- LAU1A Corals east of channel: all coral communities occurring within ECU1 to the east of the channel (NB: the envelope of this LAU and LAU 1B is only meant to indicate the coral areas—shown in red—which have been included in the coral area calculation. All other seafloor within these LAUs which is not coral has been included as soft substrate in either LAU 1C or 1D below).
- LAU1B Corals west of channel: all coral communities occurring within ECU1 to the west of the channel.
- LAU1C Sediments east of channel: all soft sandy substrates supporting low abundance ephemeral seagrasses and/or ephemeral foliose brown algae which occur east of the channel within the ECU1 boundary.
- LAU1D Sediments west of channel: all soft sandy substrates supporting low abundance ephemeral seagrasses and/or ephemeral foliose brown algae which occur west of the channel within the ECU1 boundary.

Onslow Offshore Unit (ECU2)

- LAU2A Thevenard Island: the hard substrate shoals surrounding Thevenard Island and the coral, sponge and macroalgal communities that they support.
- LAU2B Bessieres Island: the hard substrate shoals surrounding Bessieres Island and the coral, sponge and macroalgal communities that they support.
- LAU2C Airlie Island: the hard substrate shoals surrounding Airlie Island and the coral, sponge and macroalgal communities that they support.
- LAU2D Filter feeders west of channel: the sand veneered limestone pavement that supports sponge/ascidian filter feeders and occurs to the west of Thevenard Island.
- LAU2E Filter feeders east of channel: the sand veneered limestone pavement that supports sponge/ascidian filter feeders and occurs to the east of the navigation channel in the vicinity of Rosily Shoals.

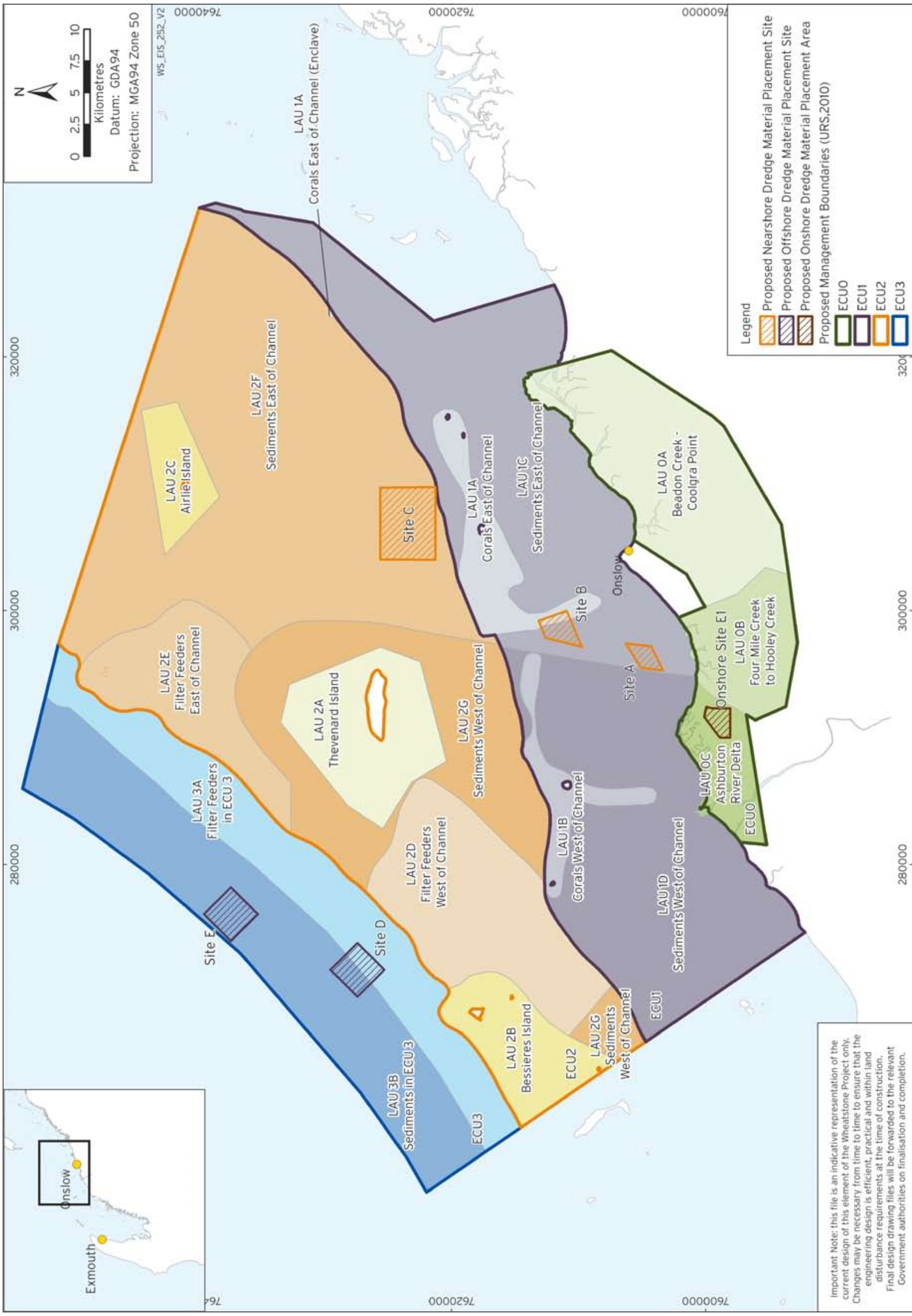


Figure 8.28: Proposed Management Boundaries And Local Assessment Units For BPPH Loss Assessment

- LAU2F Sediments east of channel: all sand/gravel substrates supporting low abundance ephemeral seagrasses and/or ephemeral foliose brown algae which occur east of the navigation channel within the ECU2 boundary.
- LAU2G Sediments west of channel: all sand/gravel substrates supporting low abundance ephemeral seagrasses and/or ephemeral foliose brown algae which occur west of the channel within the ECU2 boundary.

Inner Shelf (ECU3)

- LAU3A Filter feeders in ECU3: the variable filter feeding communities (sponge, sea whips, hydroids and sea fans) that inhabit the pavement and sand veneered pavement which occurs between 20 and 40 m CD.
- LAU3B Sediments in ECU3: the soft substrates that occur below 40 m CD and support burrowing infauna and a red microalgal mat.

Historical Loss of BPPH in Project Area

Figure 8.29 shows the location of historical and proposed areas of seafloor disturbance in the Project area. Anthropogenic activities that have potentially caused damage or loss of BPPH in the Project area to date include commercial prawn trawling in the nearshore waters of the Project area, and the development of the Onslow Salt evaporation and crystallisation ponds on tidal flats. A channel has been dredged for the export of salt from Onslow Salt Loading Terminal and the dredged material has been relocated to two dredged material placement sites immediately to the east of the channel. A small number of petroleum production platforms have been installed in the nearshore waters adjacent to Thevenard Island and are connected to both the Island and the mainland via a number of buried hydrocarbon trunklines.

The potential impacts to BPPH from prawn trawling in the Project area are difficult to estimate as a result of the sparse documentation available. The Department of Fisheries (DoF) (DoF 2003) documents the occurrence of a relatively small prawn trawling fishery, however it is suggested that minor habitat modification has resulted from this activity. DoF applied to the then Commonwealth Department of Environment and Heritage (DEH) for the OPMF to be certified as being managed in an environmentally sustainable manner. The detailed application assessed the impact of the fishery on seagrasses as negligible based on three factors:

- Most seagrass meadows are in areas that are closed to trawling
- Most trawlers actively avoid trawling near seagrass areas as rolls of broken off seagrass get caught in the mouth of the cod end, causing the net to stop fishing and for the prawns already caught in the net to become entangled and difficult to release
- The introduction of Bycatch Reduction Devices and Fish Exclusion Devices will further encourage trawlers to avoid seagrass areas since the grid component for both of the devices is highly susceptible to clogging by seagrass balls.

Based on the above assessment, and given the ephemeral nature of the seagrasses which occur in this region, no attempt has been made to assess historical seagrass loss due to trawling.

The next largest area of historical disturbance of BPPH is the development of the Onslow Salt ponds, export jetty and shipping channel. The channel and dredge material placement sites were developed in the early 1990s and are located in soft substrate habitat which has since been recolonised by organisms typically found in similar habitats (URS 2009e, Appendix N12). The salt ponds have removed approximately 190 ha of algal mats from the high tidal flats of both the Beadon Creek and the Hooley Creek LAU. This represents approximately 20 per cent of the available algal mat habitat in both LAUs. There has been very little loss of mangrove habitat within the region. Losses that have occurred are restricted to Beadon Creek and include the loss of approximately 1 ha in the vicinity of the solar ponds intake and another 1 to 2 ha on the south side of Beadon Creek where the wharf and boat ramp have been developed. There is currently no documentation of loss of corals as a result of anthropogenic activity in the Project area to date. Further detail on historic losses of subtidal BPPH is provided in URS (2009h) and in later sections of this Chapter (Section 0) for intertidal BPPH.

Summary of BPPH Irreversible Loss

A range of temporary impacts will occur to various BPPH during the construction and operation of the Project, from which rapid recovery is anticipated. As expected, the permanent "irreversible" losses of BPPH are localised to the near vicinity of the Project. While the assessment of BPPH loss is presented in the following sections, a summary of the predicted scale of irreversible loss of BPPH arising from the Project is presented in the following sections.

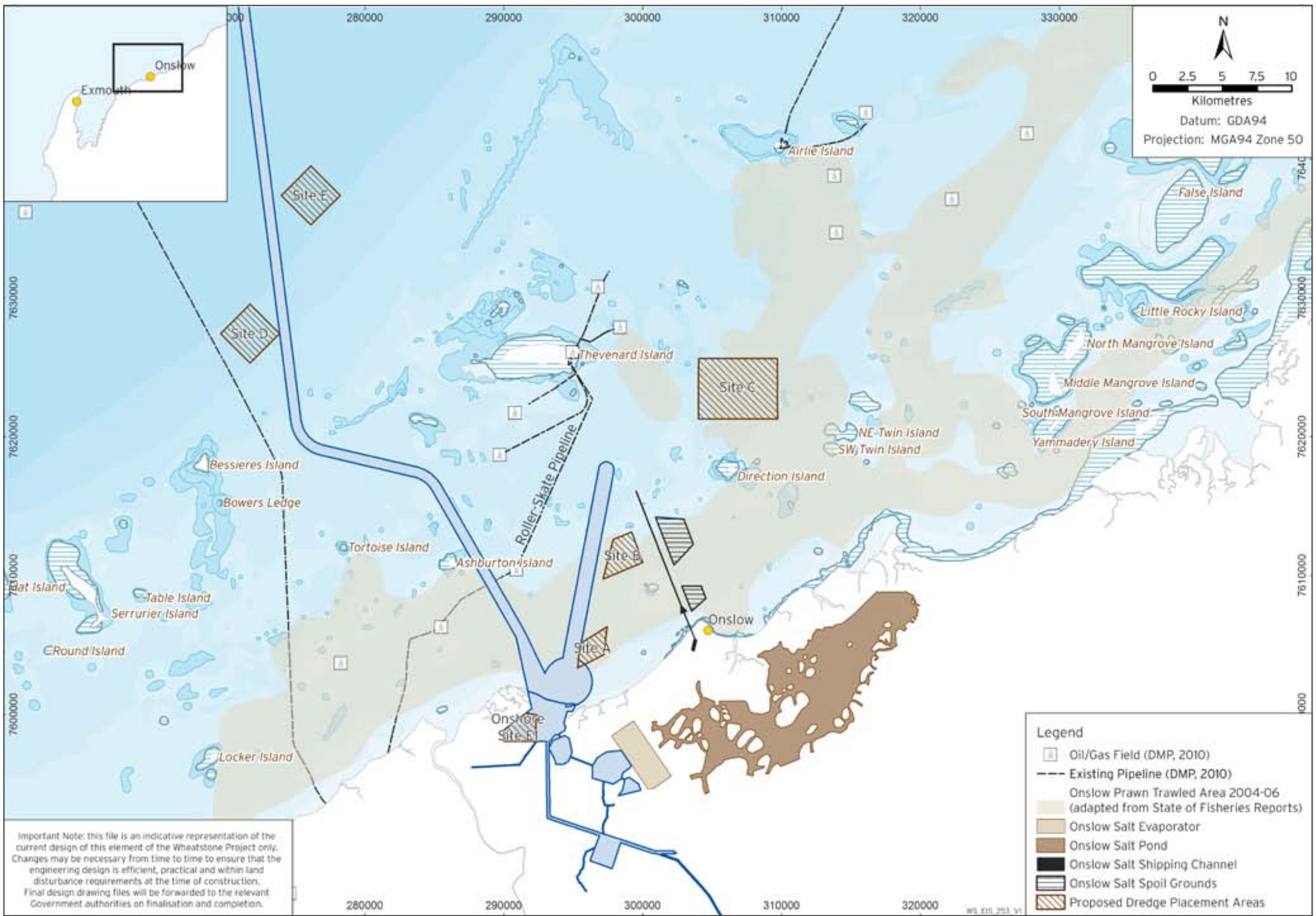


Figure 8.29: Existing and Proposed Areas of Seafloor Disturbance in the Project Area

ECU 0 – Onslow Onshore

Hooley Creek: Moderate loss of mangrove habitat (six per cent) and substantial (17 to 24 per cent) cumulative loss of samphire/bioturbated mud habitat, and algal mats arising from proposed placement of onshore infrastructure. The losses of samphire and algal mat habitat exceeds the EPA CLG of ten per cent.

Ashburton River Delta: No adverse long-term habitat loss is anticipated for the Ashburton River Delta mangrove ecosystem from installation of the trunkline shore crossing, and no adverse indirect impacts to Ashburton River Delta mangroves are anticipated from the operation of the LNG plant over the long term. Subsequent trenching of future trunklines (should this occur) may cause disturbance which will exceed applicable EPA guidelines for this habitat. In addition, condensate spills at the PLF are considered a rare event, however pose a very high risk of serious damage to mangroves in the delta should it occur. Mitigation actions will be inserted into the MOPP to manage this risk.

ECU 1 – Onslow Nearshore

Loss of coral habitat both to the east and west of the channel arising from implementation of an optimised dredging plan is not anticipated to exceed the EPA CLG of ten per cent. Coral shoals that may be seriously damaged include Saladin, End-of-Channel, north-west of Ward Reef, and the small shoal nearshore west of Beadon Point. Some form of dredging management will be required to manage the risk of adverse impacts to Paroo Shoal and Hastings Shoal. Coral reefs which surround Direction, Tortoise and Ashburton Islands are not at risk.

Temporary and seasonal damage of seagrasses is anticipated during the dredging program but no long-term loss is anticipated from the region. Similarly, there will be a temporary reduction in abundance and biomass of foliose macroalgae in the vicinity of the channel. No permanent long-term reduction is anticipated, excluding the dredge area of the proposed navigation channel (approximately 250 ha).

It is predicted that permanent modification of soft substrate habitat will occur within the proposed nearshore infrastructure area (proposed navigation channel, MOF, PLF; approximately 1378 ha). This is considered to be a minor loss of substrate given its wide-spread availability throughout the region and one which contains no significant BPPH.

ECU 2 – Onslow Offshore

No short- or long-term adverse impacts are anticipated on the corals of Thevenard, Airlie and Direction islands.

Trunkline trenching and subsequent rock stabilisation (using preferred method) will seriously damage approximately 100 ha of filter-feeder habitat which occurs between Thevenard and Bessieres islands.

Modelling of the contingency worst-case trunkline installation technique using a CSD to cut approximately 2.4 Mm^3 of soil and load it onto barges for placement at Placement Site C indicates that only filter feeder habitat is likely to be lost for a period exceeding 5 years. The area of filter feeder BPPH loss/serious damage anticipated is almost 2000 ha which represents 10.6 per cent of LAU2D.

ECU 3 – Inner Shelf

The contingency worst-case trunkline installation technique if implemented will seriously damage approximately 1077 ha of filter feeder habitat which represents approximately 5.4 per cent of LAU 3A.

No long-term irreversible loss of BPPH is anticipated from LAU 3B.

Table 8.20 summarises the irreversible BPPH losses anticipated as a result of the activities assessed in this Chapter. Reversible damage to seagrass and macroalgae are not included.

8.3.3.2 Guidance Statement No. 1

The EPA's GS 1 (EPA 2001) identifies areas of arid zone mangroves as being of high conservational significance. It also sets out the EPA's expectations for the protection of mangroves, while recognising current and potential future development areas. The guidelines are based on Semeniuk (1997), which identifies areas of regionally significant mangrove formations by establishing environmental values, namely:

- Ecological reasons pertaining to productivity, feeding grounds and fish nurseries
- Scientific reasons of heritage, research and education
- Preservation of biodiversity.

Pilbara mangrove classification can be based on a number of criteria that address significance. Significance may be international, national or regional and is dependent on:

- The extent or rarity of the habitat
- The internal diversity of the habitat
- The ecological significance of a given stand
- The nationally or internationally significant features of a given site.

The five criteria below were used by Semeniuk (1997) to select "Category A" (i.e. high conservation) areas and key features of selected areas were assessed with respect to the following criteria:

- Representation of a coastal type and its accompanying mangroves
- Globally unique mangrove habitats and their assemblages
- Scientifically explicit mangrove/habitat relationships
- Clear and distinct examples of mangrove assemblages floristically
- Clear and distinct examples of mangrove assemblages structurally.

GS 1 describes four types of mangrove management areas and has developed guidelines for each. The mangrove management areas are:

- Guideline 1: Regionally significant mangroves - Outside designated industrial areas and associated port areas
- Guideline 2: Other mangrove areas - Outside designated industrial areas and associated port areas
- Guideline 3: Regionally significant mangroves - Inside designated industrial areas and associated port areas
- Guideline 4: Other mangrove areas - Inside designated industrial areas and associated port areas.

The Ashburton River Delta mangroves are identified as being "regionally significant" (Guideline 1) and are therefore considered to have a high conservation value. The EPA's operational objective for Guideline 1 areas is that no development should take place that would adversely affect the mangrove habitat, the ecological function of the area and the maintenance of ecological processes which sustain the mangrove habitats. The EPA therefore recommends that these areas have the highest degree of protection with respect to geographical distribution, biodiversity, productivity and ecological function. Additionally, the Ashburton River Delta was assessed as satisfying criteria one and four of the "Category A" area criteria.

Table 8.20: Anticipated Irreversible BPPH Losses as a Result of Activities

ECU	LAU	Activity	Samphire zone		Algal mats		Mangroves		Seagrass		Macroalgae		Corals		Filter feeders	
		Units	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha
0	0A	Onshore Infrastructure	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-	-	-
	0B		17.0	110.0	24.0	241.0	6.0	5.0	-	-	-	-	-	-	-	-
	0C		0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-	-	-
1	1A	Dredging	-	-	-	-	-	-	-	-	-	-	6.8	14.0	-	-
	1B		-	-	-	-	-	-	-	-	-	-	3.0	4.0	-	-
	1C		-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1D		-	-	-	-	-	-	-	-	2.0	250	-	-	-	-
2	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2D	Preferred Trunkline Installation method	-	-	-	-	-	-	-	-	-	-	-	-	0.4	70.0
	2D	Contingency trunkline Installation method	-	-	-	-	-	-	-						10.6	1958.0
	2E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2G		-	-	-	-	-	-	-	-	-				-	-
3	3A	Preferred trunkline Installation method													0.1	30.0
	3A	Contingency trunkline Installation method	-	-	-	-	-	-	-	-	-	-	-	-	5.4	1077.0
	3B	-	-	-	-	-	-	-	-	-	-	-	-		-	-

The Hooley Creek – Four Mile Creek system is classified by GS 1 as being governed by Guideline 4 (all other mangroves occurring inside designated industrial areas, associated ports or other development and not covered by Guideline 3). The EPA's operational objective for Guideline 4 areas is that the impacts of development on mangrove habitat and ecological function of the mangroves in these areas should be reduced to the minimum practicable level.

8.3.4 Consequence Definitions

To enable the assessment of risks associated with the Project, specific consequence definitions have been developed. Table 8.21 provides the consequence definitions that have been used in the risk assessment of BPPH.

8.3.5 Impact Assessment and Management

Impacts to BPPH will occur to some extent as a result of Project activities. The following sections summarise the aspects and activities that may directly and indirectly affect BPPH in, and surrounding, the Project area. Chapter 7, *Impact Assessment and Methodology* contains the risk matrix used to assess the likelihood and consequence of the impacts occurring. The potential impacts and the management measures to be implemented to be implemented are discussed in detail. Table 8.37 in Section 8.3.7 provides a summary of the potential impacts, management and mitigation measures and residual risk to BPPH as a result of Project activities. The aspects which are considered in this section include:

- Construction of onshore infrastructure (LNG plant)
- Construction of nearshore infrastructure (MOF, PLF)
- Installation of trunkline and shore crossing
- Construction dredging
- Maintenance dredging
- Placement of dredge material offshore
- Placement of dredge material onshore
- Wastewater discharge.

In addition, the adjacent mangrove habitats of Ashburton River Delta and Hooley Creek may potentially be affected by the following indirect impacts of operation of the LNG plant, should effective mitigation measures not be implemented:

- Atmospheric and dust emissions
- Noise and vibration emissions
- Light emissions
- Contaminated run-off drainage water
- Hydrocarbon leaks and spills
- Seepage and alteration of water table due to the placement of dredge material onshore
- Altered river flood plain drainage.

Several baseline assessments were undertaken to document the BPPH of the Project area. These studies comprised field surveys to map the distribution BPPH in the Project area and characterise their biotic components, and field surveys to determine in detail, the ecosystem value of sensitive BPPH considered likely to be disturbed by the Project (URS 2010m, Appendix N6; URS 2010n, Appendix N7; URS 2010o, Appendix N8; URS 2009d, Appendix N9; URS 2009f, Appendix N11; URS 2009e, Appendix N12; URS 2010k, Appendix N13; URS 2010c, Appendix N15).

Impact modelling and impact assessment was also undertaken to determine the likely impact of the Project on BPPH. These studies included:

- A detailed assessment of potential direct and indirect impacts to the mangroves of the Ashburton River Delta (URS 2010b, Appendix N4).
- Preparation of a report to select and justify the proposed LAU boundaries and to determine historical losses of BPPH within various LAUs to date (URS 2009h, Appendix N5).
- Development and validation of a mathematical model to simulate the suspended sediments likely to be released by dredging and dredge material placement activities (DHI 2010a, Appendix Q1).
- Review of literature and development of tolerance limits for corals and seagrasses to suspended sediments in water and sedimentation (DHI 2009a; DHI 2010d, Appendix N3).
- Modelling of a wide range of both realistic and conservative "worst case" dredging and dredge material placement scenarios to develop indicative zones of impact (IZI), effect and influence (DHI 2010c, Appendix N2).
- Calculation of cumulative losses of BPPH based on an assessment of the most realistic, conservative scenarios applicable to each activity. This involved overlaying the impact zones onto maps of BPPH distribution and the LAU boundaries (URS 2010, Appendix N1). .

Table 8.21: Consequence Definitions for BPPH

Marine						
	1	2	3	4	5	6
	Catastrophic	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
BPPH	• Reversible, but long-term localised loss of >50% of BPPH in all categories • Irreversible localised loss of > 30% of BPPH in categories D and E (Non-designated and Development Areas) • Irreversible localised loss of >10% of BPPH in Extremely Special, Development Areas where cumulative loss threshold (CLG) already exceeded, and Marine Protected Areas (MPAs) Ecosystem highly modified and integrity adversely affected • Conservation values of MPAs reduced	• Irreversible loss of BPPH >100% in excess of EPA CLG for all categories • Conservation values of MPAs seriously threatened	• Reversible, but long-term (>10 years) localised loss of BPPH • Irreversible loss of BPPH exceeding EPA CLG for all categories • Conservation values of MPAs at risk	• Reversible, short-term (5 years) localised loss of BPPH • Irreversible loss of BPPH close to but not exceeding EPA CLG for all categories except A and F (Extremely Special Areas and Development Areas where CLG already exceeded)	• Localised seasonal (<1 year) decrease in productivity of BPPH • Small irreversible loss of BPPH but well within EPA CLG for all categories except A and F (Extremely Special Areas and Development Areas where CLG already exceeded)	• Localised seasonal decrease in productivity of BPPH during short term • No irreversible loss of BPPH

Long-term: *>10 years (2x construction period) |* ***Short-term:*** *<5 years (construction period + commissioning) |* ***Seasonal:*** *<1 year |* ***Local:*** *Within BPPH Management Unit |* ***Regional:*** *Outside BPPH Management Unit within IMCRA Pilbara bioregion*

The following sections summarise the scale of anticipated BPPH loss/damage in and surrounding the Project area as a result of the above construction and operation phase activities. It also summarises the management measures to be implemented to reduce the scale of adverse impacts.

The Readers guide to Section 8.3 (Table 8.22) defines key terms used during the BPPH loss assessment and draws the reader's attention to the fact that alternative scenarios for some construction activities have been assessed.

Table 8.22: Readers Guide to Section 8.3

Definitions
Key definitions used in this section:

Term	Definition
Loss	Direct removal or destruction of BPPH. Considered to be irreversible
Damage	Alteration to the structure or function of a community
Serious damage	Timeframe for full recovery is expected to be longer than five years
Minor damage	Timeframe for full recovery is expected to be less than five years

Alternative impact assessments for Dredging and Trunkline shore crossing

Section 8.3 provides alternative impact assessments for two activities: dredging and the trunkline shore crossing. This is done to compare the environmental implications for both alternatives, which are still being assessed in terms of their engineering feasibility.

Dredging

A non-optimised and optimised dredge impact assessment is presented. The optimised dredge scenario includes the use of restricted-over flow zones in targeted areas of the proposed navigation channel to limit impacts to BPPH. Both scenarios are described fully in Section 8.2 and the results in terms of BPPH loss described in this section. In summary, the optimised scenario results in much less BPPH loss and thus is the preferred case upon which impact assessment has been based.

Trunkline shore crossing

The two alternatives for shoreline crossing of the trunkline are trenching and microtunnelling. Microtunnelling is the preferred option from an environmental perspective, but the engineering feasibility of this approach is still under investigation and not yet proven. For this reason, an assessment of both options is presented.

8.3.5.1 Direct Losses to Subtidal BPPH arising from Nearshore Infrastructure

Residual risk to benthic habitats (direct loss) from nearshore infrastructure is	**Low**
Residual risk to benthic habitats (direct loss) from placement of dredge material at marine sites is	**Low**

Components of the nearshore infrastructure include:

- The dredged basins for the MOF and PLF and their associated approach channels
- The dredge material placement sites
- The MOF breakwaters and wharves
- The PLF
- The trunkline.

Figure 8.30 presents the optimised layout for the MOF, PLF and shipping channel overlaid on a finer scale version of the BPPH distribution map presented in Figure 8.26. Figure 8.26 shows the location of the trunkline and offshore dredge material placement sites in relation to BPPH distribution.

Table 8.23 presents the area of soft substrate lost and/ or modified by each Project component. In interpreting this table it should be understood that installation of the infrastructure components will permanently modify existing habitats by the addition of new structures and modifying the depth of water locally.

Components of nearshore infrastructure (MOF, PLF and channels) are located in soft sediment substrates. This habitat type is wide-spread throughout the Pilbara nearshore and offshore bioregion (URS 2009d, Appendix N9; URS 2009e, Appendix N12). An area of subtidal pavement occurs to the immediate west of the PLF.

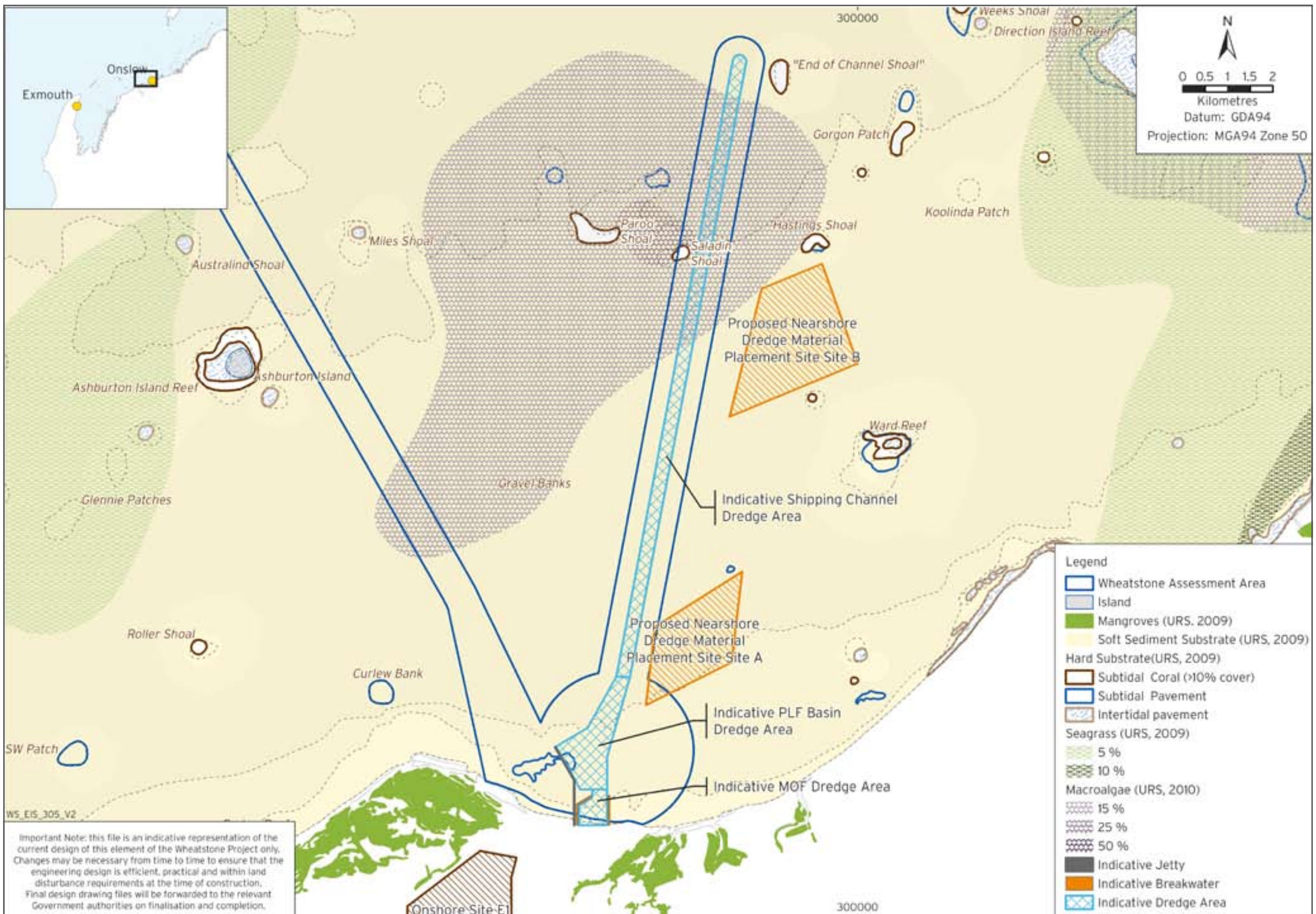


Figure 8.30: Nearshore Infrastructure Components Overlaid on BPPH Distribution

Table 8.23: Area of Soft Substrate Habitat Modified as a Result of Nearshore Infrastructure and Dredge Material Placement

Nearshore Infrastructure Component	Modification Area (ha)
MOF breakwaters and basin PLF and basin MOF approach channel	42 173 12
PLF access channel	421
Placement site A*	337
Placement site B*	533
Placement site C*	2473
Placement site D*	900
Placement site E*	900
Total	**5791**

** This is the maximum extent of the modification and it is highly unlikely that the entire area will be modified.*

This structure appears to be a relict shoreline. It has been inspected at five locations and found to be largely sand veneered pavement with a low cover (<ten per cent) of scattered sea whips and fans (URS 2009e). Given its low cover of macrobiota and predominantly sand substrate, it has been classified as soft substrate.

Saladin Shoal is located approximately 5 km west of the end of the PLF channel. It supports moderate to high cover of corals, sponges and macroalgae. The approach channel alignment has been selected to reduce impacts to this shoal and will pass within 500 m of it. End-of-Channel Shoal occurs just outside the northern end of the channel and supports a moderate to high cover of corals. The outer end of the channel also passes through an area of approximately 250 ha of soft substrate which supports a low cover of the green algae *Enteromorpha* sp. and brown foliose macroalgae.

The nearshore dredge material placement sites A, B and C have all been located over soft substrate seabed which does not support significant BPPH. The offshore placement site D is located partly over soft sediments which support a red microalgal mat, and partly over filter feeder habitat (Figure 8.26). The contingency offshore placement site E is located over soft sediments which support a red microalgal mat (Figure 8.26). Both offshore placement sites are 900 ha, however the volume of material proposed for placement at Site D is relatively small and will consist of trunkline trenching material and fine sediments from channel clean-up activities. Hence the actual area of habitat loss that will occur is difficult to estimate, but likely to be small.

The trunkline route alignment has been selected to avoid hard substrate, including that supporting coral communities. The nearest coral community to the trunkline route is that at Ashburton Island located approximately 1 km to the west. It is currently anticipated that the trunkline will require mechanical trenching or excavation and backfill with engineered fill between water depths of approximately 10 m to 40 m – a distance of approximately 35 km which extends from the Roller-Skate trunkline (Figure 8.29) to the start of the shelf break offshore. Installation of the trunkline between the shore and 40 m depth will disturb an approximately 50 m wide belt of seabed, of which the actual trench and side slopes will constitute 25 m. However engineered backfill will be confined to the trench area only, which will be approximately 5 m wide at the base.

Figure 8.26 shows that most of buried section of the trunkline passes through unvegetated sediment, macroalgae and filter feeder habitat (sponges, fans and whips), but a small section will traverse through an area where denser seagrass patches have been recorded. The area of BPPH habitat disturbance has been calculated to be:

- Macroalgae / Filter feeder habitat 100 ha (20 km x 50 m)
- Seagrass habitat 10 ha (2 km x 50 m).

The seagrass habitat loss is considered to be temporary and reversible within 5 years because this section of the trunkline will be covered by sand which is likely to be recolonised. While it is expected that rock armoured parts of the trunkline will eventually be colonised by a wide range of encrusting organisms including soft and hard corals, algae, sponges and ascidians as well as a wide variety of important reef fish species, for the purposes of this assessment it has been assumed that recovery of filter feeder habitat will not occur within 5 years. The trunkline route between the Roller-Skate pipeline and the shore traverses areas not supporting significant BPPH.

Only the MOF breakwaters, basin and the navigation channel are predicted to be permanent "loss" of habitat to the marine environment. The dredge material placement sites are expected to recolonise over time, with low density macroalgae and seagrass evident at a dredge material placement site for the nearby Onslow salt channel (URS 2009e, Appendix N12) and documentation of recovery from natural disturbance (Williams 1988). Of the total Project component area, approximately 250 ha of macroalgae BPPH is predicted to be permanently lost as a result of channel dredging.

Therefore direct losses (as defined in EAG 3) of subtidal BPPH arising from the placement of nearshore infrastructure are estimated to be:

- 250 ha of macroalgae habitat within the outer end of the channel
- 100 ha of macroalgae and filter feeder habitat within the outer part of the trunkline corridor.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that the placement of nearshore infrastructure will result in impacts to subtidal BPPH. The residual environmental risk for this potential impact was assessed as being "Low" – of "Negligible" consequence, arising from irreversible loss of BPPH, and of "Likely" occurrence.

8.3.5.2 Potential Indirect Losses of BPPH Arising from Construction Dredging and Placement of Dredge Material at Marine Sites

Residual risk to benthic habitats (indirect loss) from construction dredging is	**High**
Residual risk to benthic habitats (indirect loss) from placement of dredge material at marine sites is	**Medium**

An indicative dredging and dredge material placement works program is described in Section 8.2.5.1, which also includes an assessment of potential impacts of this activity on water quality. The assessment of dredging induced water quality impacts on BPPH described here follows on from that assessment and uses plume modelling results to derive impact zones. These impact zones are defined in the Tolerance Limits Report (DHI 2010d, Appendix N3) and are based on advice received from the Office of the EPA (OEPA) (R Tregonning [OEPA] 2009, pers. comm.). They are developed by applying a range of sensitive receptor tolerance limits to the impact classification categories (Table 8.24) and using these to assess the plume modelling outputs. Numerical sediment plume models predict "excess" SSC, which is the additional SSC generated by the dredging-related activities that are being assessed, and which does not include background SSC. This allows the segregation and assessment of the impacts due to the dredging-related activities, and the testing and implementation of specific mitigation measures to reduce those impacts.

Table 8.24: Impact Classification Categories

Zone	Definitions
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 Partial Mortality	An area within which key receptors are predicted to suffer partial mortality (up to 50 percent loss close to the channel and <1 per-cent 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 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.
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 and placement.

Excessive turbidity and sedimentation can degrade BPPH (coral reefs and seagrass meadows in particular) at local scales (e.g. Cabaco *et al*. 2008, Cooper *et al*. 2007, Erftemeijer & Lewis 2006, Fabricius 2005, Fabricius *et al*. 2007, Gilmour *et al*. 2006 see review in Appendix N3). The main potential impact pathways are light reduction and/or abrasion due to elevated suspended sediments concentrations in the water column, and smothering due to increased sedimentation rates.

To develop the tolerance limits an extensive literature review was conducted to summarise the current understanding of the tolerances of relevant receptors to the impacts of suspended sediments, reduced light and sedimentation. Receptors investigated were corals, filter feeders (sponges and sea fans), seagrasses, macroalgae, and mangroves.

The findings of the literature review were compared with limits set for previous dredging projects in WA, as well as limits previously developed by DHI for major dredging and reclamation projects in South East Asia, in order to develop end receptor tolerance limits for the Project (DHI 2010d Appendix N3). The limits were specifically developed to capture the complex relationship between the intensity, duration and frequency of exposure to suspended sediments. In line with good EIA practice, a conservative approach was taken in setting the tolerance limits, basing the limits on the most sensitive benthic species recorded in the Project area, and ensuring that the limits were comparable to or lower than limits that have been used for previous WA dredging projects. Justification for this is provided in DHI (2009a, Appendix N3), which also notes the following:

- Mangroves can be classified as highly tolerant to the magnitude of sedimentation and suspended sediments typically generated from dredging activities
- Seagrass and macroalgae can be considered as moderately tolerant, with a relatively short recovery time
- Coral reefs and benthic filter feeder communities are quite sensitive to suspended sediment and sedimentation loading, and their recovery from impacts is unlikely to be rapid.

Therefore, coral reef and benthic filter feeder communities were assessed as being the most sensitive habitats in the Project area with regard to indirect impacts from the proposed dredging activities. The coral tolerance limits were also used as a proxy indicator for filter feeders. Overall, the literature indicates that the tolerance limits of filter feeders would be equal to, or more tolerant than, the most sensitive coral species (DHI 2009a, Appendix N3). A similar approach was taken for macroalgae, using the seagrass tolerance limits as a proxy indicator for macroalgae.

Table 8.25: SSC Impact Zones on Corals in Offshore Waters for all Seasons (summer, winter and transitional) and Nearshore Waters during Transitional Periods

Zone*	Suspended Sediment Impact Thresholds
Zone of Total Mortality	Excess SSC > 25 mg/L for more than 10% of the time; OR Excess SSC > 10 mg/L for more than 25% of the time
Zone of Partial Mortality	Excess SSC > 25 mg/L for 2.5-10% of the time; OR Excess SSC > 10 mg/L for 10-25% of the time; OR Excess SSC > 5 mg/L for more than 25% of the time
Zone of Influence	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

**Where location meets criteria for multiple zones, highest zone applies*

The proposed suspended sediment tolerance limits for corals are shown in Table 8.25 and Table 8.26. Seasonal tolerance limits were established for corals and seagrasses in nearshore shallow (<5 m) waters of ECU 1. Seasonal is defined here as summer, winter and a transitional period. Water quality information from the area, presented in Chapter 6, *Overview of Existing Environment*, and MODIS Figures in Section 8.2, indicates that these shallow nearshore waters are naturally more turbid than deeper waters further offshore. This is primarily as a result of strong spring tide and wave resuspension of fine seafloor sediments and catchment run-off in nearshore waters. The proposed sedimentation tolerance limits for corals are presented in Table 8.27 and Table 8.28.

Table 8.26: SSC Impact Zones on Corals, in Nearshore Waters (within 5 m isobath) during Summer and Winter Periods Only

Zone*	Suspended Sediment Impact Thresholds
Zone of Total Mortality	Excess SSC > 25 mg/L for more than 20% of the time
Zone of Partial Mortality	Excess SSC > 25 mg/L for 5-20% of the time; OR Excess SSC > 10 mg/L for more 20% of the time; OR Excess SSC > 5 mg/L for more than 50% of the time
Zone of Influence	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

** Where location meets criteria for multiple zones, highest zone applies*

Table 8.27: Sedimentation Impact Zones on Corals for Offshore Waters during All Seasons, and for Nearshore Waters during Transitional Periods

Zones	Sedimentation Impact Thresholds
Zone of Total Mortality	Sedimentation >0.2 kg/m^2/day (>7.0 mm/14day*)
Zone of Partial Mortality	Sedimentation 0.05-0.2 kg/m^2/day (1.7-7.0 mm/14day*)
Zone of Influence	Sedimentation 0.01-0.05 kg/m^2/day (0.3-1.7 mm/14day*)
No Impact	Sedimentation <0.01 kg/m^2/day (<0.3 mm/14day*)

** assuming an initial deposition dry density of 400 kg/m^3*

Table 8.28: Sedimentation Impact Zones on Corals for Nearshore Waters during Summer and Winter Periods

Zones	Sedimentation Impact Thresholds
Zone of Total Mortality	Sedimentation >0.5 kg/m^2/day (>17.5 mm/14day*)
Zone of Partial Mortality	Sedimentation 0.1-0.5 kg/m^2/day (3.5-17.5 mm/14day*)
Zone of Influence	Sedimentation 0.025-0.1 kg/m^2/day (0.9-3.5 mm/14day*)
No Impact	Sedimentation <0.025 kg/m^2/day (<0.9 mm/14day*)

** assuming an initial deposition dry density of 400 kg/m^3*

Dredging Program Indicative Zones of Impact

The short-term scenario dredge plume modelling approach adopted by DHI for this assessment (presented in Section 8.2) provides an overview of the range of dredging activities. This has enabled assessment of a large number of climatic and dredging scenarios at a suitably high spatial resolution. This has also enabled the assessment of optimising dredge methodology to reduce potential impacts to BPPH. Manual interpolation across the small gaps between the scenarios enables determination of Indicative Zones of Impacts (IZI) for the full dredging period. DHI has used this approach to develop IZIs for seagrass and corals, based on exceedence of the SSC tolerance limits and sedimentation for corals and seagrasses (Figure 8.31). These IZIs represent the maximum areas of impact arising from the use of conservative but realistic assumptions in dredging operations. It is apparent that the zone of influence extends for many kilometres in a NE and SW direction in the nearshore waters (Figure 8.31). In addition, the zone of partial mortality is significantly smaller (Figure 8.31). This figure relates to the non-optimised scenarios (1 – 7). Differences between non-optimised and optimised dredge scenarios are described fully in Section 8.2.5.1. Briefly, the optimised scenario includes restricted overflow zones to limit the spatial extent of the turbidity plume. In reality the application of the restricted overflow will be determined by the risk to sensitive receptors prior to the dredging program.

BPPH Loss/Damage Assessment Non-Optimised

Calculation of the percentage BPPH loss/damage within LAUs involves the overlay of IZIs on both the BPPH distribution map and the LAU boundaries.

Corals and filter feeders

Figure 8.32 shows the non-optimised dredging (Described in Section 8.2.5.1) IZIs arising from exceedence of coral SSC (top) and sedimentation (bottom) tolerance limits overlaid on the distribution of corals and filter feeders in the Project area. This figure shows that:

- The IZI for partial mortality and influence arising from exceedence of SSC tolerance limits are generally larger than those arising from exceedence of sedimentation tolerance limits. In particular, the partial impact zone for SSC covers more coral shoals than does the partial impact zone for sedimentation impacts
- The total mortality zone arising from sedimentation is wider than that arising from excess SSC
- Filter feeder habitats are not predicted to suffer mortality from exposure to either excess SSC or sedimentation
- None of the regionally significant coral communities which occur around the offshore islands (i.e. Thevenard, Ashburton, Direction, Mangrove) are within the partial impact zone (although the zone boundary does come close to Ashburton Island)
- No coral communities occur within the total mortality impact zone
- A high number of coral shoals occur within the partial mortality zones including Ward Reef, Weeks Shoal, Gorgon Patch and the shoal to the south-west, Paroo Shoals and Hastings Shoal, and a small shoal west of Beadon Point.

Seagrass and macroalgae

Figure 8.33 shows the non-optimised dredging (scenario 1-7) impact zones arising from exceedence of seagrass SSC (top) and sedimentation (bottom) tolerance limits overlaid on the distribution of seagrasses and macroalgae in the Project area. This figure shows that:

- No dense seagrass areas occur within the total mortality zone but that a large portion of the dense seagrass areas which occur to the east of Onslow fall within the partial mortality zone arising from exceedence of SSC tolerance limits. This zone also impacts some of the seagrass areas located to the west of Ashburton Island
- The area of dense macroalgae which occurs adjacent the outer end of the channel falls largely within the partial impact zone arising from exceedence of SSC tolerance limits
- None of the large areas of macroalgae which occur adjacent the offshore islands and the Mangrove Island chain are predicted to be impacted.

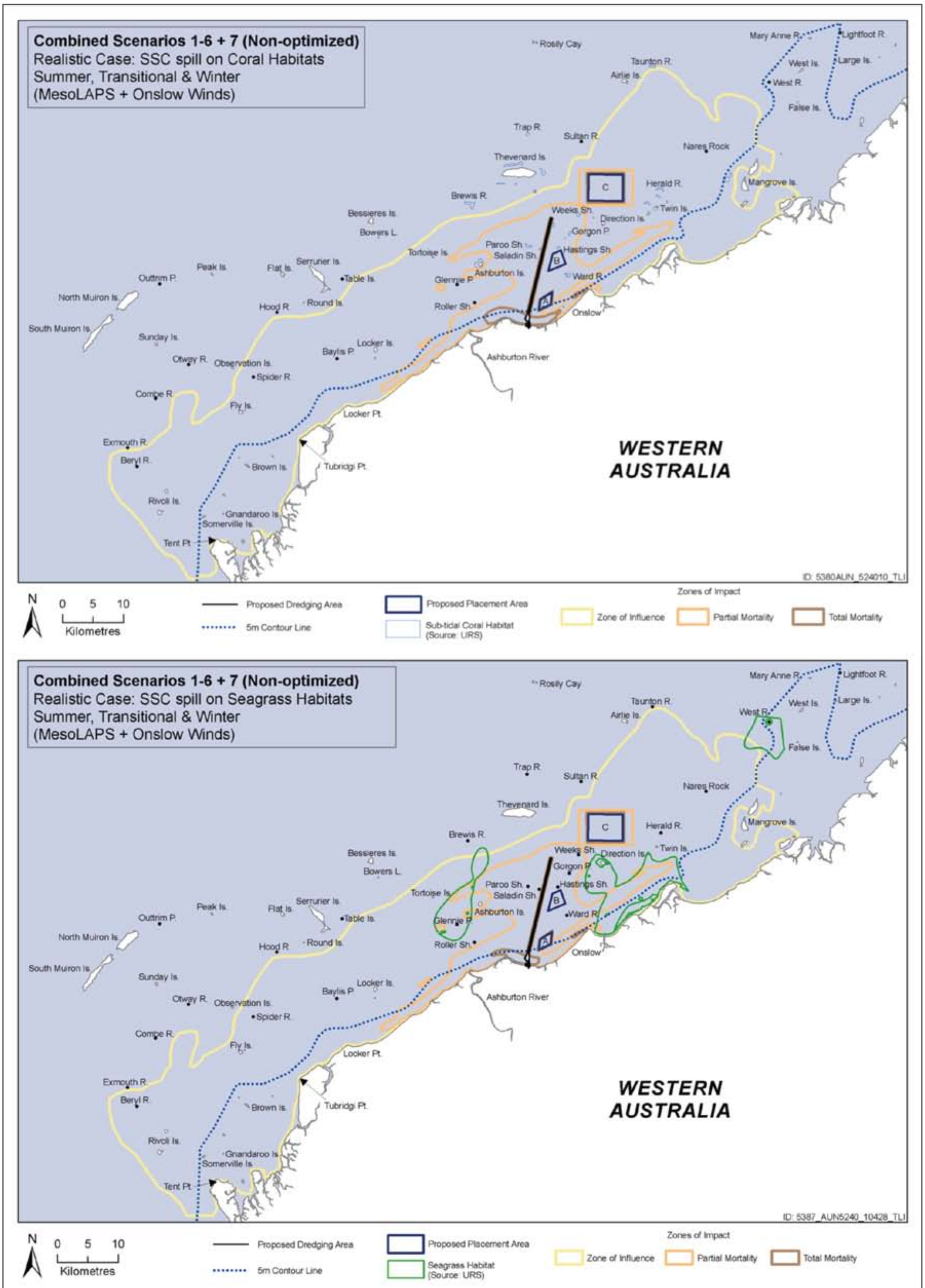


Figure 8.31: All Seasons Non-Optimised IZI for SSC Tolerance Limits on Coral (top) and Seagrass (bottom) Habitats

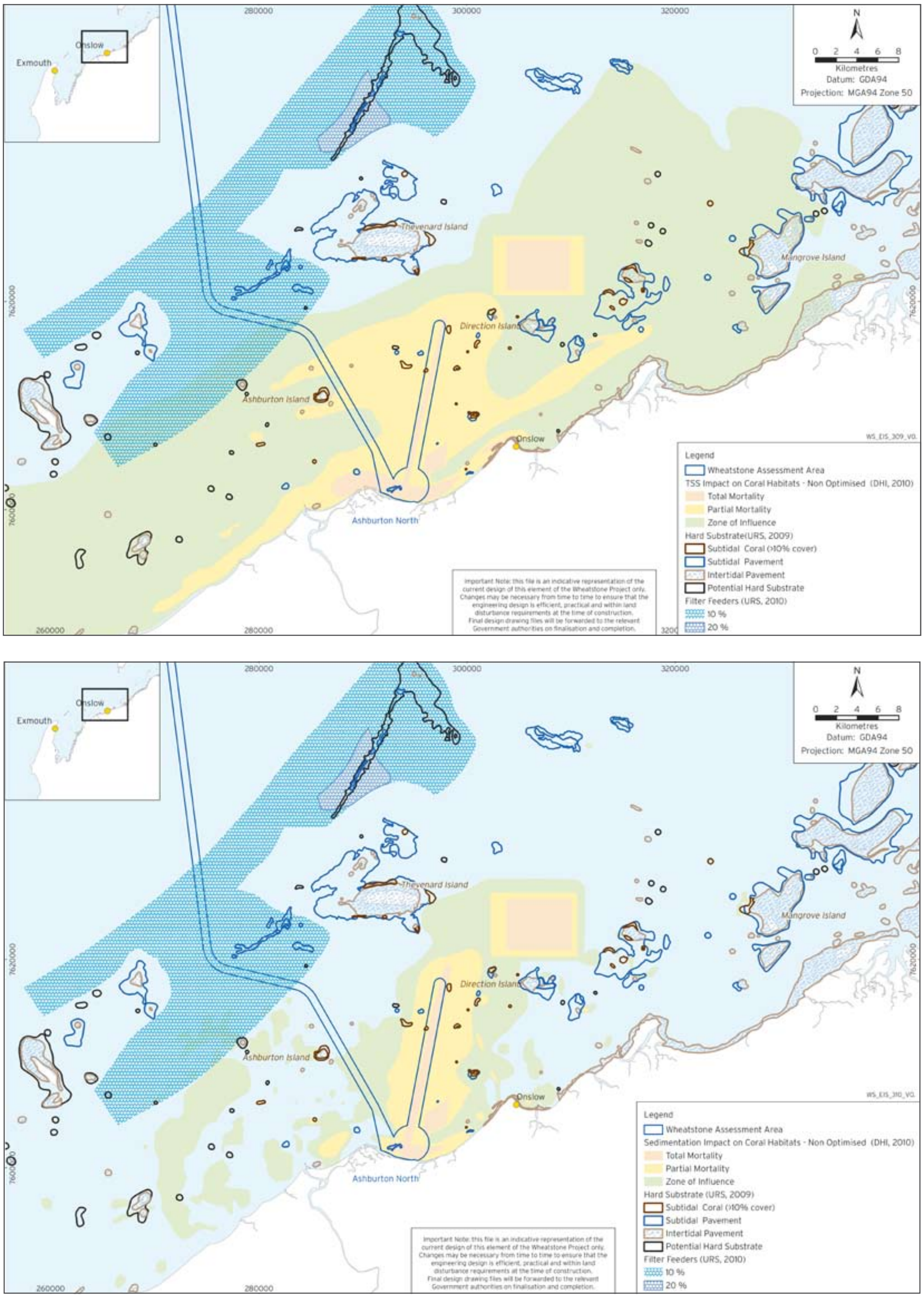


Figure 8.32: Scenario 1-7: Non-Optimised IZIs Arising from Exceedence of Coral SSC (top) and Sedimentation (bottom) Tolerance Limits Overlain on Distribution of Coral and Filter Feeder Habitats

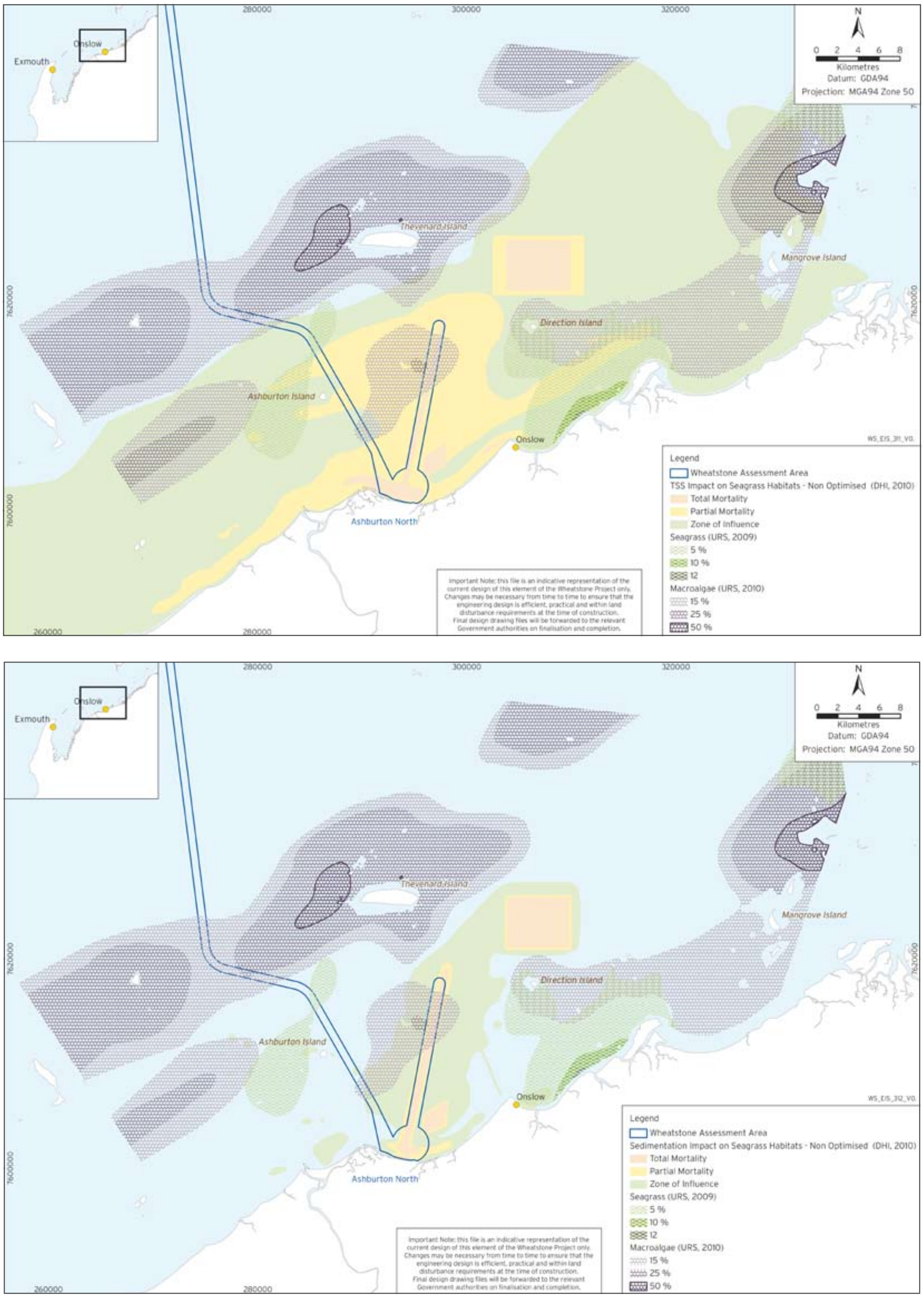


Figure 8.33: Scenario 1-7: Non-optimised IZIs Arising from Exceedence of Seagrass SSC (top) and Sedimentation (bottom) Tolerance Limits Overlain on Distribution of Seagrass and Macroalgae Habitats

Summary of loss/damage

Table 8.29 presents only the LAUs which fall within the IZIs of total and partial mortality, their total habitat area, the predicted area of habitat loss/damage, and the percentage it represents of the total habitat area within the LAU. Only the LAUs within ECU 1 and those at risk in ECU 2 are included. Most of the ECU 2 and ECU 3 LAUs are not considered at risk from this dredge program. It is predicted that sedimentation impacts will be restricted to the immediate vicinity of the channel and placement sites and do not encroach over significant BPPH habitat. Almost all impacts in Table 8.29 have arisen only from exceedence of partial mortality SSC limits. To reflect the < 50 per cent mortality anticipated in this zone, the area of partial mortality has been subsequently divided by two to determine the percentage loss/damage within that LAU. This approach provides a conservative estimate of coral habitat loss given that the percentage of coral mortality will reduce substantially with increasing distance from the proposed navigation channel. Only the macroalgae within the channel in LAU 1D will be totally removed and has been added to half of the area of partial mortality to calculate the percentage loss/damage.

Dredging impacts to BPPH can result from both SSC and sedimentation. However, in this Section only SSC related losses are presented because sedimentation was predicted not to result in loss or damage to BPPH. Modelling suggests that sedimentation impacts will largely be restricted to areas immediately adjacent to the dredge area and placement sites, and areas characterised by unvegetated subtidal sand. This is consistent with previous dredging campaigns in the Pilbara (Stoddart & Stoddart 2005). Both SSC and sedimentation modelling outputs are presented and described. No historical losses of significant subtidal BPPH have been recorded in the subtidal Project area and the EPA ten per cent CLG is applicable to the impacted LAUs presented in Table 8.29.

The results presented in Table 8.29 show that the base case non-optimised dredging plan are predicted to result in loss/damage of 30 per cent of coral communities which occur to the east of the navigation channel and 17.5 per cent of those which occur to the west. These predicted losses are likely to be reversible in the long-term, but are considered irreversible for this impact assessment based on the five year time frame specified for recovery in EAG 3.

Table 8.29: Sub-tidal BPPH Loss/Damage Assessment Resulting from Exceedence of SSC Tolerance Limits by Non-optimised Dredging Scenarios 1-7

Local Assessment Unit Code	Biotype	Total Area (ha)	Partial Mortality (ha)	Total Mortality (ha)	Per cent Loss/ Damage
LAU 1A Corals east of channel	Corals	205	121 Ward, NW Ward, Gorgon, Weeks, Hastings, SW of Gorgon, West of Beadon Pt, End-of-Channel Shoal.	0	**30**
LAU 1B Corals west of channel	Corals	132	46 Saladin Shoal, Paroo Shoal	0	**17.5%**
LAU 1C Sediments east of channel	Seagrass	10151	2570	0	**12.6%**
	Macroalgae	11425	730	0	**3%**
LAU 1D Sediments west of channel	Seagrass	3430	260	0	**3.8%**
	Macroalgae	11239	3915	250	**19.2%**
LAU2G Sediments west of channel	Seagrass	1451	356	0	**12.3%**
	Macroalgae	2585	1291	0	**25%**

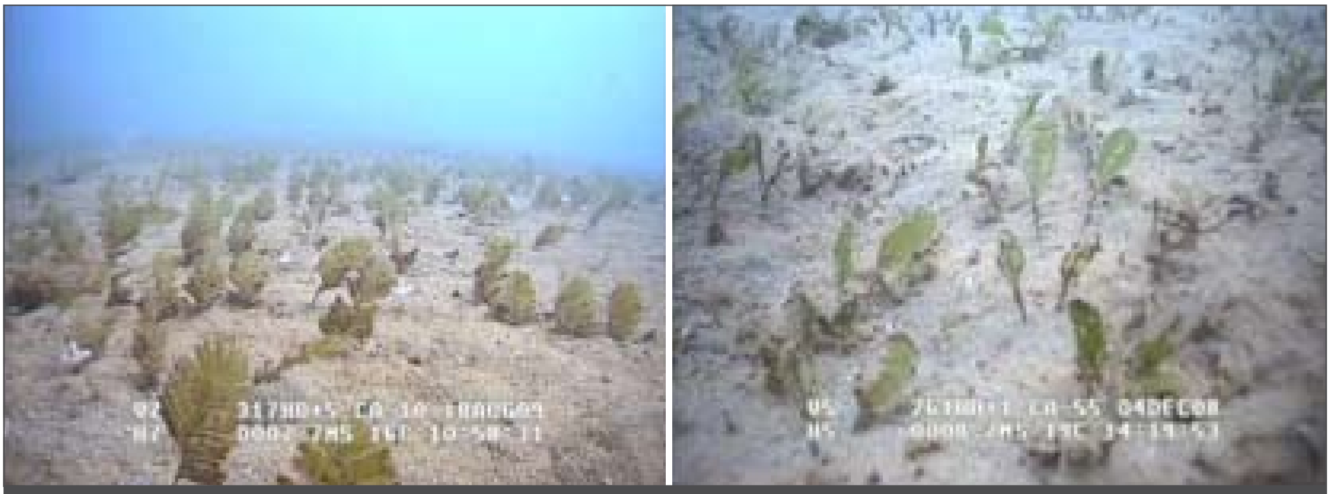
Approximately 25 per cent of seagrass habitats to the east of the navigation channel in LAU 1C may suffer up to 50 per cent reduction in abundance/biomass nearshore, resulting in damage of up to 12.6 per cent of available seagrass habitat in that area. The same scale of seagrass damage occurs to the west of the channel in LAU 2G. However, seagrass coverage in the affected area is sparse (Photograph 8.1, URS 2010c, Appendix N15). The common genus of seagrass in the Project area is *Halophila*, which is known to be an important coloniser of bare substrates in shallow waters due to its high seed output and its ability to recover rapidly after 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). Therefore, the damage predicted from Project dredging is considered temporary and reversible.

Macroalgae loss is high to the west of the channel (between 19 and 25 per cent of LAUs 1D and 2G respectively). The large area of macroalgae that occurs over soft substrates in the vicinity and to the west of the offshore end of the shipping channel in LAU 1D and 2G will suffer a substantial loss probably over the full three-year period of construction. However, it is likely that algal biomass in this area will rapidly recover once the dredging program ceases. Evidence from natural disturbance (storm events) suggests that macroalgae are capable of recovering to pre-disturbance abundance within six to eight months after the cessation of disturbance (Williams 1988). In addition, an underwater ROV survey conducted adjacent to the Onslow Salt shipping ground and dredge material placement sites found seagrass and macroalgae species present in the area that are similar to those found in adjoining areas, indicating that the species have the ability to recolonise after a disturbance. This information, in conjunction with the recruitment processes for the dominant seagrass and macroalgae species, suggests that any potential loss as a result of the Project is likely to be only temporary and will be reversible within five years.

It is recognised that highly turbid waters will prevail close to shore during the nearshore dredging campaign. Mangroves within Hooley Creek and Ashburton River Delta will be subjected to these turbid waters. Mangroves are considered to be highly tolerant to the magnitude of sedimentation and suspended sediments typically generated from dredging activities. Mangroves have adapted to inundated intertidal mudflats via use of aerial root systems called pneumatophores which rise above the mud and provide oxygen to the plant through small pores. Burial of these aerial root systems by fine marine sediments has the potential to reduce mangrove tree health, or even cause tree deaths.

Assessment of the potential for indirect impacts to mangroves from dredging related sediment deposition indicates that such impacts are unlikely given consideration of the following factors:

- Background turbidity concentrations along the Onslow coastline are high under existing conditions and the relative increase in concentrations due to dredging is limited. Mangroves in the area already cope with periods of very high turbidity during Ashburton River flood events



Photograph 8.1: Typical Seagrass Coverage in Area Recorded by ROV

- The dredge plumes are not expected to give rise to additional sedimentation at a scale that could threaten mangrove communities. A review of sediment burial of mangroves in Australia (Ellison 1998) describes the mortality of *Avicennia marina* (the dominant mangrove in the Project area) being caused by sedimentation depths of 12 to 50 cm
- Dredging activities will occur in nearshore/offshore areas and not within the mangrove fringed tidal creek systems and hence the majority of dredging related sediment mobilisation and deposition will occur in nearshore/offshore areas and not within the intertidal zone where mangroves occur. In areas of the Pilbara coast where dredging has actually occurred within mangrove fringed tidal creek systems (e.g. Port Hedland harbour) there has not been any evidence of significant indirect impacts to mangroves from dredging related sediment deposition.

Algal mats occur very close to the upper limit of the intertidal zone and receive a very low frequency of tidal inundation (i.e. they are only submerged by tides for one to three per cent of time). Therefore, the potential for dredging related sediment deposition to occur in algal mat areas is even less than that for mangroves and the risk to algal mats from this factor is negligible.

BPPH Loss/Damage Assessment – Optimised

It is clear from Table 8.29 that the predicted largest long-term impact of the base-case dredging plan will be to coral shoals which occur along the 10 m isobath. The scale of potential impact is in excess of the EPA CLG of ten per cent. To reduce the scale of impacts on the coral shoals which occur within the partial impact zone, some form of mitigation will be required particularly during summer and transitional periods, which is when most of the impacts occur.

It is proposed that two "restricted-overflow" zones be established for the dredging program to protect the coral shoals on the 10 m isobath, and to protect Ward Reef. Figure 8.34 shows the location of the recommended zones. Note that restricted overflow in these zones should only be required during specific periods when potential impacts are likely (based on monitoring results and current forecasts), as there are extended periods when impacts are not predicted to occur during dredging in these areas.

Figure 8.35 shows the all seasons IZI for SSC tolerance limits on coral (top) and seagrass (bottom) arising from modelling the optimised dredging scenario.

Figure 8.36 shows the optimised dredging (scenario 1-6+7A) impact zones arising from exceedence of coral SSC (top) and sedimentation (bottom) tolerance limits overlaid on the distribution of corals and filter feeders in the Project area. The IZI shown in this figure are the result of including the two "restricted-overflow" zones shown in Figure 8.34. Optimisation results in substantial reduction in the zone of partial mortality for corals and a minor reduction of impact on seagrasses and macroalgae. The relevant IZI for partial mortality in the optimised scenario encompasses only End-of-Channel Shoal, Saladin Shoal, the small shoal to north-west of Ward Reef, and a very small nearshore shoal halfway between the Project site and Onslow. More substantial coral communities which occur around the offshore islands (i.e. Thevenard, Ashburton, Direction, Mangrove) are not at risk under this optimised dredging plan.

Summary of Loss/Damage - Optimised

As a result of optimisation, the predicted scale of coral habitat loss/damage will reduce to the following:

- LAU 1A Corals east of channel: Small nearshore reef west of Beadon Point (2.5 ha/2) plus End-of-Channel Shoal (23 ha/2), plus northwest of Ward reef (2.5 ha/2) = 14 ha of coral habitat will be damaged, out of a total of 205 ha within the LAU = 6.8 per cent of LAU
- LAU 1B Corals west of channel: Saladin Shoal (8 ha/2) = 4 ha of coral habitat will be seriously damaged, out of a total of 132 ha within the LAU = three per cent of LAU.

It is clear that implementation of an optimised dredging plan is effective in reducing the scale of coral mortality on the shoals adjacent the navigation channel to levels that are well within the EPA CLG of 10 per cent. The BPPH loss assessment presented in Table 8.29 has been modified in Table 8.30 to reflect the predicted impacts of the optimised dredging plan.

This table now forms the basis of the BPPH loss/damage assessment for the construction dredging program proposed for the Project.

Apart from the major reduction in coral habitat damage arising from implementation of an optimised dredge plan, there is also a reduction in the scale of impacts to seagrass and macroalgae habitats to the west of the channel (LAU 1D and 2G). The scale of impacts to seagrass and macroalgae habitats to the east of the channel remains unchanged.

The mangroves and filter feeder habitats are not considered at risk from the optimised dredging program and seagrasses and macroalgae will suffer temporary damage, possibly on a seasonal basis, but are expected to recover soon after dredging ceases.

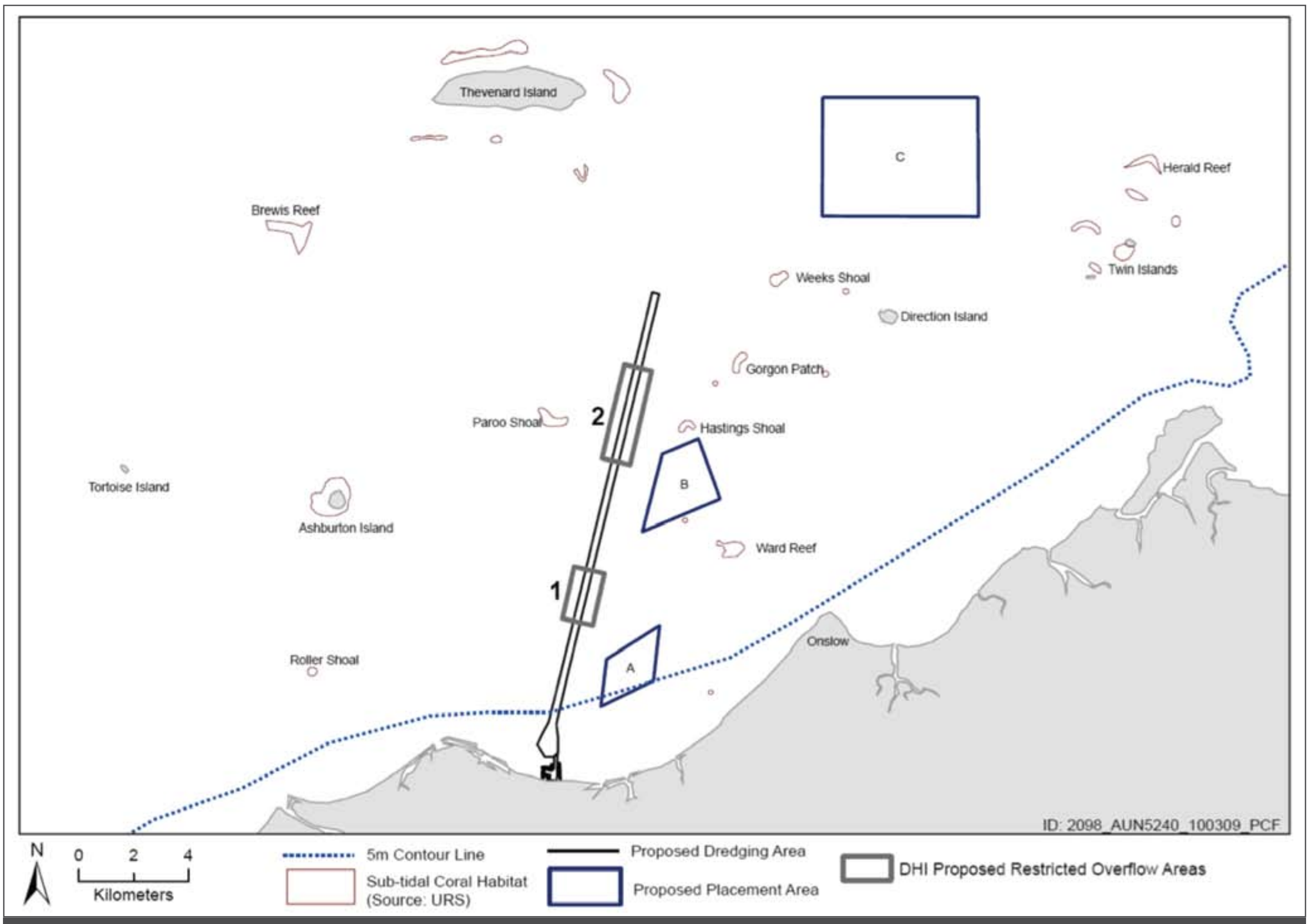


Figure 8.34: Restricted Overflow Zones 1 and 2

Table 8.30: Sub-tidal BPPH Loss/Damage Assessment Resulting from Exceedence of SSC Tolerance Limits by the Optimised Dredging Scenarios 1-6+7A

Local Assessment Unit Code	Biotype	Total Area (ha)	Partial Mortality (ha)	Total Mortality (ha)	Per cent loss/ damage
LAU 1A Corals east of channel	Corals	205	28 NW Ward, West of Beadon Pt, End-of-Channel Shoal	0	**6.8**
LAU 1B Corals west of channel	Corals	132	8 Saladin Shoal	0	**3**
LAU 1C Sediments east of channel	Seagrass	10151	2570	0	**12.6**
	Macroalgae	11425	730	0	**3**
LAU 1D Sediments west of channel	Seagrass	3430	102	0	**1.5**
	Macroalgae	11239	1234	250	**7.7**
LAU2G Sediments west of channel	Seagrass	1451	291	0	**10**
	Macroalgae	2585	1291	0	**25**

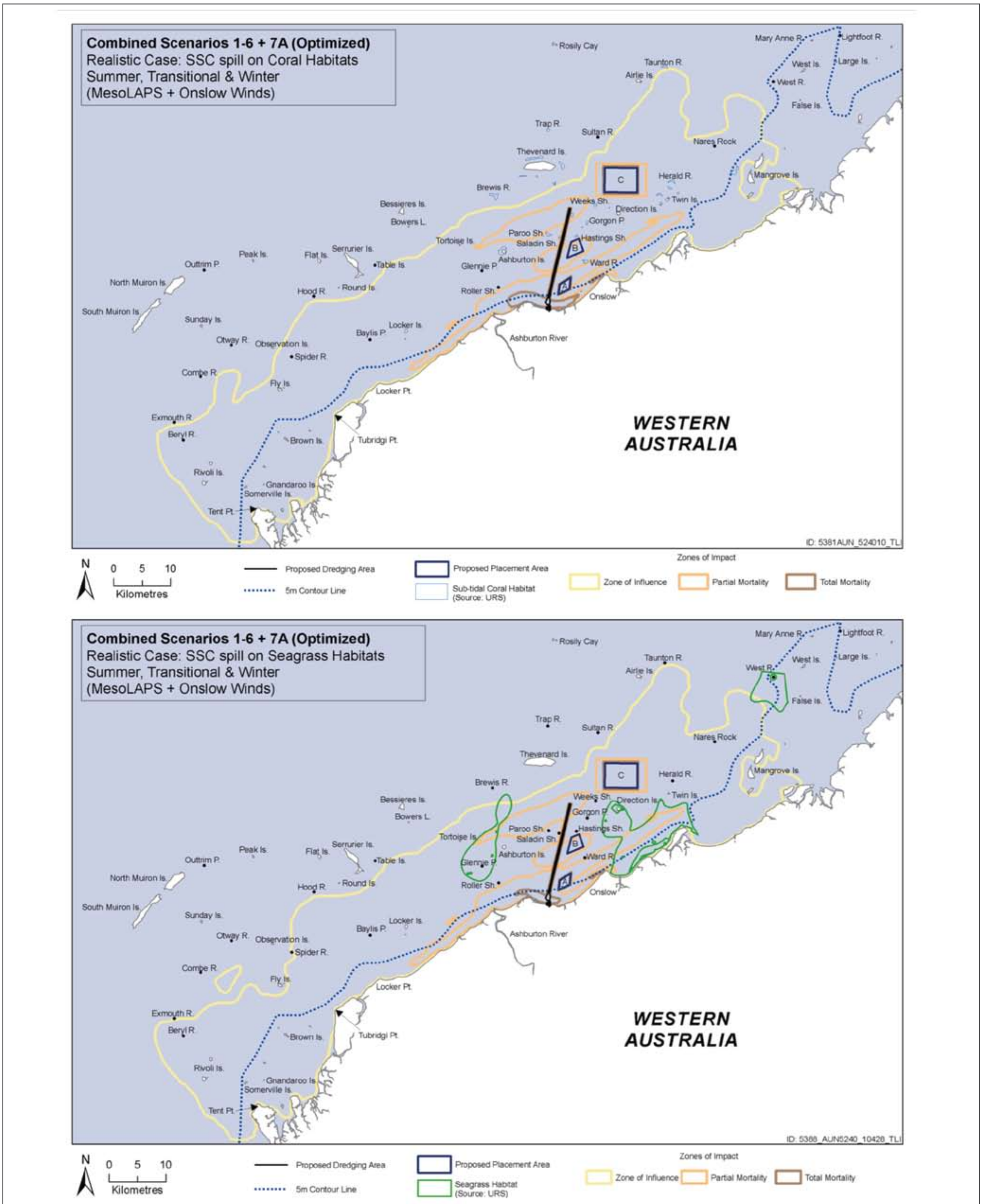


Figure 8.35: Optimised Scenarios: All Seasons IZI for SSC Tolerance Limits on Coral (top) And Seagrass (bottom)

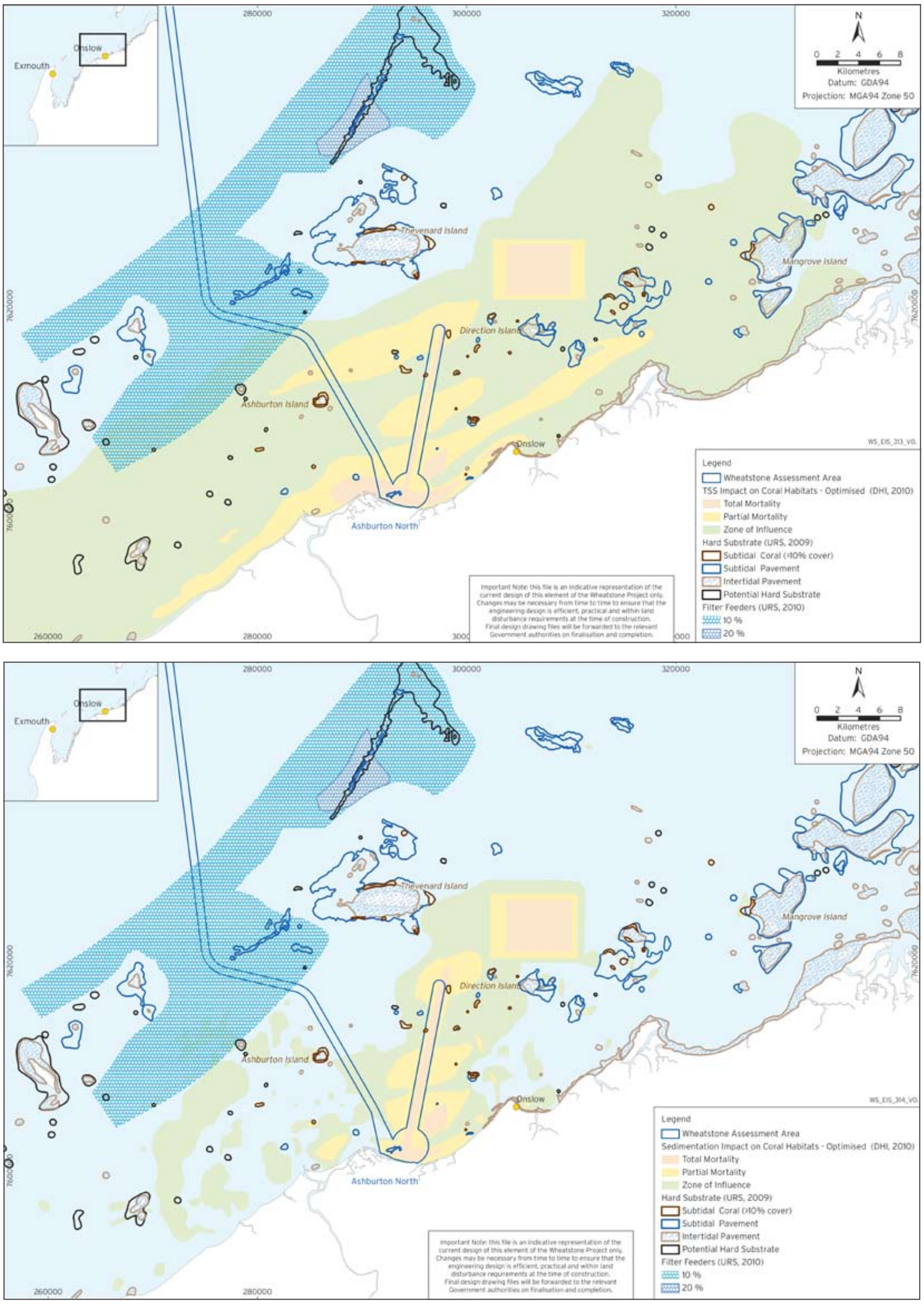


Figure 8.36: Optimised Scenario (1-6+7A) IZIs for Exceedence of SSC (top) and Sedimentation (bottom) Tolerance Limits for Coral and Filter Feeder Habitats

Therefore in conclusion, only coral communities located close to the channel are considered at risk of irreversible loss over the long term.

Summary

Construction dredging has the potential to impact BPPH, in excess of acceptable levels as defined in EAG 3.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that construction dredging will result in impacts to subtidal BPPH. The residual environmental risk for this potential impact was assessed as being "High" – of "Moderate" consequence, arising from irreversible loss of BPPH, and "Almost Certain" likelihood. To restrict, and potentially further reduce, the risk ranking to "High", the implementation of the management and mitigation measures outlined in Table 8.37 will be required.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that the placement of dredge material offshore will result in impacts to subtidal BPPH. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Moderate" consequence, arising from reversible, short-term localised damage to BPPH, and of "Likely" occurrence.

8.3.5.3 Indirect Impacts from Maintenance Dredging

Residual risk to benthic habitats from maintenance dredging is	**Low**

Damara WA (2010, Appendix P1) and DHI (2010, Appendix P2) demonstrated that under average conditions, prevailing during summer, the eastward littoral drift is likely to generate sediment infill of the MOF channel at a rate of between 50 000 to 100 000 m³/yr. Therefore, there may be a requirement for ongoing maintenance dredging of the approach channel to the MOF and the PLF basin and channel during the lifetime of the Project as a result of sedimentation resulting from both prevailing coastal processes and cyclonic events.

Modelled simulations of a direct hit from a Cyclone Vance (1999) scale event resulted in approximately 1 Mm³ of infill into the dredged areas from the single event. The infill material is likely to consist of soft sediments, as observed in the nearby Onslow Salt shipping channel. Characterisation of infill material in the nearby Onslow Salt shipping channel indicates the material is reddish brown silt to sandy silt and similar to surface sediments sampled during the field study for the proposed Project dredging program (URS 2009c).

Therefore, annual dredging of the MOF channel may be required. This may result in the removal of approximately 50 000 to 100 000 m³/yr. Less frequent dredging may be required every 3-5 years for other dredged areas. This may be equivalent to approximately 300 000 m³/yr. Estimate of total planned maintenance for 25 years of operation could be in the region of about 10 to 15 Mm³.

The location where most infill is anticipated to occur is the MOF channel adjacent the end of the breakwaters. If a TSHD is used for maintenance dredging, dredged material will be placed at either placement site C (if sandy) or at placement site D (if high in fines content). If a CSD is required to clear the MOF channel, dredged material will be pumped to placement site A. Neither placement site A nor site C presently support significant amounts of BPPH, and hence no additional BPPH damage is anticipated from regular re-use of these sites. Site D does support filter feeder habitat, but the small volumes of fine material to be placed at this location are considered unlikely to cause any irreversible loss of BPPH at this location.

Given that the habitats which occur in the Project area routinely experience elevated turbidity on a seasonal basis, the short time scale of this activity at any location within the proposed navigation channel and the short duration of the activity at any location, there is little risk to the limited BPPH which occur adjacent to the nearshore parts of the proposed navigation channel. Consequently, the scale of turbidity impacts arising from this activity has not been modelled.

It is therefore considered that regular maintenance dredging will pose significantly less risk to BPPH in the Project area than those posed by the construction dredging program. The spatial and temporal scale of the turbidity generated by such activities will be small by comparison to the construction dredging. No adverse impacts to BPPH resources adjacent to the channel are anticipated from this activity.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that maintenance dredging will result in indirect impacts to subtidal BPPH. The residual environmental risk for this potential impact was assessed as being "Low" – of "Negligible" consequence, as no irreversible loss is anticipated to occur, and of "Likely" occurrence.

8.3.5.4 Direct and Indirect Impacts from Placement of Dredge Material Onshore

Residual risk to benthic habitats from placement of dredge material onshore is	Medium

An estimated maximum of 10 Mm^3 of the dredged material may be placed at the onshore dredge material placement site (Chapter 2, *Project Description* and Chapter 9, *Terrestrial Risk Assessment and Management*). A detailed description and assessment of this potential activity is provided in Chapter 9, *Terrestrial Risk Assessment and Management*. The location of the onshore dredged material placement site has been selected to reduce the risk of impact to intertidal BPPH and no loss is anticipated from construction of the ponds. Should the onshore placement of dredge material be selected, the proposed placement site is not predicted to directly impact on nearby mangrove communities of the Ashburton River Delta or Hooley Creek.

Therefore the potential impacts to BPPH assessed with this aspect are:

- Indirect impacts on mangrove BPPH adjacent to the onshore dredged material placement site
- Indirect impacts on BPPH arising from the discharge of decanted tailings water.

Indirect impacts of pond seepage on adjacent BPPH have been assessed in detail (URS 2010) and in Chapter 9, *Terrestrial Risk Assessment and Management*. A potential impact from seepage ponds is the creation of a hydrostatic pressure head that results in altered water tables immediately adjacent to (approximately 100 m) the ponds forcing highly saline groundwater into this zone. If mangroves occur within this zone, their roots may become permanently waterlogged in high salinity groundwater resulting in mortality. Mangroves occur on the western side of the dune which may be used as the western wall of the placement site. This potential impact has been recognised and the onshore dredged material placement site has been designed to manage potential for this impact to occur by allowing water to drain to the southern end of the ponds.

Groundwater flow modelling studies have been undertaken to predict the impacts of the onshore dredge material placement site on the local groundwater environment (URS 2010e). The initial groundwater levels at the commencement of dredge material placement are those obtained from the steady-state groundwater flow model. Predictive simulations for a dredging campaign of approximately 16 months were produced to assess the mounding of the water table, increased salt loadings to the water table and seepage of seawater. The main findings of the groundwater modelling studies that are relevant to the Ashburton Delta mangrove system are:

- Changes to the water and salt budgets of the Ashburton River Delta are determined to be insignificant
- Mounding of the water table is predicted to occur under the onshore dredge material placement site due to the infiltration of seawater. Some water table mounding and seepage of seawater is predicted to occur in areas immediately adjacent to the placement site, with the majority of seepage occurring into the salt flat habitat next to the southern perimeter and south-west corner of the placement site and well away from mangrove areas. The seepage fronts are closely linked with the areas of mounded water tables and are predicted to vary over time as the mounded water tables decline
- A low rate of seepage may occur at the dune/tidal flat margin near the north-west perimeter of the placement site. This is adjacent to the landward most occurrence of mangroves that are fringing the upper reaches of a small tidal creek. When considering the low rates of seepage in combination with high evaporation rates it is unlikely that the seepage will result in any impacts to mangroves fringing the small creek and any changes will be localised to the dune/tidal flat margin. Hence no permanent loss of mangroves is anticipated.

The decanted tailwater will be stilled within the ponds prior to release from a shoreline outfall located to the west of the MOF. Dredging scenarios have been previously conducted that included onshore placement and a nearshore decant water discharge of 250 mg/L TSS at 6 m^3/s. These scenarios (not presented in this assessment) have indicated the decant water discharge is masked by the plumes generated by the nearshore dredging activity. This assessment has assumed that no material will be placed onshore and that all fines liberated by nearshore dredging will be released to nearshore waters. The effect of which has been incorporated into the BPPH loss assessment for construction dredging. There are no BPPH, sensitive to turbidity, in the nearshore zone immediately adjacent the plant site. Hence no additional indirect loss of BPPH is anticipated from discharge of decant water into nearshore waters to that identified by the BPPH loss assessment for construction dredging.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that the placement of dredge material onshore will result in impacts to BPPH. The residual environmental risk for this potential impact was assessed as being "Low" – of "Major' consequence, arising from the potential exceedence of applicable CLGs for loss of BPPH, and of "Unlikely" occurrence.

8.3.5.5 Indirect Impacts from Nearshore Construction Activities

Residual risk to benthic habitats from construction of PLF and rock placement for MOF breakwater walls is	Low

The indirect impacts anticipated from these construction activities relate to the generation of turbidity arising from rock dumping to construct the MOF.

The construction activities proposed for the MOF are described in Section 2.3.2.5, and for the PLF in Section 2.3.4.6. No rock dumping is proposed for the PLF and as such no indirect impacts on BPPH are anticipated from associated with construction of the PLF. An assessment of the risks to water quality arising from the above nearshore construction activities is presented in Section 8.2.5.5. Direct loss of BPPH, arising from the placement of nearshore infrastructure, has been assessed earlier in this Chapter. The location of these activities in relation to BPPH distribution is shown on Figure 8.30.

Rock dumping for the MOF breakwaters may generate localised and intermittent turbidity in the immediate vicinity and downcurrent of the activity. However, the amount of turbidity created is anticipated to be low because the rock material to be dumped will be engineered to required size and weight grades. Most of the rock dumped will be coarse material of cobble size and above. As shown in Figure 8.30, there is no BPPH, in the vicinity of the MOF, which is sensitive to intermittent water turbidity. The nearest BPPH to the MOF are the mangroves of Hooley Creek and the Ashburton River. Mangroves are tolerant of high water turbidity which they experience periodically when the Ashburton floods and they have been assessed as not being at risk of adverse impact from the construction dredging works. Hence given that indirect losses/damage of BPPH from construction of the MOF are most unlikely, the turbidity impacts of MOF construction have not been modelled. The core material and armour rock is not anticipated to contain fines material and the scale of turbidity is anticipated to be very small, short term and localised.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that nearshore construction will result in impacts to BPPH. The residual environmental risk for this potential impact was assessed as being "Low" – of "Negligible" consequence, as no irreversible loss of BPPH is anticipated, and "Almost Certain" likelihood.

8.3.5.6 Indirect Impacts from Trunkline Construction Activities

Residual risk to benthic habitats from trunkline trenching and stabilisation is	High

The trunkline will bring gas from the WP, approximately 225 km, to the LNG plant. Trenching for the pipelay operations is described in Section 8.2.5.5. In comparison to the construction dredging for the proposed navigation channel, the turbidity generated by trunkline trenching and stabilisation will be more transient as a result of the continual movement of the dredge along the 33 km alignment route. Therefore, turbidity will be localised and adjacent habitats may be exposed for only a short period. The rate of progress along the trunkline route is estimated at around 150 to 200 m per day. Smothering impacts arising from trunkline trenching and stabilisation activities have been addressed in the 50 m wide corridor assumed in the direct loss/damage assessment presented earlier in Section 8.3.5.1.

However, as indicated in Section 8.2.5.5, there is also a contingency case, where the pipelay may need to be performed using larger dredging equipment, particularly if the geotechnical conditions do not favour the mechanical trenching methodology. In this case it is possible that a combination of CSD and TSHD dredging may be used to create a trench for the trunkline. This may be undertaken from a water depth of approximately -5 m CD, out to approximately -40 m CD, which equates to an approximate distance of 33 km. The dredging volume could be up to 2.4 Mm^3 removed over a period of approximately 6 months. Dredged material out to approximately -10m CD would be placed at Site A, B or C, while material from approximately -10 m CD to -40 m CD would be placed at Site D.

In order to be conservative, dredge plume modelling has been undertaken using this contingency case, though the actual impacts are expected to be much lower if the preferred methodology is used.

Dredge plume modelling for the installation of the trunkline utilised the same methodology applied for modelling of the proposed navigation channel, involving the definition of short-term dredge scenarios and the use of the six climatic scenarios, as outlined in Section 8.2.5.1. The short-term trunkline dredge scenarios covered a 14-day segment of the trunkline dredge program and were associated with sediment loading of 1029t per day.

Two critical receptor locations were identified for detailed short-term scenario modelling:

- Ashburton Island – the proposed trunkline route passes approximately 1 km east of the reef around Ashburton Island, which has high cover and diversity of hard corals. Dredging in this location may also impact sensitive coral areas at Paroo Shoal and Saladin Shoal. There is also a large area of denser seagrass to the west of Ashburton Island
- Bessieres Island – the proposed trunkline route also passes within 7 km of Bessieres Island, which has moderate cover and diversity of hard corals. This location is also on a direct flow path to Brewis Reef and Thevenard Island.

Figure 8.37 shows the IZI arising from exceedence of coral SSC (top) and sedimentation (bottom) tolerance limits (resulting from trunkline dredging operations) overlain on distribution of coral and filter feeder habitats. Figure 8.38 shows the IZI arising from exceedence of seagrass SSC (top) and sedimentation (bottom) tolerance limits (resulting from trunkline dredging operations) overlain on distribution of seagrass and macroalgae habitats. The IZIs produced for the dredging of the trunkline have some uncertainty because they are based on modelling at the two most sensitive locations along the trunkline route. A conservative approach has therefore been used in determining the IZI boundaries, and the actual zones of impact are expected to be significantly smaller.

The CSD dredging along the trunkline route releases a relatively narrow plume of suspended sediments that extends a considerable distance (in the order of 5 to 10 km) from the dredging location. However, unlike the CSD dredging for the MOF and PLF basins, which requires the CSD to remain relatively stationary for extended periods, the CSD dredging the trunkline route will move relatively quickly along the route (in the order of 150 to 200 m per day). It is predicted that each day the plume will affect a slightly different area, and over the 14-day modelling duration, the CSD will have moved approximately 2 km along the trunkline route.

The SSC Zone of Partial Mortality for corals and seagrass is predicted to extend in the order of one to two km east and west from the trunkline route, potentially impacting some of the coral reef areas around Ashburton Island and seagrass areas north of Ashburton Island. The SSC Zone of Total Mortality is only predicted to extend in the order of 500 m east and west, depending on the season.

The sedimentation zones are more localised, with the Zone of Partial Mortality extending 1-2 km east and west of the dredging location (depending on season) for corals, and less than 1 km east and west (depending on season) for seagrass with some remote sedimentation also predicted to the east during summer and west during winter and transitional periods. The Zone of Total Mortality is extremely localised, and is only predicted to extend in the order of 100 to 200 m east and west of the trunkline route.

The largest Zones of Partial Mortality are predicted during the calm transitional periods, when currents are low, resulting in elevated SSC and sedimentation rates potentially impacting Ashburton Island.

Ashburton Island is the only coral receptor predicted to fall within the Zone of Partial Mortality. However, no loss of coral habitat is anticipated as a range of mitigation measures will be implemented to protect these corals.

Portions of the filter feeder habitat in LAUs 2D and 3A may also be damaged from sedimentation occurring up to 200 m either side of the trunkline and SSC derived partial mortality extending up to 2 km either side of the trunkline. Such damage may take more than 5 years to recover and as such has been considered an irreversible loss for the purposes of this assessment. Damage to similar areas of macroalgae habitat in LAU 2D is also anticipated. However, macroalgae are anticipated to recover rapidly and no permanent loss of macroalgae habitat is anticipated.

Portions of the seagrass area north of Ashburton Island also fall within the Zone of Partial Mortality and the Zone of Total Mortality as the trunkline route passes through some of this seagrass area. However, the seagrass coverage is relatively sparse (in the order of five per cent) and consists mostly of the seagrass genus *Halophila*, which is able to quickly regenerate and re-colonise an area following disturbance (Birch & Birch 1984; Lanyon & Marsh 1995; Rasheed 2004). Hence no permanent loss of seagrass is anticipated from this activity.

It is anticipated that only filter feeder habitat is likely to be lost for a period exceeding 5 years, with areas of loss/serious damage as follows:

- LAU 2D: 1958 ha, which represents 10.6 per cent of LAU (total area 18 409 ha)
- LAU 3A: 1077 ha, which represents 5.4 per cent of LAU (total area 19 908 ha).

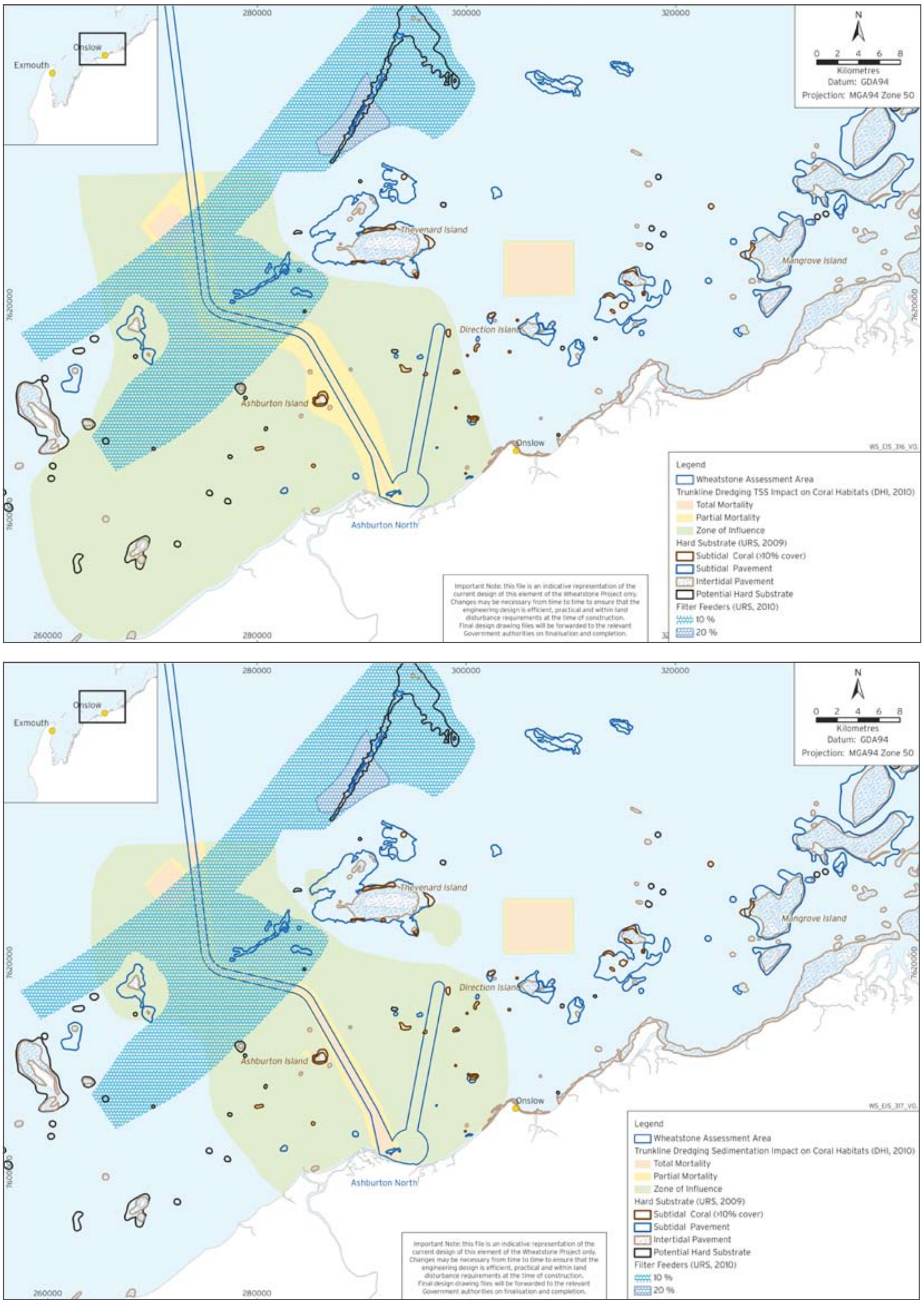


Figure 8.37: Trunkline Dredging IZI Arising from Exceedence of Coral SSC (top) and Sedimentation (bottom) Tolerance Limits Overlain on Distribution of Coral and Filter Feeder Habitats

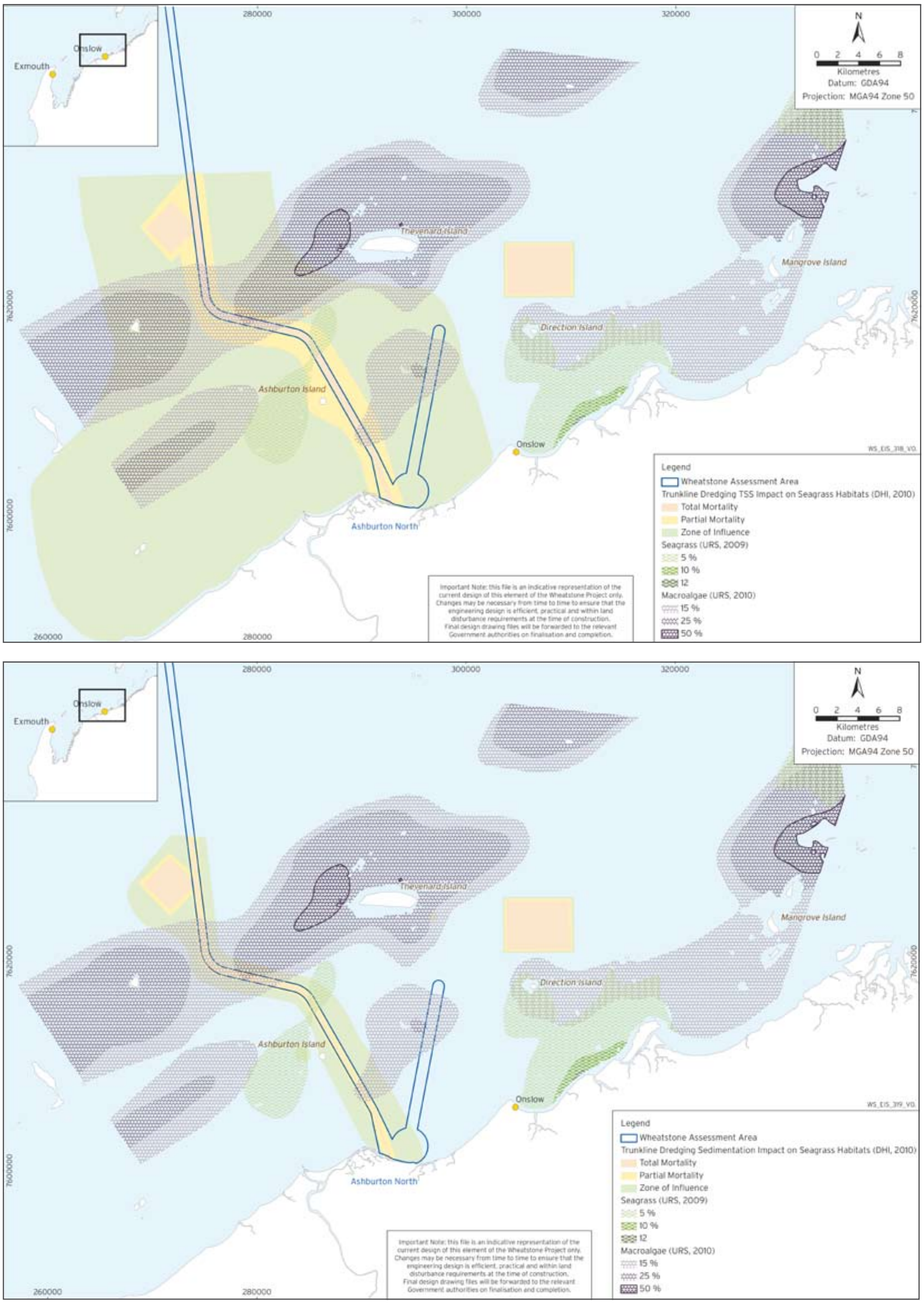


Figure 8.38: Trunkline Dredging IZI Arising from Exceedence of Seagrass SSC (top) and Sedimentation (bottom) Tolerance Limits Overlain on Distribution of Seagrass and Macroalgae Habitats

Table 8.31: Filter Feeder Loss Assessment Resulting from Exceedence of SSC (Partial Mortality) and Sedimentation (Total Mortality)

Local Assessment Unit Code	Biotype	Total Area (ha)	Partial Mortality (ha)	Total Mortality (ha)	Per cent loss/ damage
LAU 2D	Filter feeders	18 409	3 558	358	10.6
LAU 3A	Filter feeders	19 908	1 486	669	5.4

Table 8.31 presents the filter feeder loss assessment resulting from exceedence of both the Partial Mortality Threshold for SSC and the Total Mortality Threshold for sedimentation.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that construction of the trunkline will result in indirect and direct impacts to BPPH. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Moderate" consequence and of "Likely" occurrence.

8.3.5.7 Direct and Indirect Impacts from Trunkline Shore Crossing

The proposed shore crossing will traverse the lagoon system that forms the current eastern entrance to the Ashburton River. This lagoon system and dynamic spit-chenier have been described in Section 8.5, Chapter 6, *Overview of Existing Environment*, and further discussed in Damara WA (2010, Appendix P1). Figure 8.16 shows the location of the trunkline shore crossing in the north-west corner of the onshore Project area.

Section 2.3.2 describes the trunkline shore crossing works and indicates that two options are under investigation:

- Microtunnelling
- Trenching.

Assessment of Microtunnelling Option

Residual risk to benthic habitats from trunkline shore crossing by microtunnelling is	**Low**

Microtunnelling is the preferred engineering and environmental option for installation of the trunkline shore crossing as it is logistically less difficult, reduces disturbance of the lagoon and reduces the risk of adverse impacts to the environment. Trenching is a secondary option for shore crossing installation in the event that microtunnelling is not feasible from an engineering perspective, due to the length of tunnelling required (1.2 km). A tunnel of this length is close to the current technological limit for a tunnel of the proposed diameter (3 m).

There are three areas of potential environmental effects of micro tunnelling:

- Terrestrial
- Marine lagoon
- Offshore.

Terrestrial

Terrestrial effects caused by micro tunnelling would be construction of an access road through the sand dune, storage of material excavated from the tunnel and disturbance of an area seaward of the dunes for the actual micro tunnelling. Broad-scale vegetation mapping of the dune has already been undertaken, but further specific vegetation survey may be required and heritage issues would also need to be addressed. Note that these requirements are common to both micro tunnelling and trenching.

Marine lagoon

As micro tunnelling would commence in the dune system landward of the lagoon, extend under the lagoon and emerge in the nearshore zone approximately 100-200 m seaward of the barrier spit, there would be no direct impacts on the lagoon and Ashburton Delta arising from this option.

Offshore

Micro tunnelling would require construction of a small channel to allow a pipelay vessel into shallow water to join the shore pipe with the offshore trunkline. This work would probably be undertaken by backhoe dredge and would involve only a small volume of excavation.

Channel dredging would be assessed separately with the other components of the marine construction of the trunkline. Note that these requirements are common to both micro tunnelling and trenching. Habitat mapping surveys have not detected any BPPH (e.g. seagrasses, corals) in this area, the seafloor comprising barren and bioturbated silty sands.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that construction of the trunkline shore crossing by microtunneling will result in indirect impacts to BPPH. The residual environmental risk for this potential impact was assessed as being "Low" – of "Negligible" consequence, as no impact to BPPH is anticipated, and of "Likely" occurrence.

Assessment of Trenching Option

Residual risk to benthic habitats from trunkline shore crossing by trenching is	High

Detailed assessment of the impacts of trenching the trunkline shore crossing on water quality is presented in Section 8.2.5.5. That assessment concluded that impacts to water quality were minor, short term and localised. Given the lack of BPPH sensitive to water turbidity in the vicinity of the shore crossing, no irreversible loss/damage of BPPH is anticipated from the indirect impacts arising from this activity.

However, the trenching option risks potential direct impacts to mangroves. There will be limited destruction of mangrove seedlings and samphires in the lagoon during construction works, as most of the lagoon flat habitat is, at present, predominantly unvegetated sand with a very low density (zero to five per cent) of plant cover (Figure 8.40). While this area is not mapped as existing mangrove habitat due to low seedling density, the EPA may view this area as potential BPPH in accordance with guidance provided in EAG 3.

Once the groynes have been removed, the sand spit should reform and the lagoon should recover to its previous topography. Hence installation of the first trunkline is likely to result in a temporary impact from which the lagoon should recover from within five years of disturbance. No long-term loss or irreversible damage to BPPH is anticipated from this activity.

It is considered unlikely that subsequent trenching works for future trunklines can be undertaken in a way that meets the EPA's objectives for protection of mangrove habitat. However, considering the known dynamic nature of the sand spit, it is equally possible that a future cyclone may substantially modify it during the next 10 to 20 years and the subsequent impacts to the lagoon and potential mangrove habitat could be far more significant than those predicted from trenching activities. These uncertainties in future habitat condition make it difficult to provide a reliable BPPH loss/damage assessment for this option.

In conclusion, no loss/damage of BPPH from the Ashburton River Delta is anticipated to arise from the first trenching operation. Subsequent trenching operations are likely to result in mangrove habitat loss/damage at a scale that is yet to be determine, but is likely to exceed the applicable EPA CLG of zero loss.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that the construction of the trunkline shore crossing by trenching will result in impacts to BPPH. The residual environmental risk for this potential impact was assessed as being "High" – of "Moderate" consequence, arising from the potential disturbance of mangrove habitat, and "Almost Certain" likelihood. To restrict, and potentially further reduce, the risk ranking to "High", the implementation of the management and mitigation measures outlined in Table 8.37 will be required.

8.3.5.8 Direct impact from Onshore Construction Activities

Residual risk to benthic habitats from construction of the LNG plant and access road is	High

The construction program for the Project has been described in Chapter 2, *Project Description*. A representation of the plant, MOF and PLF layout is presented in Figure 8.39. The Project includes common user infrastructure that may be utilised by other proponents operating within the Ashburton North SIA and will house a multi-train LNG and domestic gas plant at the proposed SIA. Common user infrastructure includes a MOF, channel and turning basin, and an AQIS area.

Potential environmental impacts addressed in this section include direct impacts to intertidal BPPH, due to onshore placement of infrastructure.

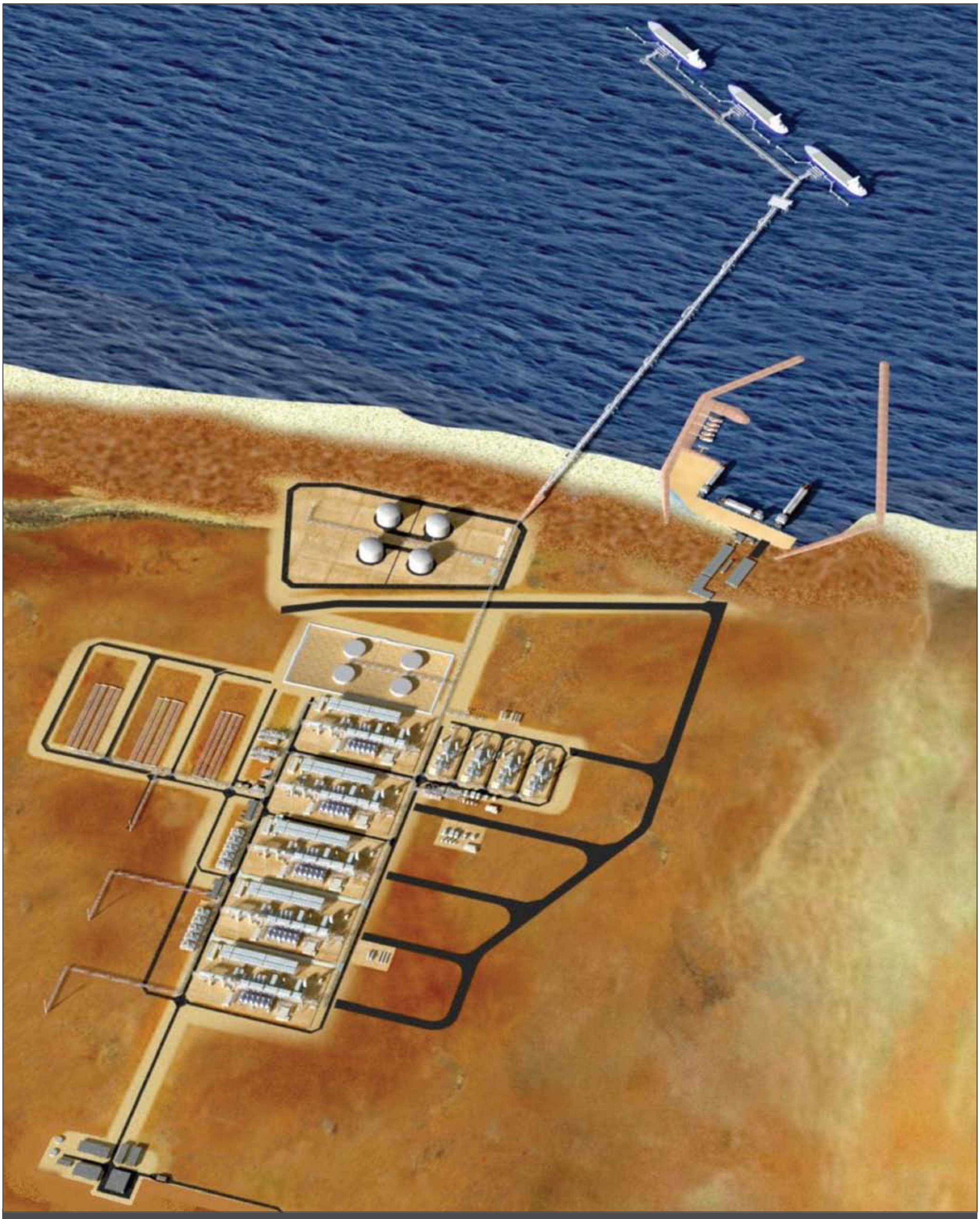


Figure 8.39: Representation of Onshore Infrastructure Layout

Ashburton River Delta is identified as being a Guideline 1 mangrove management area, while Hooley Creek-Four Mile Creek is classified as a Guideline 4 mangrove management area (EPA 2001).

Avoidance of mangroves and associated high tidal mudflat habitats has been a key design constraint for the Project. Recognition of the ecological importance and conservation significance of the Ashburton River Delta mangrove system has resulted in the design of a Project area that reduces the risk of direct impact to intertidal BPPH within the delta. However, due to the physical constraints placed upon the Project by the orientation of coastal landforms there are areas of BPPH (i.e. mangroves, bioturbated mud flats with samphire communities and algal mats) that will be impacted in the upper reaches of the west arm of Hooley Creek, located on the eastern side of the Project area.

Figure 8.40 shows the onshore Project area overlaid on the intertidal habitats of the Hooley Creek tidal complex. It also shows the extent of BPPH loss anticipated in the Hooley Creek area arising from placement of onshore infrastructure and the excavation of borrow pits. Note that the access roads between the borrow pits are only temporary (less than 6 months) hence algal mat habitat affected by these roads is anticipated to recover once the roads have been removed.

Figure 8.40 shows the location of these temporary haul tracks overlain on the intertidal habitat map. The tracks are required to provide access to the sand islands for earthmoving equipment. Sand and rock material contained in these islands may be used for onshore infrastructure construction and to raise the plant site to the required level. The standard practice with Borrow Pits in this environment is to remove material from the inside of the island but leave a small buffer untouched adjacent the tidal flat to manage potential for disturbance of the adjacent tidal flat and mangrove areas (i.e. so sediment run-off is contained within the borrow pit area and sediment deposition does not occur in adjacent BPPH areas).

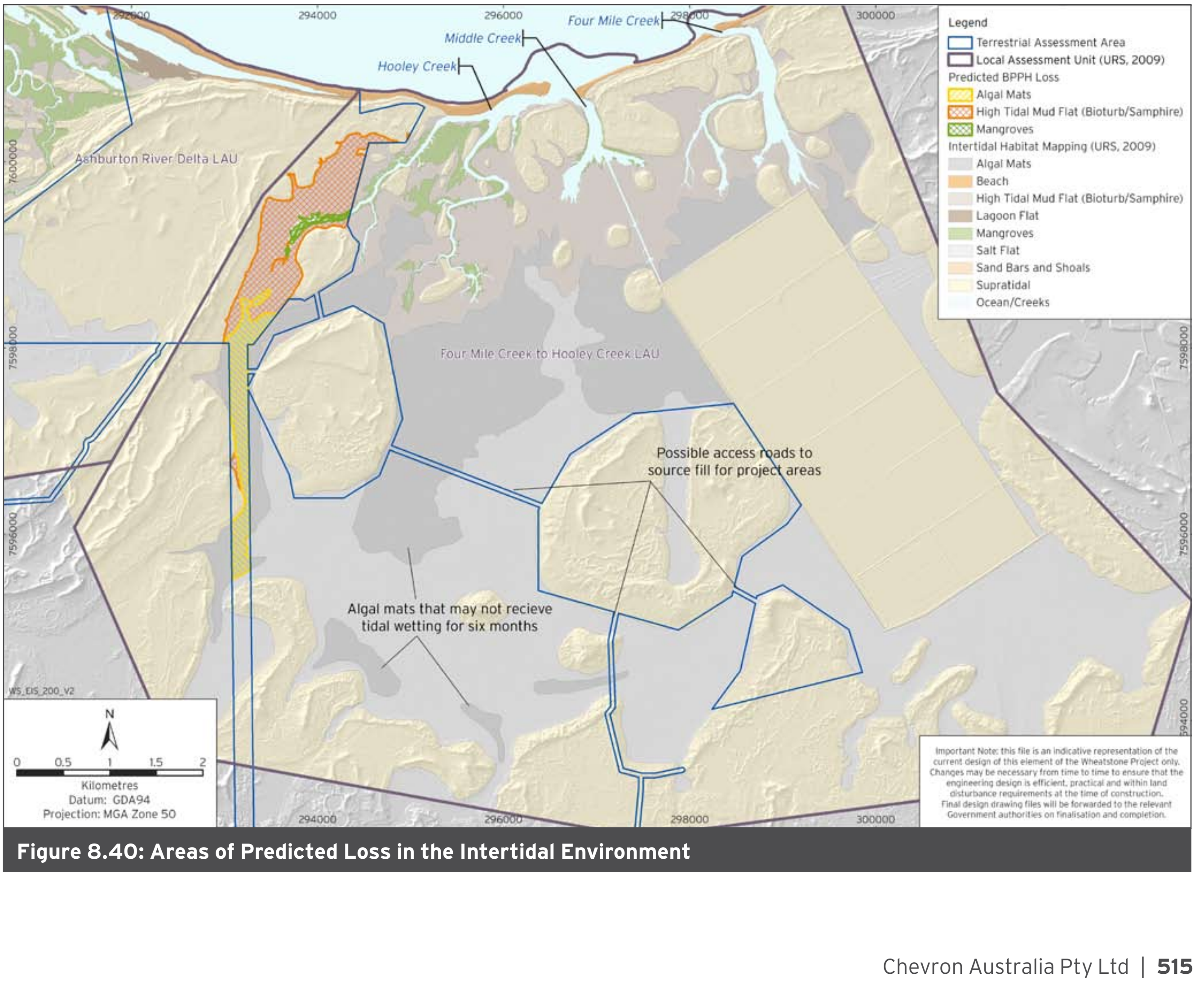


Figure 8.40: Areas of Predicted Loss in the Intertidal Environment

The access roads will be designed and engineered such that they can be removed and the ground surface at tidal flat level re-instated. The roads will also contain culverts to allow passage of both tide and small flood flows during their relatively short period of installation. The roads will be 2 m high by 8 m wide and will be constructed of crushed and graded rock (cobble size) overlain on geotextile cloth.

As indicated in Figure 8.40, the main east-west access road between the horseshoe shaped island near the Onslow salt crystalliser ponds and the island located near the plant site will cross approximately 1 km of algal mat habitat. This will result in temporary loss of 1 ha of algal mat (1 km by 10 m). Minimal temporary loss of algal mat habitat is anticipated to the south of the access road given the provision of culverts and the coarse road construction material. Algal mats occurring in such high tidal flat settings on the Pilbara coast typically experience very harsh conditions and dehydration for long periods (i.e. no wetting from either tidal inundation or freshwater floods for long periods).

Once the roads are removed and the ground surface at tidal flat level re-instated, no long-term irreversible losses are expected.

BPPH Loss Assessment

The total area proposed for clearing, together with total area of proposed BPPH loss, is provided in Table 8.32. These values represent maximum loss/damage estimates based on the assumption that the total area within the outer disturbance boundary from the layout is cleared. To calculate the direct loss/damage estimates, the Project area has been overlayed onto the intertidal habitat map (Figure 8.40) and the area of each BPP habitat which occurs within the Hooley Creek LAU calculated by GIS analysis using ARCView software. Table 8.33 summarises existing and potential cumulative loss/damage estimates for the Hooley Creek area based on the revised onshore Project area, shown in Figure 8.40.

For the Hooley Creek – Four Mile Creek LAU, the proposed total loss/damage for the mangrove BPPH is less than the CLG while the loss of high tidal mud flat and algal mat BPPH exceeds the ten per cent CLG threshold for Category E development area. For algal mat habitat there was a historical (existing) loss of 19 per cent (189 ha) from construction of the Onslow Salt crystalliser ponds which means that Category F may apply to the algal mats BPPH.

EAG 3 makes it clear the CLGs should not be considered as rigid limits, but the acceptability of such losses will be a judgement of the EPA based primarily on its consideration of the overall risk to the ecological integrity of the remainder of the ecosystem within the defined LAU.

Table 8.32: Intertidal Habitat Areas and Predicted Clearing Areas

Intertidal BPPH Type	Ashburton River Delta		Hooley Creek	
	Current Area Mapped (ha)	Predicted clearing (ha) and (%) of area mapped	Current Area Mapped (ha)	Predicted clearing (ha) and per cent of area mapped
Mangroves	526	0	83	4 ha or 5 per cent
High Tidal Mud Flat (Samphire/ Bioturbated Zone)	683	0	637	108 ha or 17 per cent
Algal Mats	0	0	815	52 ha or 6 per cent

Table 8.33: Cumulative Loss Assessment Summary: Hooley Creek – Four Mile Creek LAU

BPPH type	CLG (Category and per cent Loss)	Historical Cumulative Loss (per cent)	Cumulative Loss/Damage including Project area
Mangroves	E (10 per cent)	1 per cent	6 per cent
High tidal mud flat (bioturbated mud flat and samphires)	E (10 per cent)	0.3 per cent	17 per cent
Algal mats	F (0 per cent)	19 per cent	24 per cent

Dr Eric Paling of Murdoch University has been engaged to advise on this issue. His advice is as follows:

"Algal mats have been shown to be able to fix atmospheric nitrogen (Paling et al. 1989) and potentially provide a source of nutrients for seaward ecosystems (Paling & McComb 1994). This is the reason for their inclusion as a potentially significant intertidal habitat and BPPH unit in EAG 3. In terms of ecological value, algal mats, in addition to the above, provide a habitat for microbes, a form of fixed carbon and a food source for grazing crustaceans, particularly on high spring tides (Paling 1986).

However the contribution that algal mats make to seaward ecosystems has not yet been verified as several factors have not been studied. For example, although algal mats leach nutrients into retreating seawater on an outgoing tide, much of this material will not be able to be absorbed by mangrove root systems due to the speed of seawater flow and its channelling towards tidal creeks. Additionally, algal mats only leach nutrients on the first few spring tides to inundate them or after sporadic rainfall events. They do so because their cells walls, when dried, lose integrity and allow the leaching of material after rewetting (Paling and McComb 1994). Once their cell walls reinstate their integrity, they provide much more protection for the cell contents and less leaching occurs. The only definitive method to trace nutrients (e.g. nitrogen) between algal mats and mangrove systems would be by isotope labelling.

In addition several pieces of evidence suggest that mangroves do not receive a great degree of assistance from algal mats. This is derived from the observation that where algal mat loss has occurred there appear to be no adverse affects on adjacent mangroves or the integrity of the system in which they occur. The most relevant example is the adjacent solar salt development around Onslow where 380 ha of algal mat were removed. Long-term pre and post monitoring of mangroves associated with the operation have shown no observable impact on mangroves, either around the crystallisers or the evaporative ponds east of the Onslow town site (Biota 2003). Examples are also provided in Dampier (solar salt development, Paling 1986) and Port Hedland (harbour development, Paling et al. 2003), although these had much less extensive pre-monitoring than Onslow.

Thus, based upon the evidence described above, it is unlikely that the ecological integrity of the Hooley Creek/ Four Mile Creek system will be compromised by the removal of the algal mat from this development.

It is more difficult to assess the significance of any loss of the high tidal mud flat (samphires and bioturbated mud flat) as there is less information available on their production ecology (both primary and secondary) and these are not generally well-studied worldwide. There are also no data available on the ecological connectivity, if any, between mangroves and samphires. Generally, apart from their own intrinsic ecological value, it can be inferred that the loss of high tidal mud flat does not influence the ecological integrity of adjacent mangrove systems. This conclusion is based upon the lack of ecological effects on mangroves noted from the observed loss of 42 ha of this habitat in the Onslow Salt development and substantial losses around the Dampier and Port Hedland areas."

It is therefore considered highly likely that the direct losses of algal mat and samphire habitat proposed by the Project will threaten the integrity of the remaining BPPH within the Hooley Creek – Four Mile Creek LAU.

Changes to tidal inundation regimes have the potential to result in more gradual, indirect impacts to mangroves over the longer-term. Tidal exchange and flows are the dominant and prevailing processes that maintain the Pilbara mangroves as they regulate many of the physical, chemical and biological functions (URS 2010).

The location of the majority of the Project area is such that it is unlikely to lead to any significant changes to current tidal inundation regimes within mangrove areas. An assessment of impacts to coastal processes from the Project indicates that the MOF breakwaters map disrupt the alongshore sediment supply and this may result in changes to morphology of the sand spit located at the mouth of Hooley Creek and hence the creek entrance itself (Section 8.6.5). The historical aerial photographic record shows that the sand spit at the entrance to Hooley Creek is highly dynamic and has been deflated and rebuilt a number of times during the last thirty years (Damara WA 2010, Appendix P1). Intertidal habitat surveys of the area (URS 2010f) did not find any evidence of historical mangrove mortality in Hooley Creek that may be attributed to changes in tidal inundation patterns resulting from the natural modification to the alignment of the sand spit or creek entrance.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that the construction of onshore infrastructure will result in impacts to BPPH. The residual environmental risk for this potential impact was assessed as being "High" – of "Major" consequence, arising from the potential for damage to mangrove habitat, in excess of the EPA's CLGs, and of "Likely" occurrence.

8.3.5.9 Indirect impacts to the Ashburton River Delta mangrove system from onshore operations

Residual risk to the Ashburton River Delta mangrove system from onshore operations is	Low

The location of the Project area, immediately adjacent the Ashburton River Delta mangrove system, allows the potential for indirect impacts to occur as a result of onshore Project operation. URS (2010b, Appendix N4) provides a full assessment of potential direct and indirect impacts to the mangrove system by:

- Developing a conceptual model to guide the assessment of potential impacts to the Ashburton River Delta arising from construction and operation of the Project
- Undertaking an assessment of the key processes responsible for maintenance of the ecosystem and the potential for the Project to affect these processes
- Assessing the potential for the mangrove system to be adversely affected in the long term.

Potential indirect impacts from Project operation include the following:

- An increase in sediment deposition as a result of dredging works
- Localised seepage from the onshore dredge material placement site, if this option is utilised
- Potential for leaks and spills of hydrocarbons
- Atmospheric emissions (dust, air, noise, light).

A summary of the impact assessment for indirect impacts to the mangroves is provided below.

Construction and maintenance dredging

An assessment of the potential for indirect impacts to mangroves in the Delta from dredging-related sediment deposition indicates that such impacts are unlikely given consideration of the following factors:

- Background turbidity concentrations along the Onslow coastline are high under existing conditions, and the relative increase in concentrations due to dredging should be localised and short-term. Mangroves in the area are naturally subject to periods of very high turbidity, particularly during flooding of the Ashburton River
- Dredge plumes are not expected to cause sedimentation at a scale that would threaten mangrove communities
- Dredging activities will occur in nearshore and offshore areas and not within the Ashburton River Delta tidal creek system, therefore the majority of mobilised sediment will be deposited in nearshore and offshore areas and not within the intertidal zone, where mangroves occur.

Onshore dredge material placement site

The containment of large volumes of water in settling ponds constructed within a tidal flat environment is known to cause water logging and increased groundwater and/or soil water salinity. This has resulted in localised mangrove mortality, for a distance of up to 100 m from the perimeter of the settling pond bund (i.e. seepage effects superimpose a water logging effect over the natural water table fluctuation which impedes the normal physiological function of the mangroves) (Gordon *et al*. 1995; LeProvost, Dames & Moore 1998).

The proposed onshore dredge material placement site has been designed to incorporate a buffer zone between the outermost mangroves of the Ashburton River Delta and the western perimeter of the placement area (approximately 200 m). The dune system which forms the northwest bund for the onshore placement site acts as a buffer area between the placement area and the upper most reaches of a tidal creek that supports a narrow band of mangroves.

Groundwater flow modelling studies have been undertaken to predict the impacts of the onshore dredge material placement site on the local groundwater environment (URS 2010e, Appendix F1). Mounding of the water table is predicted to occur under the onshore dredge material placement site due to the infiltration of seawater from the material. Some water table mounding and seepage of seawater is predicted to occur in areas immediately adjacent to (but outside of) the placement site, with the majority of seepage occurring into the salt flat habitat next to the southern perimeter and southwest corner of the placement area. These areas are not adjacent to the mangroves. A low rate of seepage may occur at the dune/tidal flat margin near the northwest perimeter of the placement site.

Hydrocarbon leaks and spills

Accidental leaks or spills of hydrocarbons have the potential to impact mangroves of the Ashburton River Delta. This is a potential high risk as it is difficult to undertake cleanup activities in such an environment (Hensel *et al*. 2002). The proposed "worst-case" modelling scenario for a leak or spill of hydrocarbons would originate from a ruptured trunkline at the shipping channel crossing. Other scenarios that may result in hydrocarbons infiltrating the mangroves included a loss of well control offshore, a condensate spill at the PLF and a diesel spill occurring at the MOF (DHI 2010e, Appendix Q2). This has the potential to be damaging if the slick arrived at the delta, prior to the more toxic components evaporating. Section 8.3.5.14 provides detail on times and trajectories of hydrocarbon movement, if a leak or spill were to occur.

Atmospheric emissions

Increased atmospheric emissions are anticipated as a result of Project operations. Limited information exists relating to the impacts of atmospheric deposition on native flora and vegetation and very little is known about atmospheric impacts to mangrove systems.

Dust emissions

Dust emissions from the Project have the potential to adversely impact the condition of the mangroves. Like other vegetation types, dust deposition can adversely affect the photosynthetic processes by causing blockages of the leaf stomata, thereby preventing adequate uptake of oxygen, carbon dioxide and sunlight, causing an overall decline in vegetation health. It is unlikely that there will be any adverse effects from dust arising from construction and operation of the proposed development. Paling *et al*. (2001) indicates that few declines in mangrove health have occurred adjacent to iron ore stockpiles which act as continual dust emitters. Dust emissions are likely to be confined largely to onshore construction-related activities within development areas. Source activities may include construction traffic, drill and blast activities, land clearing, earthworks and temporary stockpiling. Deposition processes in the Project area are anticipated to be dominated by dry deposition during the dry season and a combination of wet and dry deposition during the wet season. However, dust emissions are not expected to cause significant impacts to mangroves and are expected to be limited to dry season conditions.

Air emissions

Native vegetation may be adversely affected by exposure to a number of atmospheric pollutants, or a combination of pollutants. However, air emissions from the Project are not expected to adversely impact the abundance, diversity, geographic distribution, productivity or conservation status of the mangroves surrounding the Project area and are considered to be low risk.

Increased noise emissions

Increased background noise resulting from operation of the LNG plant may disturb mangrove-dependent bird species that use the mangroves of the Ashburton River Delta. Increased noise levels may lead to reduced usage of mangrove habitats, however observational evidence from other Pilbara locations suggests that many mangrove birds adapt to increased noise levels over time (e.g. port and conveyor operations in similar mangrove habitats at Finucane Island, Port Hedland (G Humphreys [Biota], pers. comm.), and in mangroves at North East Creek, immediately next to the Woodside LNG plant on the Burrup Peninsula (A Bougher [URS], pers. comm.). It likely that, while some small-scale changes in behaviour could occur, the majority of mangrove avifauna species would continue to use these habitats.

Increased light emissions

Modelling of light spill within, and adjacent to the Project area (URS 2010a, Appendix O1), indicates that the majority of Ashburton River Delta mangrove habitat will not experience any increase in light levels from the Project. The primary receptor for light increases in the mangroves is the Little Northern Free-tail Bat (*Mormopterus loriae coburgensis*), a mangrove specialist, WC Act Priority 1 species. *M. loriae coburgensis* has been recorded utilising the Project area (Biota 2009a). Increased light levels typically lead to increased activity and concentrations of nocturnal insects, which form the primary dietary items of *M. loriae coburgensis* (Churchill 2009). As a result of lighting increase it is possible that there may be a localised increase in bat activity adjacent to the Project, leading to an increased risk of bat strikes. However, it is likely that this would only represent a localised loss of individuals, rather than an impact to local populations.

Summary

Based on the impact assessment conducted for the Project, and existing information from other projects, it is anticipated that none of the key processes identified as being responsible for maintaining the delta will be modified to the extent that resultant indirect short-term impacts will occur. Additionally, it is not expected that long-term indirect impacts to mangrove habitats will occur, under normal operating conditions.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that onshore operations will result in indirect impacts to the Ashburton River Delta mangrove system. The residual environmental risk for this potential impact was assessed as being "Low" – of "Negligible" consequence, as no short or long-term impacts to the mangroves or their inhabitants are anticipated, and "Almost Certain" likelihood.

8.3.5.10 Offshore Construction Activities

Residual risk to benthic habitats from offshore construction activities is	Low

The construction program for the Project has been described in Chapter 2, *Project Description*. Offshore construction activities include construction of the WP and well heads and pipelay operations. The offshore Project area is illustrated in Chapter 2, *Project Description*. A detailed description of the field investigation and characterisation of benthic habitat in the offshore Project area is provided in URS (2009d, Appendix N9). Due to the deep water location (>70 m) of the offshore infrastructure, where the benthic zone does not receive sufficient light, it is anticipated that BPPH will be extremely sparse. Surveys undertaken by UWA (2009a, Appendix N8) indicate that a red micro phytobenthic algal mat occurs at depths between 40 and 70 m CD. Offshore construction is considered unlikely to result in the loss/damage of significant BPPH.

Offshore Platform

Surveyed areas consisting of hard substrate (limestone/ sandstone), and isolated rock outcrops found along the proposed trunkline route generally hosted sparse (one to two per cent) to occasional (two to ten per cent) coverage of a diverse array of benthic sessile invertebrates, dominated by gorgonians (sea fans and whips), sponges and soft corals (UWA 2009a, Appendix N8).

The proposed location of the WP is on a large ridgeline (approximately 11 km long). Overall, no ecologically isolated, sensitive, unique or significant habitats were found in the study area. Construction of the WP in an area of occasional (two to ten per cent) sessile invertebrate coverage may have an adverse localised effect on the benthic biota, but rapid re-colonisation is expected to occur.

Subsea Trunkline

The trunkline from the WP to the Ashburton North SIA is approximately 225 km long and traverses a range of benthic habitat regions. For most of this length, the trunkline will be weight-coated and laid on the surface of the seabed. It will only be buried once it gets close to shore and into depths of <40 m CD. The nearshore section of the trunkline route has been assessed in a previous section.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that offshore construction activities will result in impacts to BPPH. The residual environmental risk for this potential impact was assessed as being "Low" – of "Negligible" consequence, as limited BPPH exists in the offshore environment, and of "Likely" occurrence.

8.3.5.11 Discharges from Onshore Construction

Residual risk to benthic habitats from accommodation village, stormwater run-off and reverse osmosis brine discharges is	Low

The onshore construction program for the Project has been described in Chapter 2, *Project Description*. It requires up to 5000 workers (at peak period) located at an accommodation village at the Ashburton North SIA. The accommodation village wastewaters include clean stormwater, treated domestic wastewater (including sewage), and RO brine. The wastewater will be discharged at a nearshore outfall into 5 m depth of well flushed water near the PLF.

The potential impacts to BPPH arising from this discharge relate to the possibility of nutrient enrichment in waters of the mixing zone leading to algal blooms and light attenuation which could reduce productivity of light dependant organisms within the mixing zone.

Assessment of potential impacts on marine water quality in the Project area is presented in Section 8.2.5.6. That section concluded that a mixing zone of 200 m was required to achieve the dilutions necessary (1:70) to return the nutrient concentrations in the discharge to the concentrations given in ANZECC/ARMCANZ (2000) for total nitrogen (100 µg/L) and total phosphorus (15 µg/L). Given that there are no significant areas of BPPH within the proposed mixing zone and for some distance beyond, adverse impacts to subtidal BPPH are not anticipated. The nearest BPPH to the proposed outfall are the mangroves of Ashburton River and Hooley Creek. These BPPH types are known to be tolerant of elevated nutrient concentrations in seawater (Krauss *et al*., 2008).

The proposed management and mitigation measures for this activity are discussed in the factor relating to Marine Water and Sediment Quality (Table 8.18).

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that onshore construction activities will result in impacts to BPPH. The residual environmental risk for this potential impact was assessed as being "Low" – of "Negligible" consequence, as no irreversible damage is anticipated to occur to BPPH, and "Almost Certain" likelihood.

8.3.5.12 Discharges from Onshore Operations

Residual risk to benthic habitats from wastewater, process wastewater, contact stormwater, reverse osmosis brine discharges and PW is	**Low**
Residual risk to benthic habitats from PW is	**Low**

The onshore operations program for the Project has been discussed in Chapter 2, *Project Description*. Initially, the Project will bring ashore gas from Petroleum Titles WA-356-P, WA-253-P, WA-16-R and WA-17-R, following treatment at the offshore WP to remove PW and other process water constituents. The gas will be brought onshore via a trunkline to the LNG plant at the Ashburton North SIA. The expansion phase for the Project will bring gas from other fields (unspecified at this stage) via additional trunklines. The expansion phase potentially includes PW being removed from the gas onshore rather than at the offshore WP. Discharge volumes and loadings to the marine environment will increase substantially at this stage.

Characterisation of operational discharges from the Ashburton North SIA is found in Chapter 4, *Emissions, Discharges and Wastes*. The proposed treatment and disposal of operational wastewater is considered in Chapter 4, *Emissions, Discharges and Wastes*. Assessment of potential impacts on marine water and sediment quality in the Project area is presented in Section 8.2.5.7. The proposed management and mitigation measures for this activity are discussed in the factor relating to Marine Water and Sediment Quality (Section 8.2.7).

Domestic wastewater, process water, clean stormwater, and RO brine will be discharged from the nearshore outfall in 5 m depth of well flushed waters. PW will be discharged in 20 m depth, near the inner shelf break approximately 30 km offshore which contain well flushed waters.

Nearshore Outfall

The potential impacts to BPPH assessed with this aspect are related to the surface water run-off from plant and surrounds, routine discharges from onshore infrastructure including RO brine, treated sewage and routine discharges from the LNG plant, including process water. The environmental effects considered included indirect impacts to BPPH due to increased turbidity and light attenuation; loss or damage to BPPH due to eutrophication; and potential for contaminant pollution of BPPH from waste water.

The scenario assessed for this impact was for the full scale operations. The scale of the domestic wastewater discharge is much smaller than that for the construction stage, due to fewer workers on site during operations (400 instead of 5000). Section 8.2.5.6 concluded that a mixing zone of 200 m was adequate to achieve the dilutions necessary to achieve a "Minor" consequence of localised long-term exceedence of background and applicable ANZECC/ARMCANZ WQ guidelines but within approved mixing zone given in ANZECC/ARMCANZ (2000) for total nitrogen (100 µg/L) and total phosphorus (15 µg/L). Given that there are no significant areas of BPPH within the proposed mixing zone and for some distance beyond, adverse impacts to subtidal BPPH are not anticipated.

Summary

Following the implementation of appropriate management and mitigation measures presented in Table 8.37, the residual environmental risk for the potential impact on BPPH as a result of discharges from onshore operations with a nearshore outfall is assessed as being "Low" with a "Negligible" consequence arising from no irreversible loss/damage of BPPH and a "Likely" likelihood.

Offshore Outfall

Assessment of the potential impacts to BPPH arising from the PW discharge at the deep water offshore location is based on the detailed assessment of water quality impacts presented in Section 8.2.5.7. This assessment concluded that nutrients and hydrocarbon toxicants were the main contaminants associated with the PW discharge. The hydrocarbons in the plume will volatilise rapidly and are not predicted to come into contact with BPPH. Therefore, they are not considered a risk to BPPH.

However, the nutrient load in inner-shelf waters will increase as a result of the PW discharge. It will add approximately 100 t/yr each of nitrogen and phosphorus to the region. This represents a 25 to 75 per cent increase respectively over the nutrient contribution from the average annual discharge from the Ashburton River. Worst-case modelling has shown that ANZECC/ARMCANZ WQ guidelines (2000) for total nitrogen and total phosphorus can be met within the mixing zone. This discharge may result in the development of localised increase in benthic cover of macroalgae (e.g. *Enteromorpha* or *Lyngbya* sp.) and possibly algal blooms in the area particularly during calm transition periods and neap tides because such blooms already occur periodically in nearshore waters.

It is not possible to accurately predict the scale and concentration of these blooms but like the natural blooms which already occur, they are likely to be transient and only occur periodically. Since the naturally occurring blooms do not appear to adversely affect regional BPPH, it is considered unlikely that large areas of BPPH will be adversely affected by these algal blooms should they occur within and downcurrent of the mixing zone.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that onshore operational discharges from an offshore outfall will result in impacts to BPPH. The residual environmental risk for this potential impact was assessed as being "Low" – of "Negligible" consequence, as no irreversible or wide spread damage to BPPH is anticipated, and of "Likely" occurrence.

8.3.5.13 Discharges from Offshore Construction and Operations

Residual risk to benthic habitats from discharges from offshore construction and operations is	**Low**

The offshore construction program for the Project has been discussed in Chapter 2, *Project Description*. Due to the location of the offshore operations, which are located in deep water (50 to 70 m) where the benthic zone does not receive light, there will be no direct impact on BPPH.

Field investigation and characterisation of benthic habitat in the offshore Project area is presented in URS (2009d, Appendix N9). The substratum is predominantly bare sand. Survey sites targeted areas consisting of hard substrate (limestone/sandstone), and isolated rock outcrops found along the proposed trunkline route. These generally hosted sparse (one to two per cent) to occasional (two to ten per cent) coverage of a diverse array of benthic sessile invertebrates, dominated by gorgonians (sea fans and whips), sponges and soft corals.

Characterisation of discharges and waste from the offshore construction program are found in Section 8.2.5.8, as is an assessment of potential impacts on marine water and sediment quality in the Project area. The key discharges include PW, MEG, drill cuttings, drilling mud, sludges and sands and CW. The proposed management and mitigation measures for this activity are discussed in the factor relating to Marine Water and Sediment Quality (Table 8.18).

The potential impacts to benthic habitat assessed with this aspect are primarily related to the direct loss or damage to benthic habitat due to release of drill cuttings, and discharges including drill mud, sludge and sand. Environmental impacts associated with the discharge of drill cuttings are likely to include localised short-term smothering of benthic communities and alteration of sediment particle size. Studies elsewhere have shown no evidence of acute impact on species abundance or richness 3 years after drilling and measurable differences in species richness were restricted to within 100 m of the cuttings discharge point (Oliver and Fisher 1999). No loss/damage of BPPH is anticipated from these discharges.

Although the MEG discharge modelled scenario presented in Section 8.2.5.9 indicates an exceedence of the low reliability trigger over a relatively broad area, the large volume discharge of MEG (in isolation or co-mingled with CW) only occurs for approximately four one-day periods per year, so exceedence will be short term and impact localised. The MEG is expected to disperse within 24 hrs of cessation of the MEG being discharged. MEG toxicity is very low (ANZECC/ARMCANZ 2000) and is described as a chemical posing little or no risk to the environment (PLONOR) under the Oslo and Paris Commissions Recommendation 2000/4 on Harmonized Pre-screening Scheme for Offshore Chemicals. MEG is also readily biodegradable in water with degradation likely to occur through aerobic bacterial activity (Price *et al*. 1974). It does not bioaccumulate or persist in sediments (WHO, 2001). Given the above, no BPPH loss is anticipated as a result of periodic discharges of MEG.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that discharges generated from offshore construction and operation will result in impacts to BPPH. The residual environmental risk for this potential impact was assessed as being "Low" – of "Negligible" consequence, as no irreversible damage to BPPH is anticipated, and of "Likely" occurrence.

8.3.5.14 Hydrocarbon Leaks and Spills

Background

This section assesses the risk of impacts from hydrocarbon leaks and spills on BPPH in the Project area. Background on the biology and susceptibility of BPPH is provided followed by the modelling of condensate and diesel leaks and spills, their potential impacts to BPPH and associated risks.

Table 8.34: Probability of a Hydrocarbon Leak or Spill Events

Spill Source	Spilled Fluid	Probability of Leak or Spill Occurring
Central manifold	Condensate	7.5×10^{-5}/y
Feed gas line	Condensate	1.41×10^{-5}/km/y
Condensate offloading trunkline	Condensate	7.40×10^{-5}/km/y
MOF	Diesel	9.0×10^{-3}

Offshore leaks and spills of hydrocarbons may occur during the construction, operations or decommissioning phases of the Project. For the purpose of this document, a leak is defined as the escape, entry, or passage of condensate or diesel through a breach or flaw in a pipe or tank, while a spill is defined here as a layer of condensate floating on water or covering the shoreline of a body of water. The main substances of concern are condensate (leaks and spills may occur during the drilling, extraction, processing or transportation phases) and diesel (leaks and spills may occur from equipment failure, deck drain discharge, or during regular vessel movements e.g. accidental discharge, collision, deck-drain discharge, during refuelling etc.). While the impacts from a hydrocarbon leak or spill can be severe, the overall risk to BPPH is greatly diminished by the very low probability of a hydrocarbon leak or spill occurring.

The probability of hydrocarbon leaks or spills occurring at various locations within the Project area are listed in Table 8.34 (Chevron 2005). For example, the probability of the occurrence of a leak or spill from the export trunkline is 1.41 incidents every 100,000 years for every km of trunkline. The risk of a leak varies along the trunkline length with exposed shore crossing sections having a higher likelihood of leaks than remote deepwater sections. Therefore Table 8.34 provides an estimate of the average probability.

Condensate originating from the NWS, as a by-product of natural gas, tends to be a light hydrocarbon with a density of 0.77 g/cm^3 and an API gravity of 53.1° (Volkman *et al*. 1994). NWS condensate is also known to evaporate rapidly (within 12-24 hours) in warm tropical waters (Kagi *et al*. 1988). It is expected that the condensate will contain a low concentration of aromatic hydrocarbons (between approximately three and six per cent), which are the most toxic component (Neff 1990 in Basheer *et al*. 2003). A more detailed description of the composition of the condensate from the Project Petroleum Titles is presented in Chapter 2, *Project Description*.

Diesel is primarily comprised of cycloparaffins (between 20 per cent and 40 per cent) and, relative to condensate, is more easily entrained in the water column. Diesel contains a higher proportion of aromatic hydrocarbons, at around 24 per cent (DHI 2010e). Although the amount of cycloparaffin in diesel makes it "heavier" than condensate, it is still expected that the majority of any spill is likely to evaporate within approximately 48 hours (International Tanker Owners Pollution Federation 2002).

Scenario Selection and Modelling

Credible hydrocarbon spill scenarios were identified during risk assessment workshops. The likelihood of these scenarios occurring (primary risk) has been calculated using a quantitative risk assessment approach (Moore Consulting & Engineering 2009). In some instances, the worst case scenarios have been presented here (rather than smaller, more realistic volume scenarios) as the worst case scenarios define the outermost extent of potential impacts. No mitigation has been assumed in the model.

The results of the primary risk assessment have been used to select appropriate spill scenarios for determination of the probability of spilt hydrocarbons reaching particular receptors (secondary risk). The latter step uses a hydrodynamic modelling approach (further details below). The final step in the process describes the predicted impacts from spilt hydrocarbons reaching certain receptors (tertiary risk).

Five spill scenarios (Table 8.35) at offshore and nearshore locations (Figure 8.41; Figure 8.42) were selected in accordance with the results of the quantitative risk assessment for simulation using a probabilistic modelling approach (DHI MIKE 21/3 SA spill simulation model [DHI 2010e, Appendix Q2]). Using this approach, the likelihood of a potential impact on a specific receptor is the product of the likelihood of the spill occurring (Table 8.35) and the likelihood of receptor exposure as shown in Figure, 8.45 to Figure 8.59.

Spill scenarios were not modelled for a leak or spill from a compression platform. The use of a compression platform is only a contingency measure for the Project. If required, a compression platform would be installed adjacent to the WP therefore no greater inventory of hydrocarbons than those proposed for the WP would be necessary.

Additionally, spill scenarios (DHI 2010e, Appendix Q2) were modelled for diesel tank leak or rupture at the WP, assuming the entire loss of the diesel tank (135m^3). This is a volume greater than the potential loss of condensate from the production separator at the WP, which would largely evaporate on escape due to pressure and temperature conditions. As such, further modelling is not considered necessary.

Hydrocarbon leak or spill, as a result of grounding of an LNG or condensate ship, was not modelled and is considered unlikely to occur due to the following points:

- All restricted waterways and the proposed navigation channel will have IALA navigation beacons installed to delineate safe entrance and exit routes
- All restricted waterways have had detailed metocean analysis conducted, including current, wave and wind observations, to establish the required transit and berthing criteria
- Channel dimensions (depth, width) have been established utilising real-time simulation with vessel sizes, corresponding to the planned traffic requirements, and full tug interaction used in various failure scenarios
- The slow speeds at which ships will move through the proposed navigation channel and PLF basin
- Pilot and tug boats will be used to guide ships into the PLF
- Availability of weather warnings and the low occurrence of poor visibility conditions in the Project area
- Navigational aids, including admiralty charts and beacons, will be used at all times
- The design of the proposed navigation channel provides sufficient under-keel clearance for the largest vessel draft at LAT
- Only trained and experienced pilots, carrying PPU devices, will be used for restricted waterway navigation
- Only double hulled LNG and condensate ships will be used for product transportation
- Schedule management of all vessels arriving at, and departing from, the PLF will ensure that all initial cargos will be exported through the proposed navigation channel during daylight hours and without opposing traffic
- Vessels will be refused entrance to all restricted water ways and the PLF, or will depart in sufficient time, in the event of impending cyclonic conditions.

In the event of the grounding of a vessel near the PLF or in the proposed navigation channel, hull rupture is unlikely, given the seafloor is dominated by soft sediment and not rock.

The spill scenarios listed in Table 8.35 were modelled for winter, summer and transitional season periods. For the purpose of assessing potential impacts as a result of these spills, a statistical approach has been adopted which involves the running of multiple simulations for each scenario. The simulations differ only in the start time of the spill. This approach has been designed to account for the variability in wind and tidal conditions at the onset of the spill event as the direction of spill advection is highly dependent on prevailing wind and currents. Additionally, variations in spill degradation will occur in response to a range of weathering processes. It is important to note that the model outputs represent a "worst case".

Table 8.35: Modelled Hydrocarbon Spill Events

Scenario #	Leak/Spill Location	Leak/Spill Event	Total Spill Volume (m^3)	Composition	Water Depth	Temperature	Duration
1	Subsea well	Loss of well control, rig is not on location (production scenario)	165 380	Condensate	100 m	60˚C - ambient	90 days
2	WP	Diesel tank leak or rupture	135	Diesel	Sea surface	Ambient	10 minutes
3	Shipping Channel	Trunkline leak at shipping channel	5568	Condensate	30 m	25˚C - ambient	5 days
4	PLF	Condensate spill at PLF	100	Condensate	Sea surface	25˚C - ambient	1 minute
5	MOF	Fuel spill at the MOF	2.55	Diesel	Sea surface	Ambient	Instantaneous

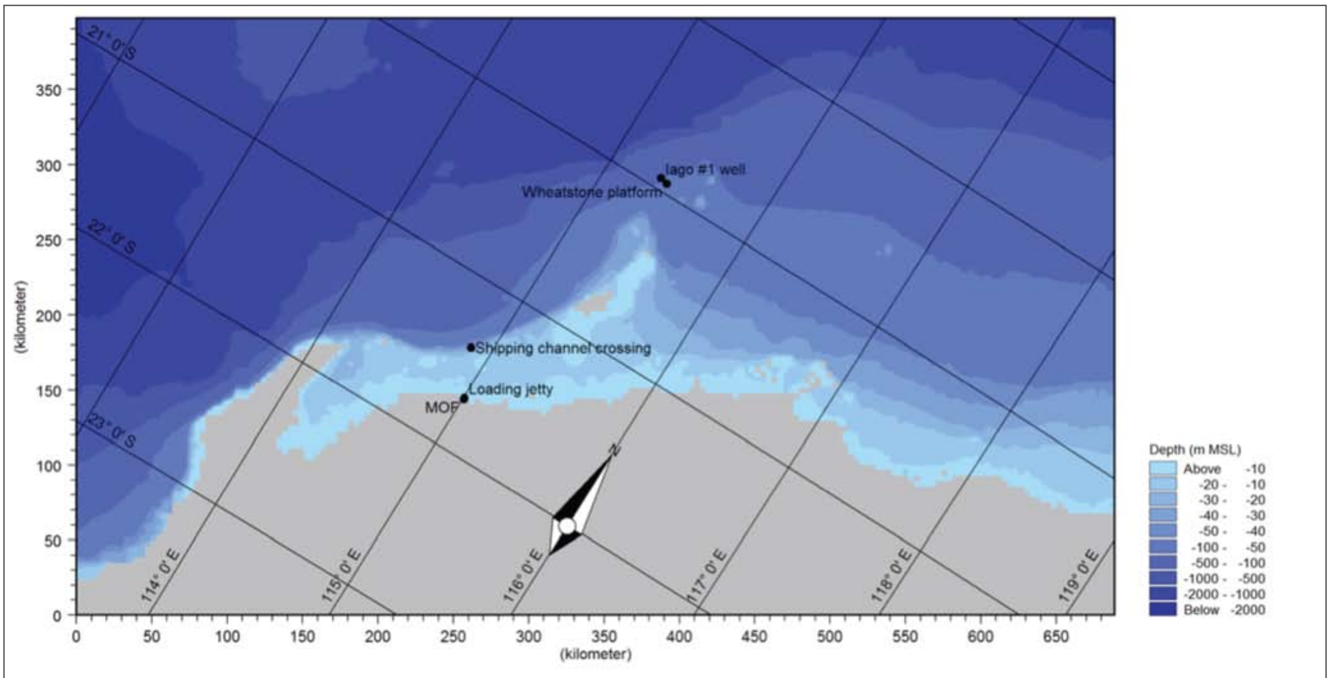


Figure 8.41: Location of Offshore and Nearshore Spill Events

Modelling Results

Due to the volume of the spill and the proximity to the coastline and sensitive receptors, the "worst-case" spill scenario is considered to be a leak or spill of 5568 m^3 of condensate over a five day period from a ruptured trunkline at the shipping channel crossing. This scenario is presented below to explain the type of information that is provided by the modelling. For each of the multiple simulations, the spill trajectory was tracked for a period of 15 days. Figure 8.43 and Figure 8.44 show the plume trajectory from a single simulation after Day 1 through to Day 15.

To assess the risk of exposure, the results of multiple spill simulations under a wide range of seasonal conditions have been combined into composite maps (envelopes) of maximum slick thickness, minimum time of arrival, and probability of exposure (per cent) of slick of 0.001 mm or more reaching any given area (DHI 2010e, Appendix Q2). When interpreting the figures it is important to understand that the composite maps represent the combined impact of a large number of simulations per spill scenario and are not snapshots in time.

The plots show where one or more of the simulations may have predicted the spill to be present at some stage. Only the probability of exposure maps for all climatic scenarios are presented here for the purpose of explanation. Full model simulations of maximum oil thickness and minimum oil arrival times are presented in DHI (2010e, Appendix Q2).

The probability of exposure to condensate leaking from an offshore well that has lost control over 90 days (Scenario 1, Table 8.34) during summer (Figure 8.45), during the transitional period (Figure 8.46) and during winter (Figure 8.47) is presented below. The probability of the condensate spill at the offshore well impacting BPPH on the coastline is the product of the low likelihood of the event occurring in the initial instance multiplied by the likelihood of exposure under particular weather conditions. There is a five to ten per cent probability of BPPH along the coastline including the Ningaloo Marine Park, being exposed to condensate from a leaking subsea well, only during the transitional period (i.e. autumn). The weathering over the ten days, taken for the condensate to reach the marine park, would be significant and most condensate would have evaporated within five days of release. The BPPH at the intertidal zones of Barrow and Montebello Islands have the greatest risk of exposure to a condensate leak or spill at the offshore well during the summer and transitional periods (Figure 8.45 and Figure 8.46). It is important to note that the spill plume leaves the figure domain at the northern boundaries in summer (Figure 8.45) and the western boundaries in winter (Figure 8.47), however there are no known sensitive environmental receptors northward or westward of the figure domain .

Composite figures showing the probability of condensate exposure during summer, winter and transitional periods, arising from a ruptured trunkline in the shipping channel, are presented in Figure 8.51 to Figure 8.53.

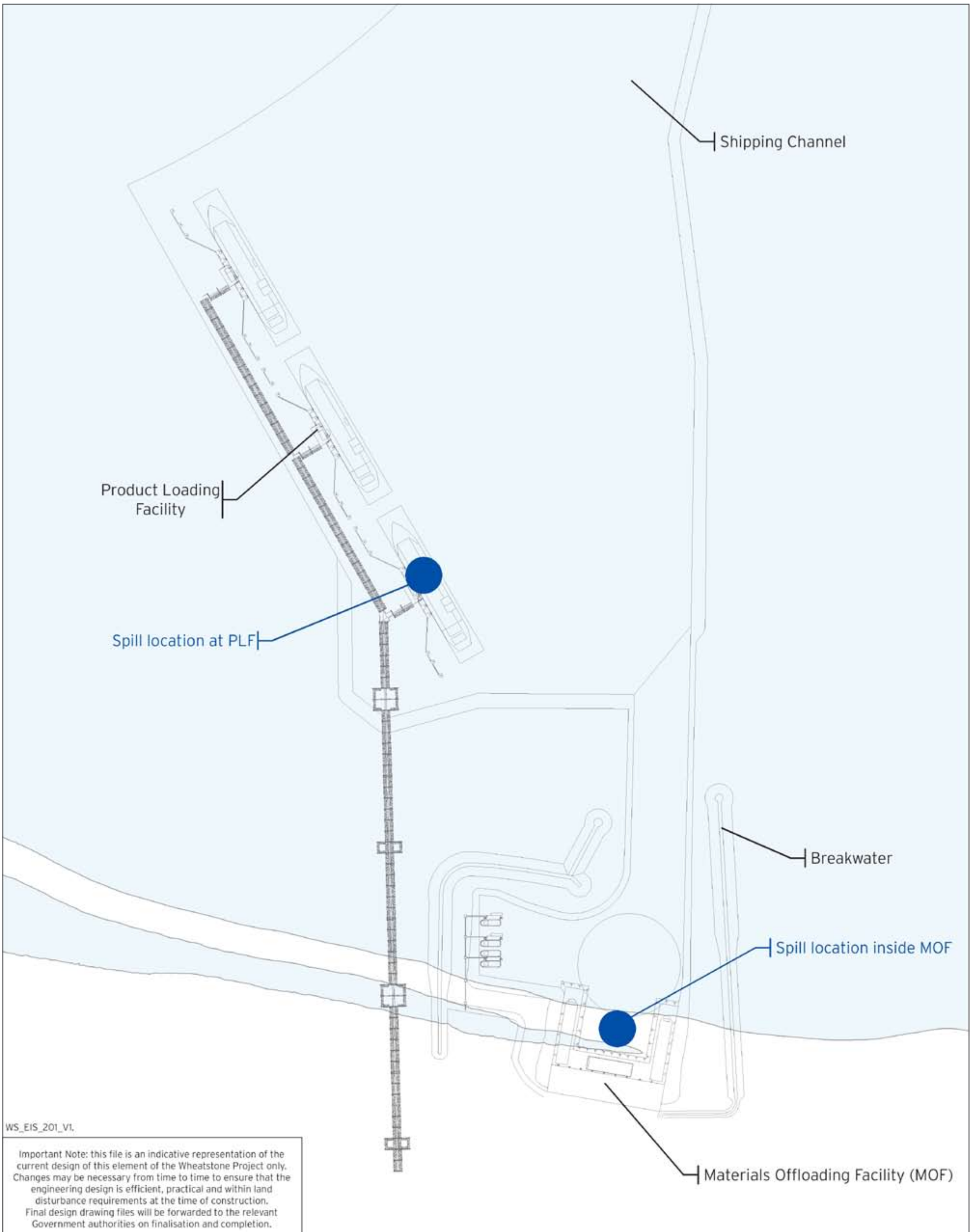


Figure 8.42: Nearshore Spill Locations at PLF and inside MOF

The models predict that diesel spills arising from a ruptured tank at the WP (Scenario 2, Table 8.34) poses limited risk of impacting BPPH (Figure 8.48 to Figure 8.50).

However, condensate leaks and spills that occur in the nearshore area (Scenario 3, Scenario 4, Table 8.34) pose the greatest risk to BPPH (Figure 8.51 to Figure 8.56) although the likelihood of occurring is low (Table 8.34). The probability of exposure from condensate leaks and spills occurring in the shipping channel or the PLF is greatest for BPPH on the coastline (up to 50 per cent), including the Ningaloo Marine Park (up to five per cent), and at Barrow Island (up to 40 per cent). In reality, on leak detection it is likely the trunkline would be blowndown rapidly and the leak rate reduced. The modelled scenario is considered conservative, as the initial leak rate would reduce rapidly and the duration of the leak is likely to shorten. Majority of the condensate would evaporate as gas on escape and weathering would reduce the toxicity of a number of the more volatile components prior to impacting the BPPH.

Diesel leaks and spills at the MOF (Scenario 5, Table 8.34) also pose a risk to BPPH along the coastline (Figure 8.57 to Figure 8.59); however, the area of predicted impact is much smaller than nearshore condensate leaks and spills. No inclusion of spill response (such as boom deployment) has been assumed. The close proximity of both the PLF and the MOF to mangrove habitats, means that the likelihood of adverse impacts on a large scale is high in the unlikely event that a hydrocarbon leak or spill occurs. To predict the overall risk of a hydrocarbon leak or spill impacting BPPH, the probability of a hydrocarbon reaching a BPPH must be considered in the context of the very low probability of a leak or spill occurring (Table 8.34).

Potential Impacts to Offshore BPPH

The direct impacts of hydrocarbon leaks and spills at offshore locations are likely to be minimal. Firstly, few BPPH occur in deep water locations due to the limited penetration of sunlight required for photosynthesis. Secondly, due to their low density and highly hydrophobic nature, spilled hydrocarbons remain mostly on the sea surface and do not come into contact with the few BPPH that occur in deep waters. Therefore, the risk of impacts to BPPH at offshore locations is minimal. In the event that a large spill or leak occurs offshore there may be some risk of impacts to nearshore (corals and seagrass) and coastal (mangroves) BPPH. This will, however, be determined by size and duration of the spill, and prevailing weather and metocean conditions at the time of the leak or spill.

Potential Impacts to Nearshore BPPH

Nearshore leaks and spills pose the greatest risks to BPPH due to their greater abundance in the nearshore environment. Mangroves are the BPPH at greatest risk from nearshore hydrocarbon leaks and spills. Their niche within the intertidal zone results in the surface of the plants being in regular contact with the water's surface. Therefore hydrocarbons are more likely to come into contact with the surface of mangrove plants. BPPH such as corals, seagrass and macroalgae are much less susceptible to impacts by hydrocarbon leaks and spills. The very small proportion of corals, seagrasses and macroalgae that are exposed to the sea surface during LAT will be impacted, only if a spill or leak event coincides with such a tidal event. Finally, it is also possible that a hydrocarbon leak or spill that occurs during the annual mass coral spawning period may impact on coral propagules that are dispersed by currents on the water's surface. However, corals only mass spawn for brief periods in the Pilbara region (Baird 2009).

Potential Impacts to Onshore BPPH

Hydrocarbon leaks and spills that occur onshore have the potential to impact BPPH within the intertidal environment, in the event that hydrocarbons enter the marine/estuarine environment. The BPPH at greatest risk are mangroves, algal mats and bioturbated samphire zones.

Potential Impacts to BPPH

Mangroves

Mangrove habitat in the Project area is described in Chapter 6, *Overview of Existing Environment*. Mangroves are highly sensitive to hydrocarbon spills, which can cause major defoliation and mortality (e.g. Duke & Burns 1999). The physical smothering of aerial roots (pneumatophores) causes damage to the mangals, while the chemical composition of the hydrocarbon may cause leaf loss. Subsurface feeding roots can also be smothered, effectively starving the tree (Duke & Burns 1999), while regenerated aerial roots have been observed to be deformed (Peters *et al*. 1997). Tropical flora have higher respiratory rates than their cooler water counterparts and they exist on the cusp of their lower oxygen level tolerance limit. Spilt hydrocarbons have a high biological oxygen demand, which exacerbates the oxygen shortage (Peters *et al*. 1997). Additionally, the aromatic components of the hydrocarbon may be relocated to other parts of the plant, prolonging its toxic effects, while they are also thought to be able to impair the salt exclusion process (IPIECA 1993). Long-term impacts of a hydrocarbon spill can include seedling failure, while indirect coinciding impacts include the loss of epifauna that use mangrove areas as habitat.

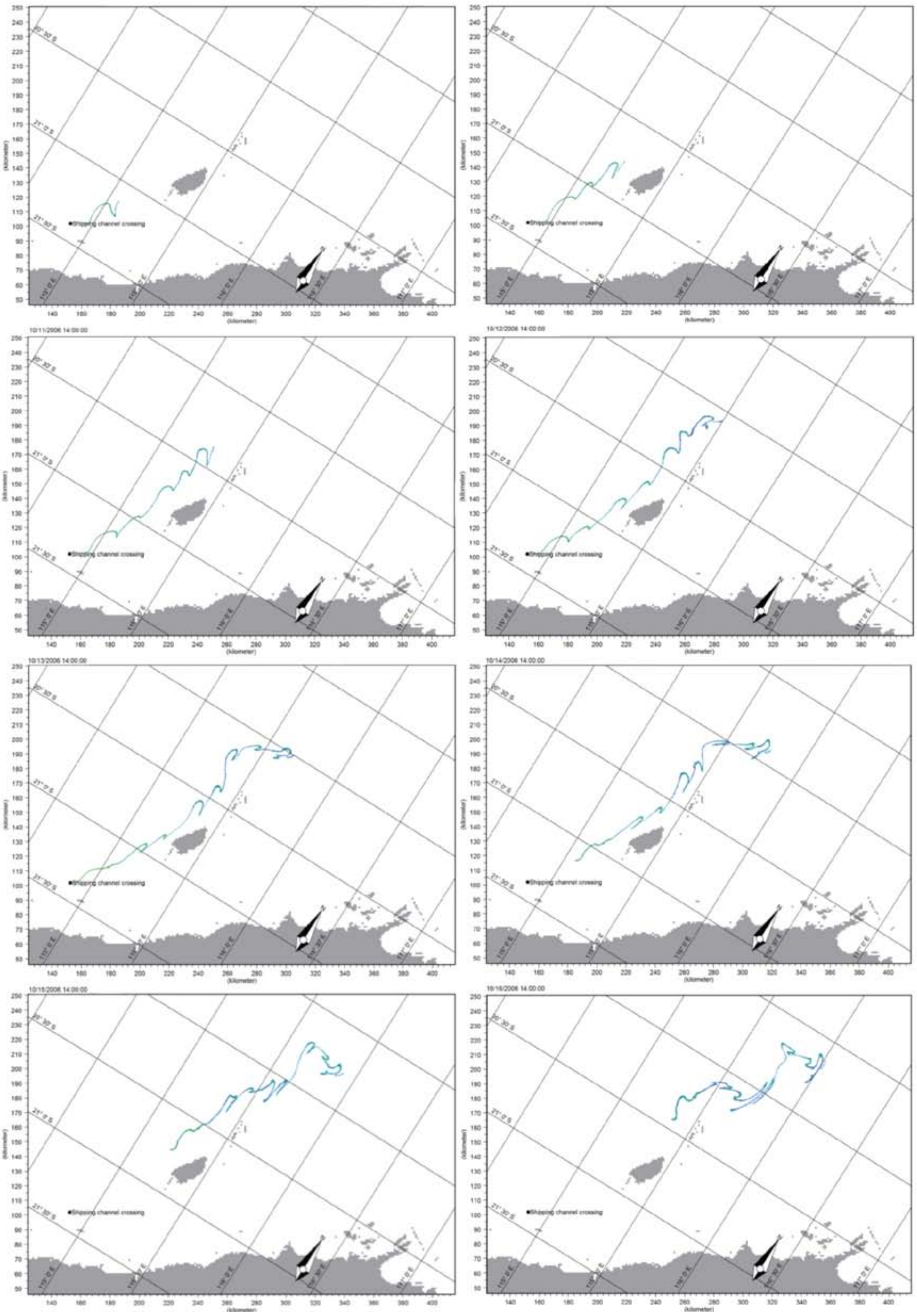


Figure 8.43: Spill Simulation for Ruptured Subsea Trunkline at the Shipping Channel Crossing (summer period), Simulation Results Shown After 1, 2, 3, 4, 5, 6, 7, and 8 Days (read from left to right)

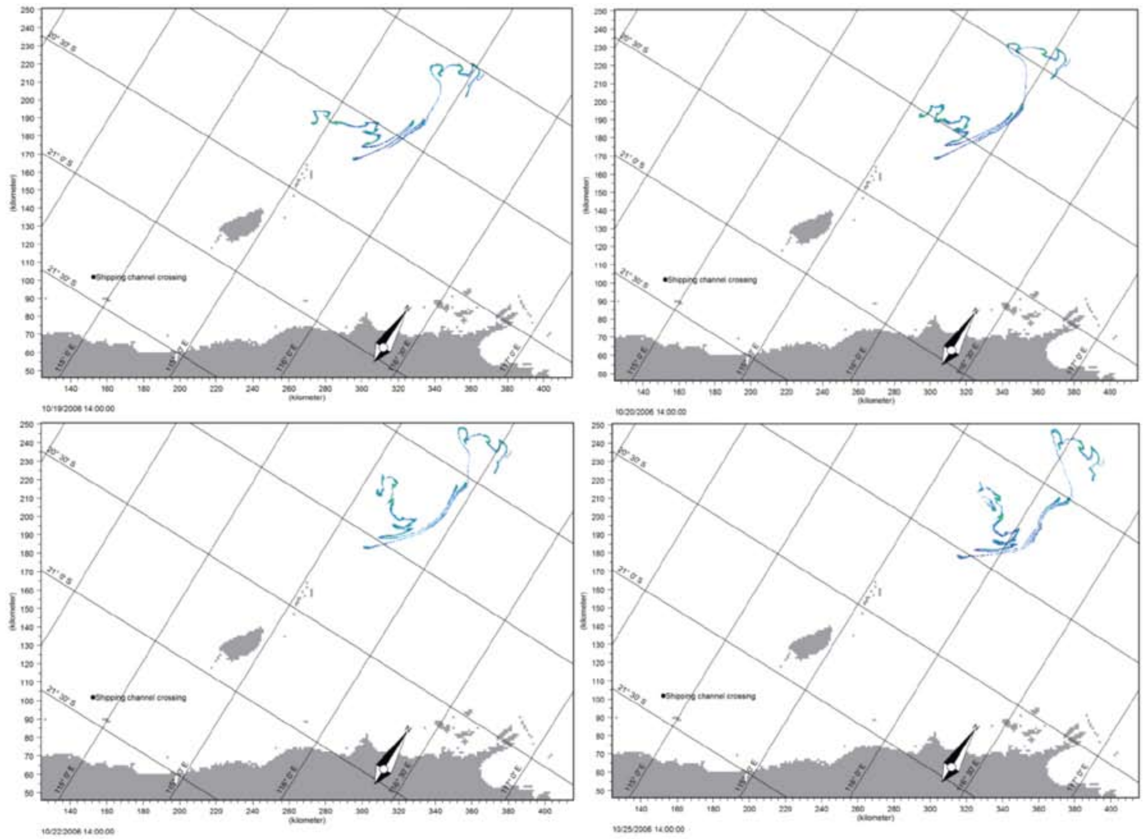


Figure 8.44: Spill Simulation for Ruptured Subsea Trunkline at the Shipping Channel Crossing (summer period), Simulation Results Shown after 9, 10, 12, and 15 Days (read from left to right)

As mangroves tend to occur in sheltered nearshore areas with low wave action, remediation of hydrocarbon from within the habitat can be extremely difficult and can remain a long-term issue (Peters *et al*. 1997). In addition, it is possible for certain types of sediment to entrain the hydrocarbons and slowly release them over time, thus delaying the impact by way of decreasing seed recruitment and retarding recovery for remaining mangals (Duke & Burns 1999). This occurs particularly easily around root systems as the root acts as a pathway where hydrocarbons are able to permeate deeper into the sediment. Although little data exists with regard to long-term function and sustainability of oiled mangals, it is suggested that, over decades, partial habitat loss may still occur along with a loss in canopy cover by between 20 and 30 per cent (Duke & Burns 1999). However, previous studies indicate that offshore gas field condensate is toxic to seedlings and can result in mortality (Duke *et al*. 1998), however "deceased" mangals are able to partially recover and recolonise disturbed areas, seven years after the original spill (Woodside 2006).

Coral Communities

Coral communities in the Project area are described in Chapter 6, *Overview of Existing Environment*. Hydrocarbons have the potential to affect corals in a number of ways. Physical oiling of coral tissue can cause a decline in metabolic rate and may cause varying degrees of tissue decomposition and death (Jackson *et al*. 1989 in Negri & Heyward 2000). Corals secrete mucus, more so when stressed, and entrained hydrocarbons will tend to cling to the mucus, thus resulting in smothering. Hydrocarbons may also cling to certain types of sediment causing oil to sink to the seafloor, covering corals in oiled sediment (IPIECA 1993). A surface slick of spilt hydrocarbons may limit the amount of light penetrating the water, limiting the photosynthetic ability of the associated zooxanthellae (Guzman *et al*. 1994).Corals in the intertidal or shallow subtidal will be susceptible to direct oiling from spilt hydrocarbons. Corals are more susceptible to hydrocarbons on the sea surface than from the dissolved hydrocarbon components (aromatic fractions) within the water column which are thought to be more toxic than the floating surface slicks (Volkman *et al*. 1994).

There is little literature regarding ongoing impacts to reproduction and juvenile recruitment, however the number and size of sex organs, spawning, fertilisation, gametogenesis and larval development may all be impacted by the presence of hydrocarbons (Fadlallah 1983; Negri & Heyward 2000; Guzman & Holst 1993). Evidence of the recovery of coral communities after spill events exists (Dubinsky & Stamble 1996), however recovery times are highly dependent on species type and can be in excess of 10 years.

Seagrass

Seagrass habitat in the Project area is described in Chapter 6, *Overview of Existing Environment*. There is little data available with regard to the interaction between seagrass and petroleum hydrocarbons within a tropical intertidal environment with most data describing impacts in temperate areas and to more tolerant species (Volkman *et al*. 1994). Direct impacts may include mortality, due to smothering and chemical toxicity, and indirect impacts due to light loss, decrease in habitat and the accumulation of potentially carcinogenic or mutagenic substances (Peters *et al*. 1997). It is likely, however, that impacts in intertidal areas would be similar to those for impacts to mangrove habitat. As with coral communities, the degree of impact is dependent on the seagrass species and the type of hydrocarbon spilt. The seagrass-dependant fauna is usually more heavily impacted. Seagrass in the intertidal zone is most likely to be impacted by surface slicks, which decreases the amount of light that is able to penetrate through the water column in the event of a large spill. The decline in cover of seagrass may have indirect impacts on the juvenile life stages of recreationally and commercially important fish and crustacean species that utilise seagrass meadows as a nursery ground (Skilleter *et al*. 2005).

No known meadows of perennial seagrass genera, such as *Thalassodendron* or *Enhalus*, occur in the Project area. Rather, the area is characterised by species such as *Halophila* spp. Seagrasses recorded in surveys of the Project area are generally sparsely distributed (<ten per cent cover), occurring in small patches within larger areas of suitable substrate, as shown in Figure 8.26. The *Halophila* genus is known to rapidly recolonise areas after natural disturbance events (Lanyon & Marsh 1995).

Macroalgae

Macroalgae distribution in the Project area is described in Chapter 6, *Overview of Existing Environment*. As with seagrass, little data exists with regard to impacts to algae beds in tropical intertidal areas (Volkman *et al*. 1994). With the majority of the published data relating to impacts to algal beds on rocky temperate shores. Studies have demonstrated the ability of algae to be exposed to high volumes of hydrocarbon pollution and to recover from this. Recovery is most likely due to the fact that new growth originates from the base of the organism, and that a layer of mucilage is present on most species, preventing the penetration of toxic aromatic fractions (Volkman *et al*. 1994). This was also reported by Connell *et al*. (1981) who suggest that fine hairs, complex frond arrangement and the thickness of the mucilage covering may determine how much oil is trapped within or on the surface of the algae, thus determining its chance of survival. As with coral and seagrass, recovery is highly dependent on the species involved and the hydrocarbon type, however at some locations recovery has occurred between 12 and 18 months after the initial impact. Algae has also been observed to colonise areas of coral, impacted by a spill. However, it is proposed that sedimentation of hydrocarbons reduce the amount of suitable substrate on which algae spores can settle and become established (Connell *et al*. [1981]).

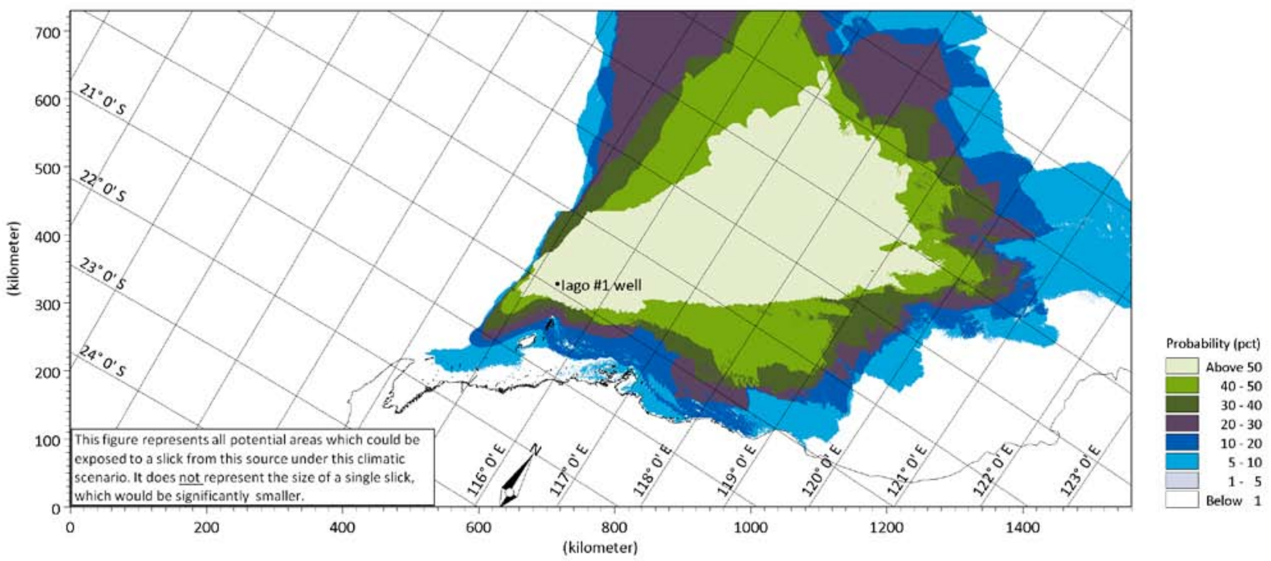


Figure 8.45: Condensate Leak from Loss of Well Control at Iago #1 Well, Summer, Probability of Exposure

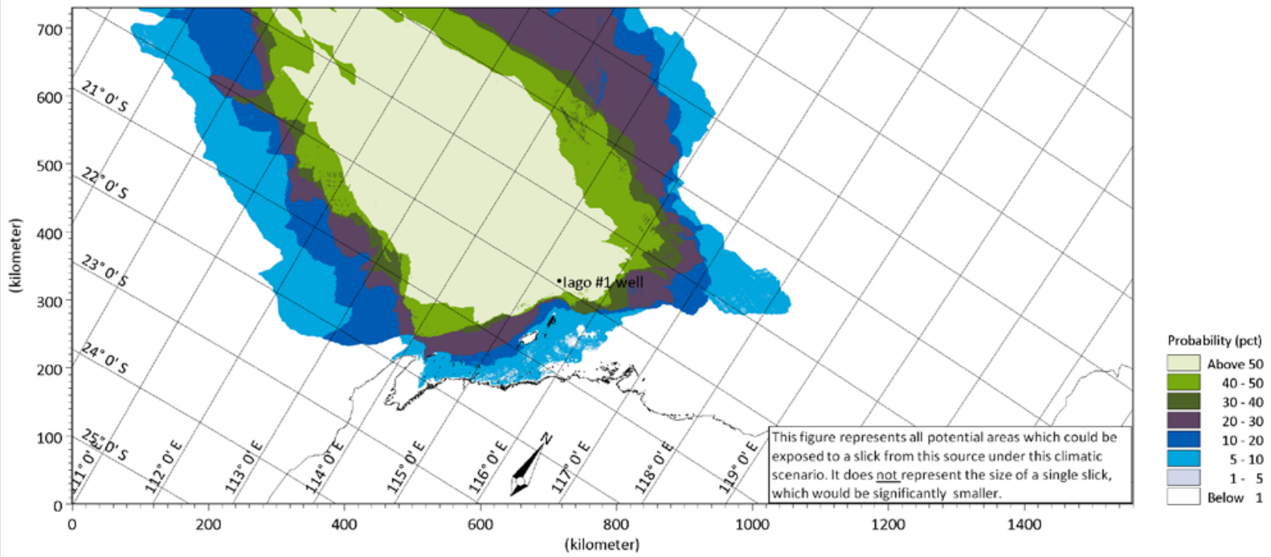


Figure 8.46: Condensate Leak from Loss of Well Control at Iago #1 Well, Transitional Periods, Probability of Exposure

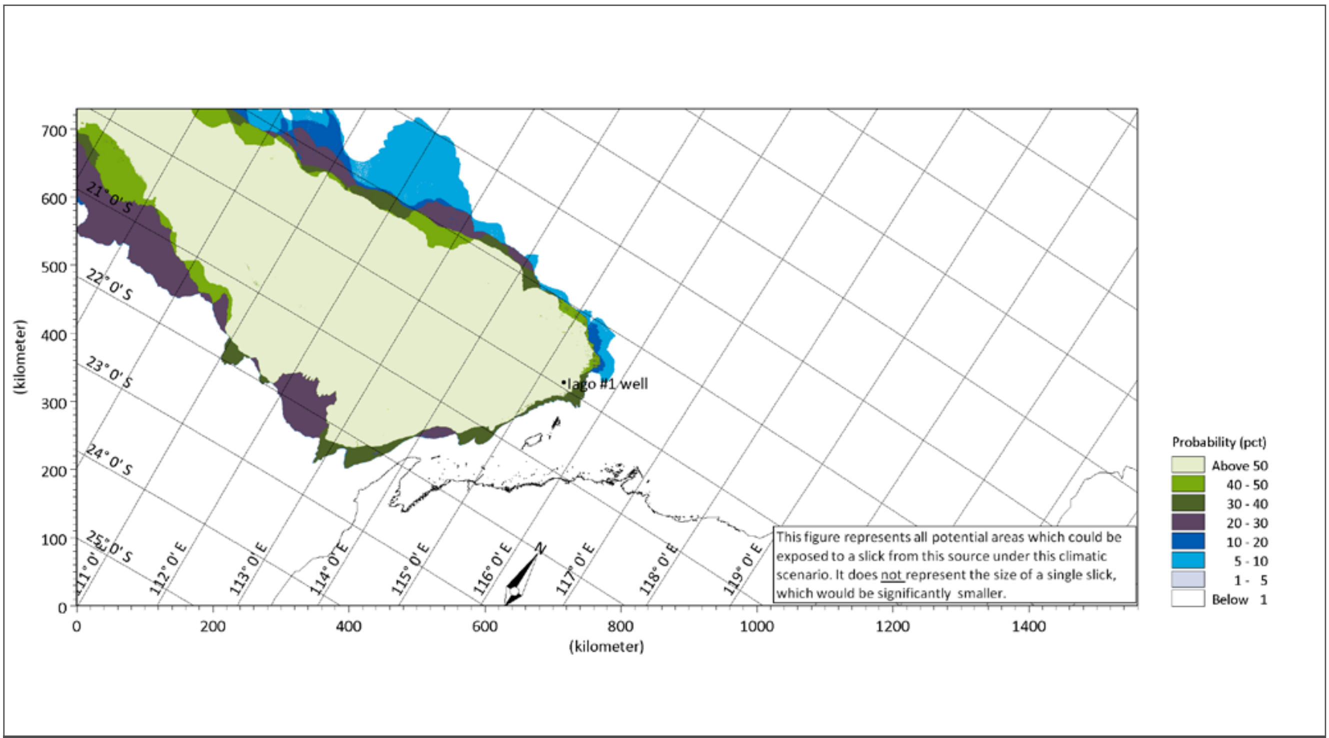


Figure 8.47: Condensate Leak from Loss of Well Control at Iago #1 Well, Winter, Probability of Exposure

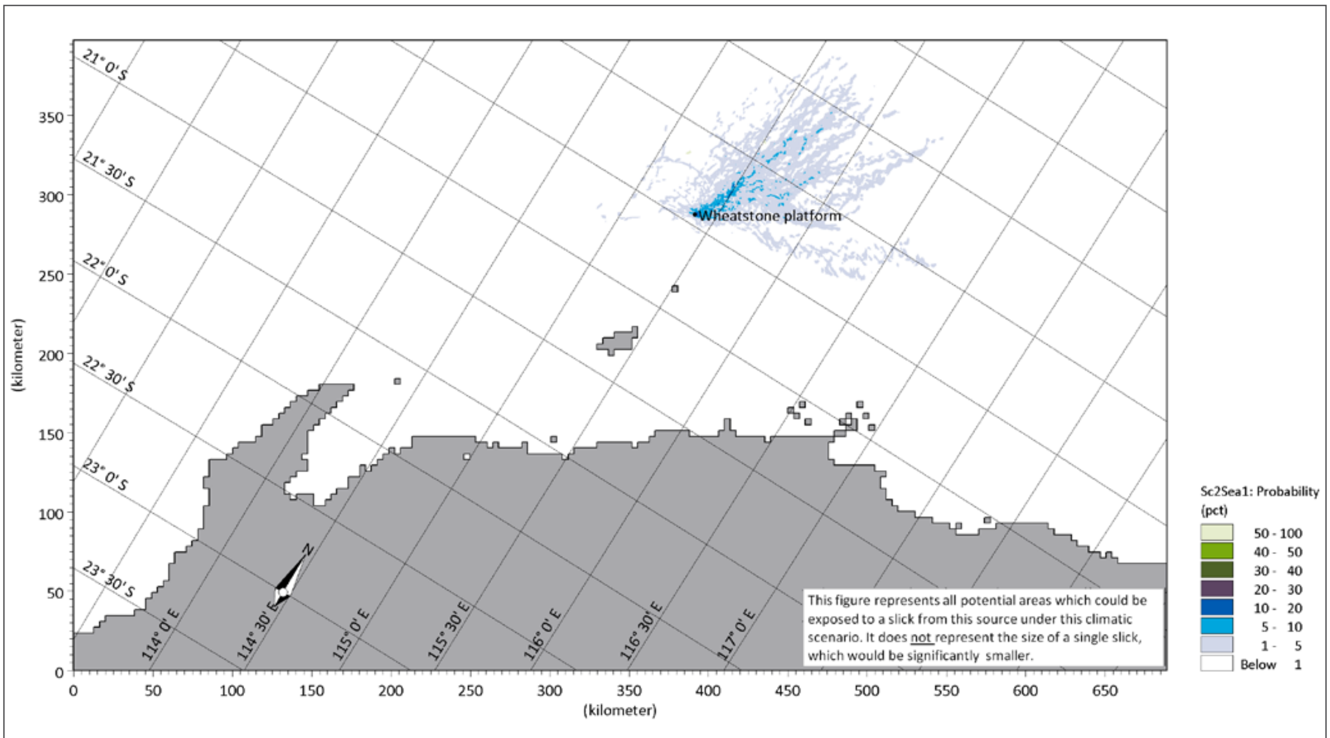


Figure 8.48: Diesel Spill at Wheatstone Platform, Summer, Probability of Exposure

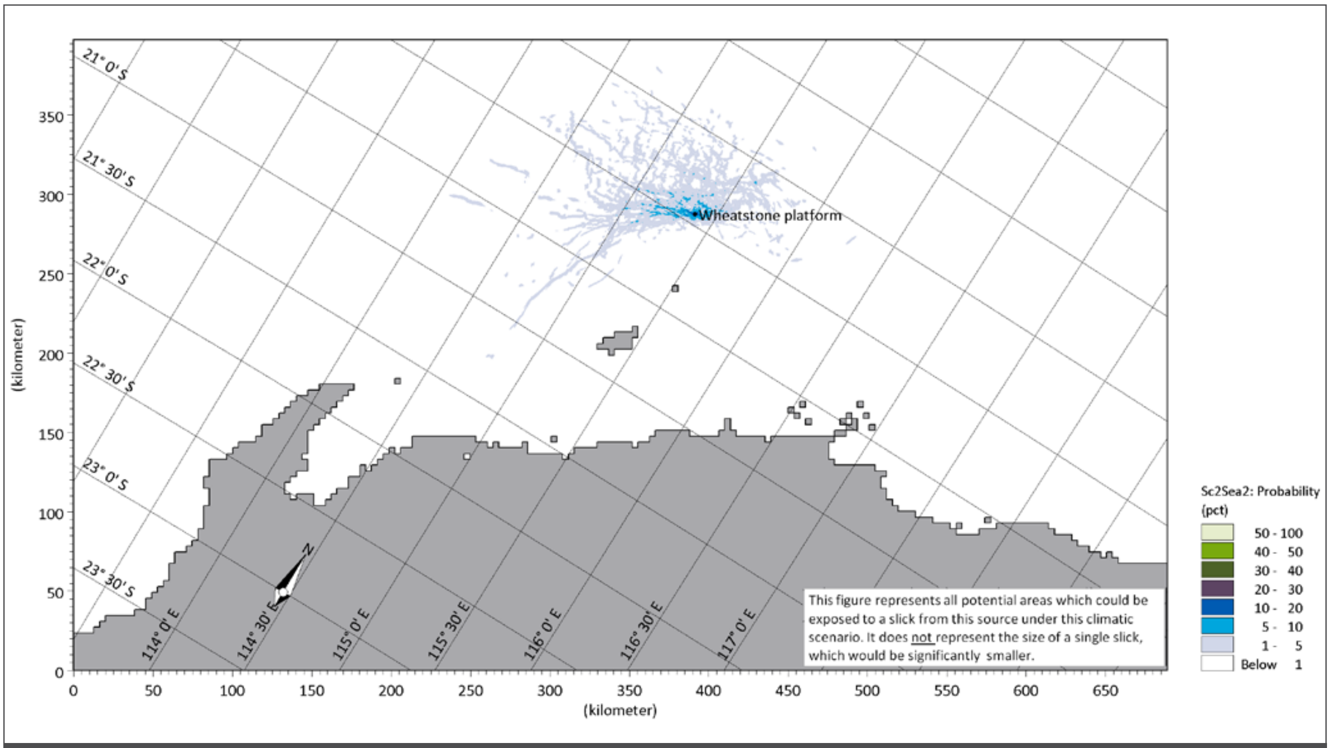


Figure 8.49: Diesel Spill at Wheatstone Platform, Transitional Periods, Probability of Exposure

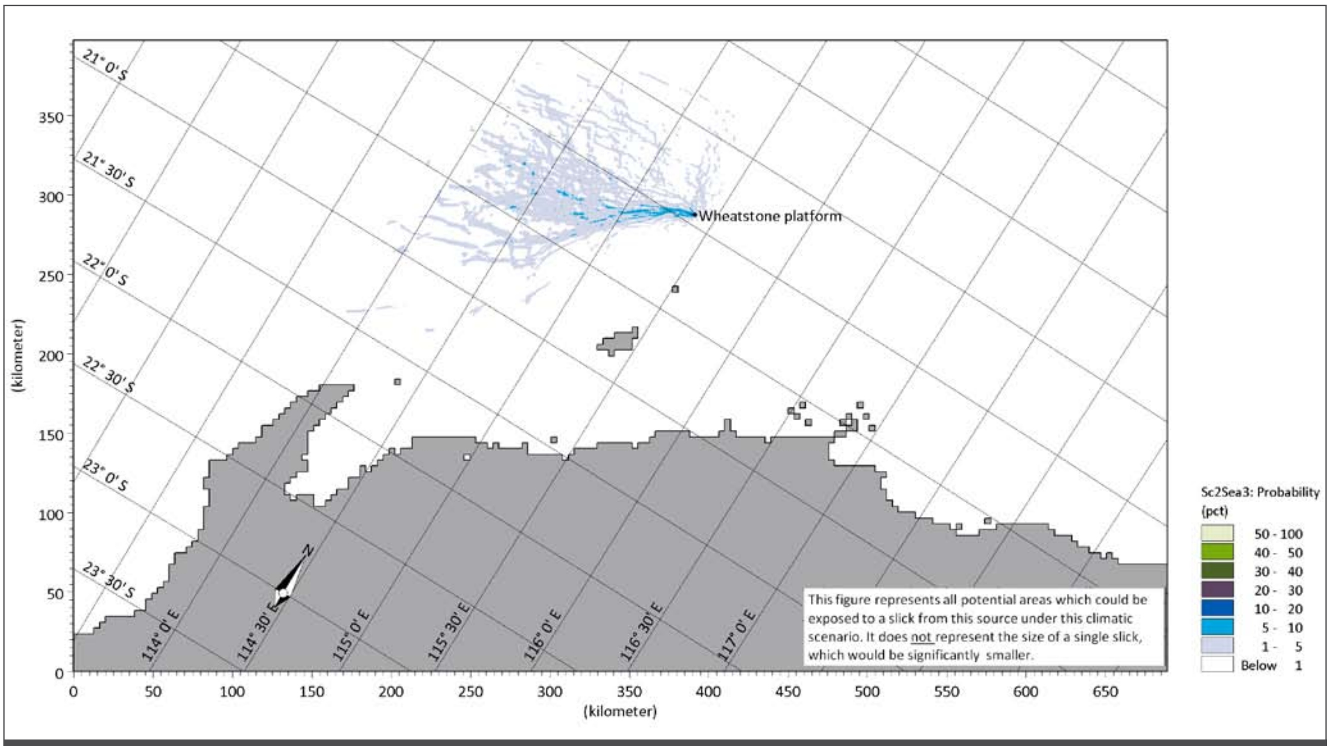


Figure 8.50: Diesel Spill at Wheatstone Platform, Winter, Probability of Exposure

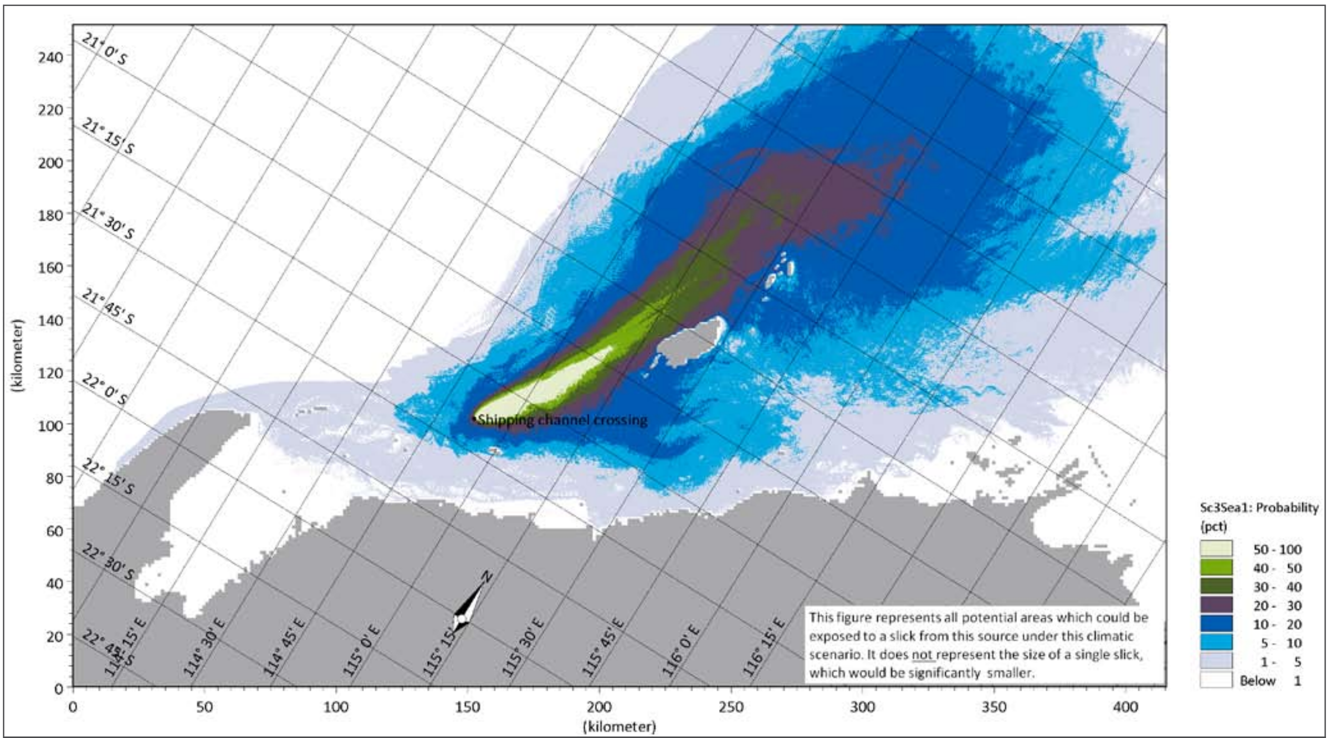


Figure 8.51: Condensate Leak or Spill at Shipping Channel, Summer, Probability of Exposure

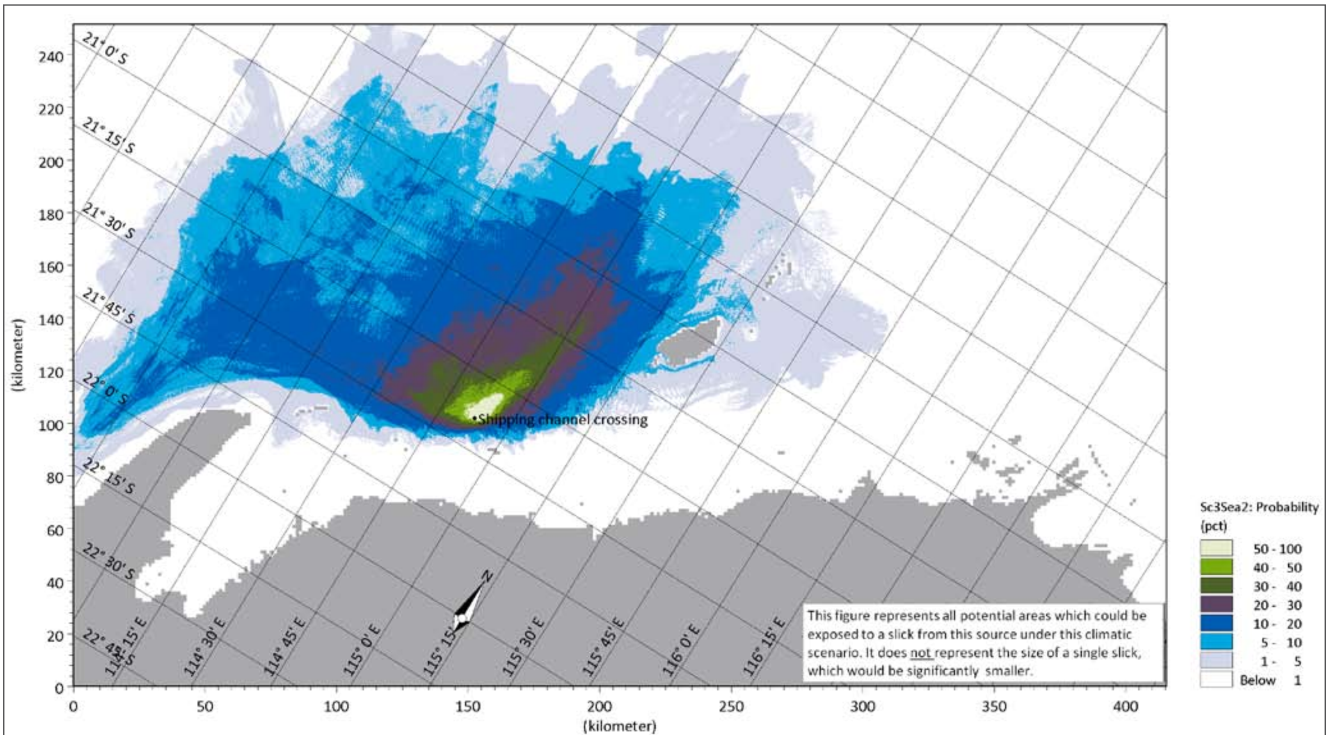


Figure 8.52: Condensate Leak or Spill at Shipping Channel, Transitional Periods, Probability of Exposure

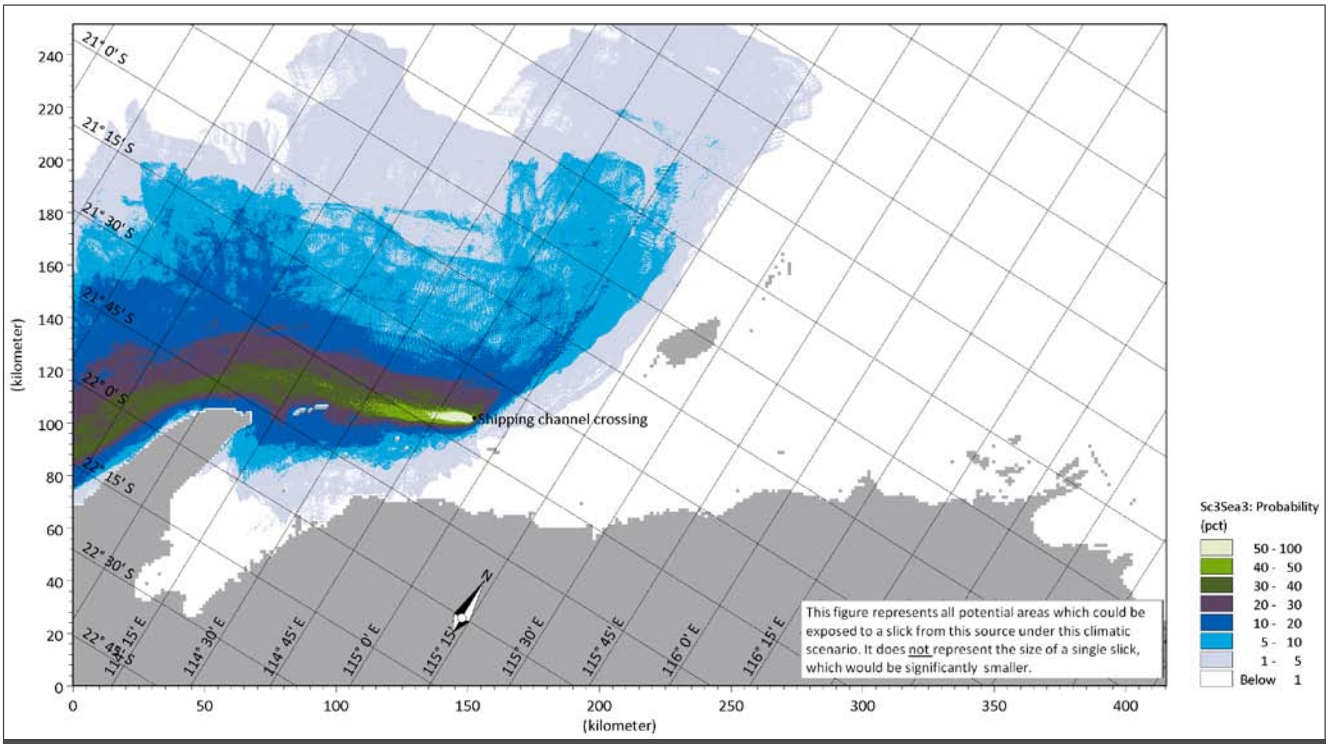


Figure 8.53: Condensate Leak or Spill at Shipping Channel, Winter, Probability of Exposure

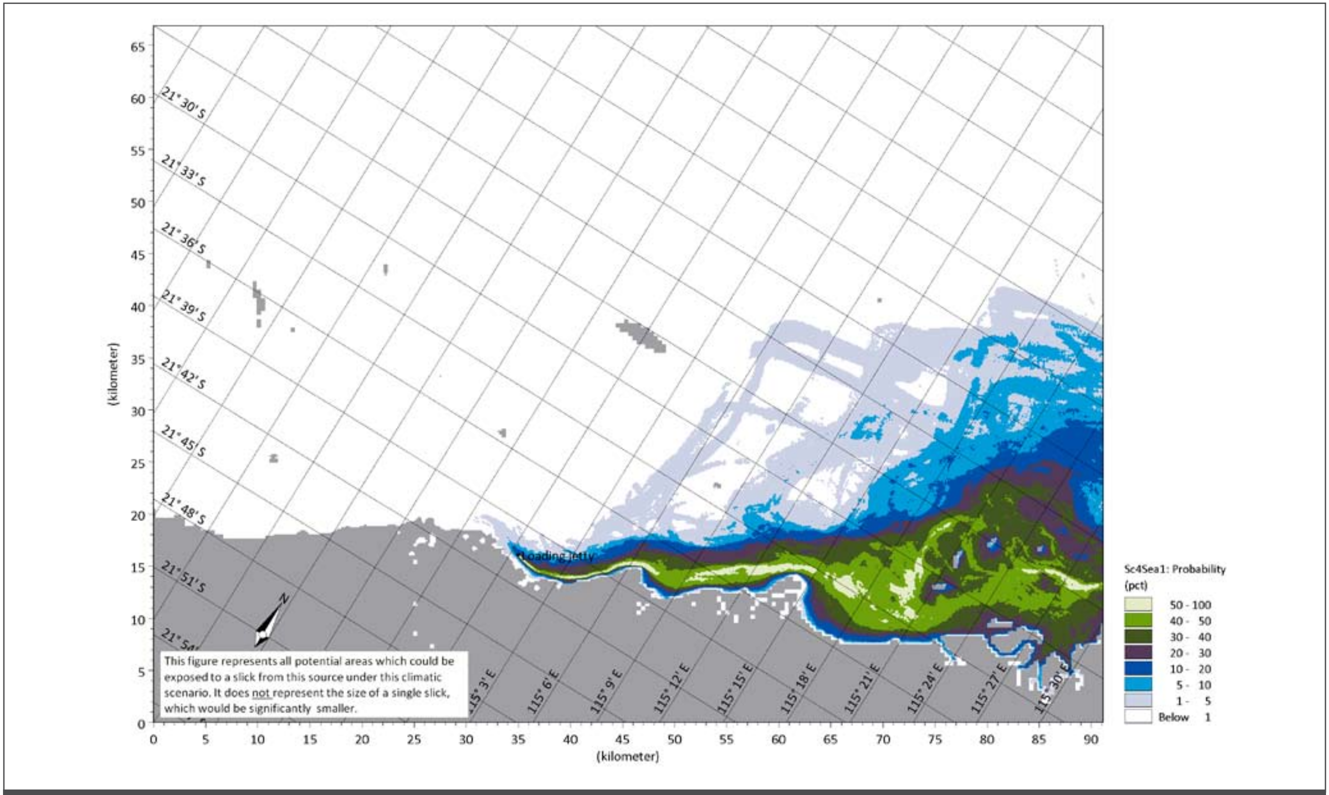


Figure 8.54: Condensate Spill at PLF, Summer, Probability of Exposure

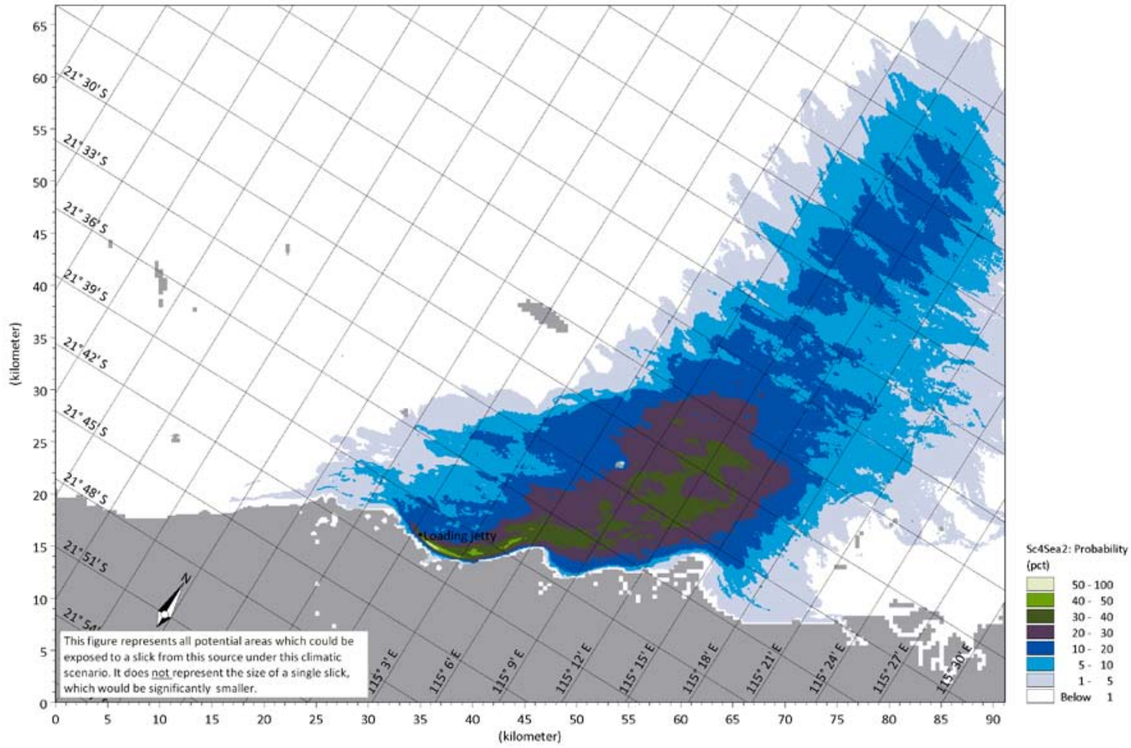


Figure 8.55: Condensate Spill at PLF, Transitional Periods, Probability of Exposure

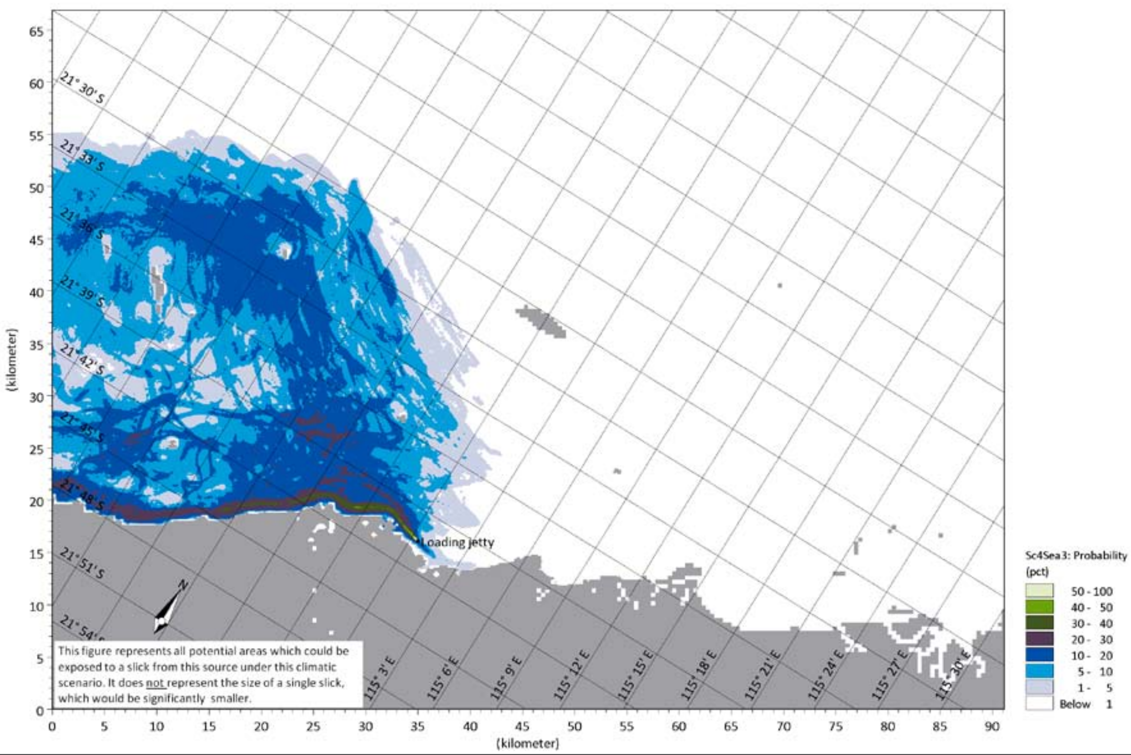


Figure 8.56: Condensate Spill at PLF, Winter, Probability of Exposure

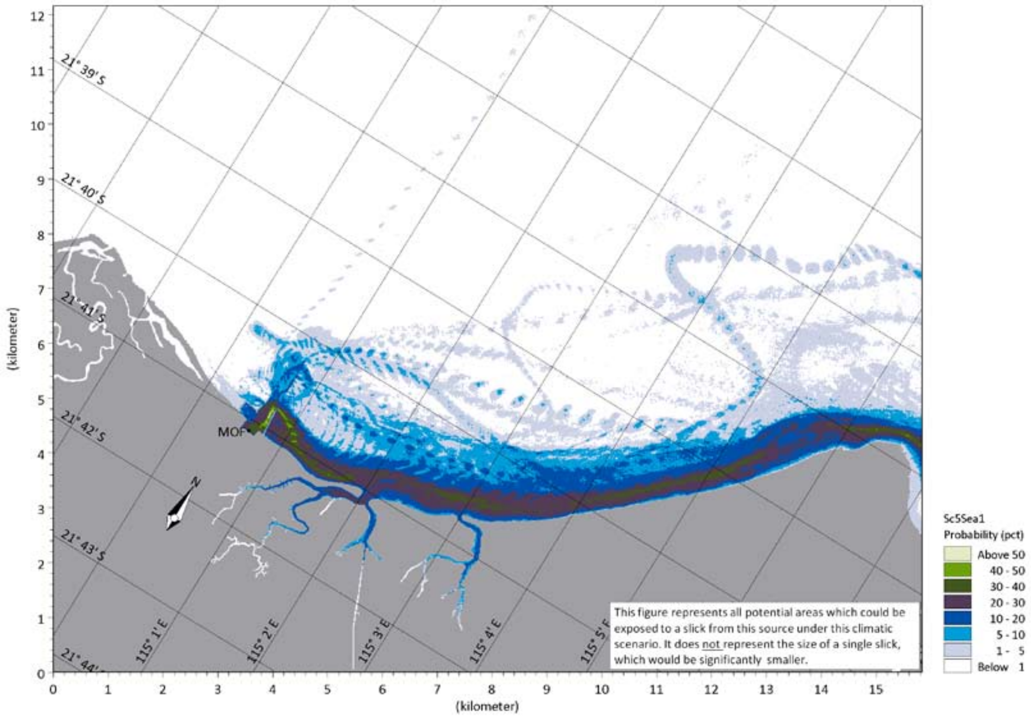


Figure 8.57: Diesel Spill at MOF, Summer, Probability of Exposure

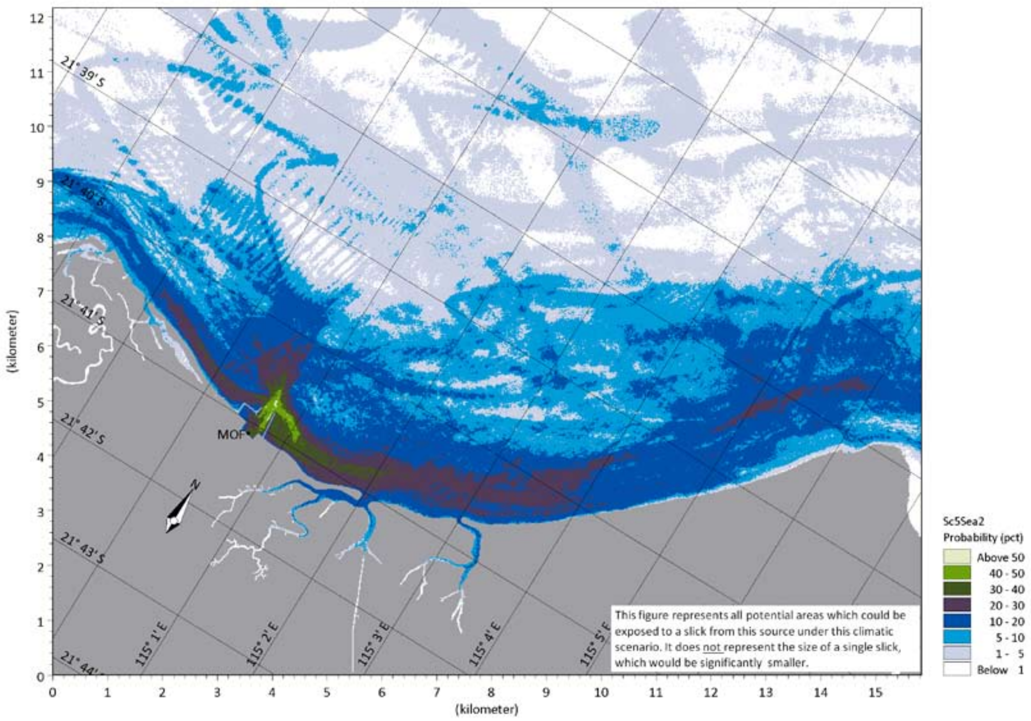


Figure 8.58: Diesel Spill at MOF, Transitional Periods, Probability of Exposure

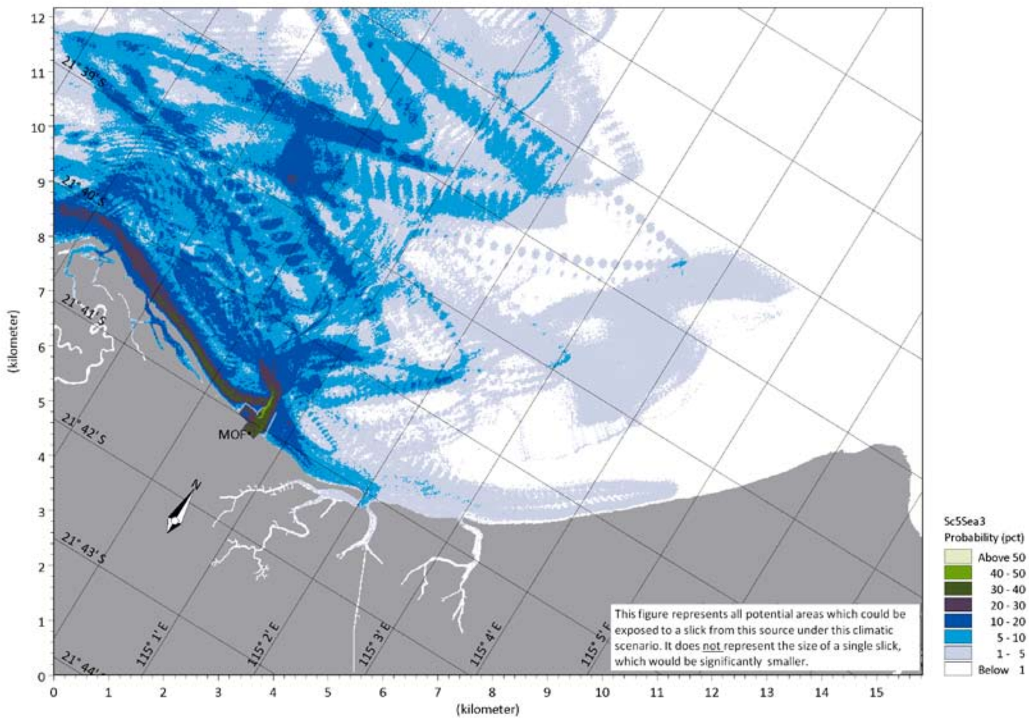


Figure 8.59: Diesel Spill at MOF, Winter, Probability of Exposure

8.3.5.15 Offshore Hydrocarbon Leaks and Spills

Residual risk to benthic habitats from offshore leaks and spills is	**Low**

Potential leaks and spills from the Project have been described in Chapter 2, *Project Description*. Details of field investigation and characterisation of BPPH in the offshore Project area are documented in URS (2009d, Appendix N9). Characterisation of potential leaks and spills from the Project area are found in Chapter 4, *Emissions, Discharges and Wastes*. The proposed management and mitigation measures for this activity are given in Table 8.37.

The probability of an offshore hydrocarbon leak or spill occurring is very low (Table 8.34), which, coupled with the low probability of hydrocarbons reaching BPPH (from zero per cent to 20 per cent), results in a prediction that offshore hydrocarbon leaks and spills pose very little risk to BPPH. The low risk is partly a consequence of the remoteness of the platform from land and associated intertidal BPPH. Should spilled condensate reach the shores of the Montebello Islands or Barrow Island, most of the volatile toxic components will have evaporated or weathered considerably and impacts are unlikely to be significant.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that offshore leaks and spills of hydrocarbons will result in impacts to BPPH. The residual environmental risk for this potential impact was assessed as being “Low” – of “Massive” consequence, arising from the potential for irreversible loss or damage to 100 per cent of BPPH causing exceedence of the EPA CLGs, and “Remote” likelihood, arising from the remote location of the WP to sensitive BPPH receptors.

8.3.5.16 Nearshore Hydrocarbon Leaks and Spills

Residual risk to benthic habitats from nearshore leaks and spills is	**Medium**

Nearshore hydrocarbon leaks and spills present the greatest risk to BPPH. These include condensate leaks and spills in the shipping channel and at the PLF (Figure 8.42). Leaks and spills of condensate at these locations pose the greatest risk to BPPH within the Ashburton River Delta and the Hooley Creek tidal creek system, and intertidal BPPH at Barrow Island, Montebello Island, and the Ningaloo Marine Park (Figure 8.51 to Figure 8.56). Diesel leaks and spills at the MOF (Figure 8.42) also pose a risk for BPPH within the Ashburton River Delta, the Hooley Creek-Four Mile Creek system, and the intertidal BPPH along the immediate coastline.

Hydrocarbon leaks or spills that occur at the PLF or MOF are predicted to rapidly gain access to the mangrove habitat of the Ashburton River Delta and could result in large-scale mortality of mangroves in this highly sensitive area.

To correctly assess the overall risk of nearshore hydrocarbon leaks and spills to BPPH within the vicinity of the Project area, it is necessary to incorporate the probability of a leak or spill occurring in conjunction with the probability of hydrocarbons reaching BPPH in the event of a leak or spill. Given the extremely low probability of a leak occurring in the nearshore area (Table 8.34), the overall risk to BPPH is much lower than the probabilities shown in Figure 8.45 to Figure 8.59. Additionally it is important to note that the model outputs, conservatively, do not take into account the use of any mitigation measures for the management of spread of any leaks or spills to BPPH in the nearshore area.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that nearshore leaks and spills of hydrocarbons will result in impacts to BPPH. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Catastrophic" consequence, arising from the potential disturbance to the nearby Ashburton River Delta and Hooley Creek-Four Mile Creek mangrove systems and other nearshore BPPH, and "Remote" likelihood, arising from the low probability of a leak or spill occurring in the nearshore environment.

8.3.5.17 Onshore Hydrocarbon Leaks and Spills

Residual risk to benthic habitats from onshore leaks and spills entering the marine environment is	**Very Low**

The BPPH at risk from onshore spills are the mangroves and samphires of Hooley Creek, because plant stormwater drainage could potentially enter the Creek. All areas of the plant which are in potential contact with hydrocarbons will be drained to a treatment plant to remove any oil contained in water. In addition, all condensate and diesel tanks will be bunded to hold the required volume of fluid contents in the event of tank failure. Therefore the likelihood of hydrocarbons escaping from the plant is very low.

Should an escape occur, the scale of impacts will depend very much on the volume released and the height of tide at the time of release. A wide range of impact scales is possible from negligible loss/damage of BPPH to substantial loss/damage of BPPH inside Hooley Creek. Given the bunding and plant drainage system proposed, the scale of any release is unlikely to be large.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that onshore leaks and spills of hydrocarbons will result in impacts to BPPH. The residual environmental risk for this potential impact was assessed as being "Low" – of "Moderate" consequence, arising from the potential for reversible, localised, short-term loss (five years) or damage to BPPH, and "Remote" likelihood, arising from the low probability of a leak or spill reaching the intertidal or subtidal areas.

8.3.5.18 Ship Movements

Residual risk to benthic habitats from ship movements is	**Low**
Residual risk to benthic habitats from discharge of ballast water is	**Low**

The ship movements for the Project area have been discussed in Chapter 2, *Project Description*. Ship movement aspects relate to general ship movements, discharge of ballast water, use of anti-fouling agents and movements within the dredged approach channel and MOF.

In terms of plant construction, it is estimated that approximately 100 module barges will be required, based upon the proposed amount of modularisation for the Project. The MOF is expected to be in use for five years for LNG trains one and two and a further five years for future trains.

Typical construction traffic is expected to comprise one transport vessel per week utilising a RORO offloading method. It is anticipated that each vessel will spend in the order of two days at the MOF. General cargo is expected to start arriving at the MOF from month 18 and will continue over the entire period of plant construction and operation.

Materials for construction of the nearshore infrastructure (excluding the MOF), such as piles and marine equipment, will be transported on barges. There will also be piling barges, trencher support vessels, dredges, a pipelay barge, anchor handling tugs, rock dump vessels and other associated support vessels.

Table 8.36: Indicative Annual Number of LNG Ship Arrivals during the LNG Production Phases

LNG ships	2 LNG trains		5 LNG train expansion	
	No. of vessels per annum	Inter-arrival period (days)	No. of vessels per annum	Inter-arrival period (days)
130 000 m^3	148	2.5	434	1.0
165 000 m^3	118	3.2	342	1.1
205 000 m^3	95	3.9	276	1.3

Table 8.36 provides an indication of the number of LNG ships and inter-arrival period by ship size.

Double hull oil product ships, capable of lifting cargoes of up to 650 000 barrels of condensate, will only be partly laden due to draught restrictions. For indicative purposes the impact assessment assumes 12 condensate ships/yr for two LNG trains and 40 condensate ships/yr for five trains. In addition the following support vessels may be required:

- Four large tugs (80 tonne plus bollard pull) fitted for escort duty
- Four line handling boats
- Two security boats
- Pilot launch.

A description of the field investigation and characterisation of benthic habitats in the ship movement area is found in Appendix N6 to N15. Characterisation of ship movements, discharge of ballast water and use of anti-fouling are found in Chapter 2, *Project Description*. Assessment of potential contamination impacts on the Project area are described in the factor relating to marine water and sediment quality, as are the proposed management and mitigation measures (Section 8.2). Impacts on marine fauna from ship movements, as are the proposed management and mitigation measures, are described in Section 8.4.

The potential impacts to benthic habitat assessed with this aspect are related to the direct loss or damage to benthic habitat from propeller wash, toxicity effects of anti-foulants on marine flora and fauna, introduction of marine pests and pathogens, and increased turbidity, sedimentation and light attenuation.

Any physical impacts from propeller wash will be restricted to the vicinity of the dredged channel or basin floor which does not support BPPH. Likewise, toxicity effects of anti-foulants will be localised to the immediate vicinity of the PLF and MOF basin, neither of which support BPPH. Propeller wash from regular passage of vessels will create intermittent turbid plumes behind vessels as they navigate to and from the PLF. These plumes will occur regularly, but will be short term and localised in duration and extent.

Given that there are no significant sensitive BPPH close to the nearshore portion of the channel, no losses of BPPH are anticipated. However it is likely that the coral communities of Saladin Shoal and End-of-Channel Shoal near the outer end of the channel, will remain degraded permanently as a result of frequent occurrences of intermittent turbidity after each vessel passage. These shoals have already been identified as being potentially damaged as a result of construction dredging.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that the movement of vessels within the Project area will result in impacts to BPPH. The residual environmental risk for this potential impact was assessed as being "Low" – of "Massive" consequence, arising from a localised, seasonal (<one year) decrease in BPPH productivity, and "Remote" likelihood.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.37, it is possible that the discharge of ballast water from vessels within the Project area will result in impacts to BPPH. The residual environmental risk for this potential impact was assessed as being "Low" – of "Massive" consequence, arising from a localised, seasonal (<one year) decrease in BPPH productivity, and "Remote" likelihood.

8.3.6 Implications for Matters of National Environmental Significance

Matters of NES exist, in the form of protected marine fauna, in relation to the presence of BPPH in the Project area.

Both Dugongs and marine turtles occur in the Project area and are protected under the EPBC Act (Cth). Tropical seagrasses are a known food source for both turtles and Dugongs. Results of aerial surveys are presented in Section 8.4 and CWR (2010a, Appendix O4), and indicate that the areas of seagrass located within the Project area are used as feeding grounds for Dugongs and potentially Green Turtles.

Temporary and seasonal loss or damage of seagrass is anticipated during dredging activities, however no long-term loss or damage is anticipated. The only irreversible loss of tropical seagrass habitat (approximately 10 ha) will arise from rock stabilisation works associated with trunkline stabilisation. Denser seagrass beds, occurring between Direction Island and Coolgra Point, may reduce in abundance and/or cover during summer, however evidence suggests that *Halophila* spp. (the more common species in the Project area) recover from natural disturbances within approximately two years (Birch & Birch 1984; Lanyon & Marsh 1995; Rasheed 2004). Therefore, it is likely that disturbed seagrass meadows in the Project area will recover within this time, assuming no further disturbances.

It is possible that Dugong and turtle distribution and abundance may vary as animals move away from the disturbed areas, while construction is in progress. These impacts are likely to be attributed to the reduced availability of seagrass. Given the availability of feeding grounds outside of the Project area, it is likely that Dugongs and turtles will forage elsewhere. No reduction in population size is anticipated. Further details on the impact assessment of this receptor are provided in Section 8.4.

8.3.7 Residual Risk Summary

The following table (Table 8.37) provides a summary of the aspects, activities and potential impacts to BPPH as a result of Project activities. Indicative management and mitigations measures are also listed, along with the residual risk following the implementation of the proposed management and mitigations measures.

Where applicable, reference has been made to the Proposed Operational Marine Water and Sediment Quality Management OBCs, the Proposed Benthic Primary Producer Habitat Management OBCs and the Proposed Mangrove and Estuarine Habitat Management OBCs (Chapter 12, *Environmental Management Program*). These OBCs have been developed in alignment with the EPA's EAG 4 (EPA 2009f).

Table 8.37: Summary of Management Measures and Residual Risk Analysis for BPPH

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Dredging Program							
Construction dredging of the channel, trunkline and berthing area							
	Direct loss of subtidal BPPH through removal within Project area.	Design: Nearshore infrastructure location based on presence or absence of BPPH and MPAs.	6	1	**Low**	**Reasonable to High** Modelling conducted but calibration shows occasional aberration from occurrences. Excellent survey data.	Not applicable.
	Indirect impact to BPPH due to increased turbidity, sedimentation and light attenuation leading to loss of BPPH in excess of acceptable levels as defined in EPA Guidelines.	Refer to DSDMP for complete list of mitigation measures. Monitoring: Implementation of monitoring programs outlined in the DSDMP: • Water quality monitoring located in areas of key sensitive receptors. • Coral health monitoring within the Zone of Partial Loss, with an associated tiered management response. • Contingency coral health monitoring within the Zone of Influence undertaken in the event that water quality triggers are exceeded, with an associated tiered management response. • Pre-spawning and post-spawning monitoring of coral gravidity. • Monitoring of seagrass and other BPPH will be carried out pre and post dredging operations and during summer and winter to capture seasonality.	4	1	**High**	**Reasonable to High** Modelling conducted but calibration shows occasional aberration from occurrences. Excellent survey data.	Not applicable.

Maintenance dredging							
	Indirect impact on BPPH due to increased turbidity, sedimentation and light attenuation.	Refer to DSDMP for complete list of mitigation measures. Refer to Chapter 12, *Environmental Management Program* for Proposed BPPH Management OBCs. Design: Selection of Project site based on such key considerations as BPPH disturbance and avoid MPAs. Design: Selection of channel to avoid BPPH.	6	1	**Low**	**Low** No modelling conducted. Available information inadequate.	Not applicable.
Placement of dredge material offshore							
	Direct loss of sub-tidal BPPH due to placement of dredge material offshore.	Refer to DSDMP for complete list of mitigation measures. Refer to Chapter 12, *Environmental Management Program* for Proposed BPPH Management OBCs. Design: Selection of dredge material placement sites to reduce risks to BPPH where practicable.	6	1	**Low**	**Reasonable to High** Modelling conducted but calibration shows occasional aberration from occurrences. Excellent survey data.	Not applicable.
	Indirect impact on BPPH and habitats due to increased turbidity, sedimentation and light attenuation.	Refer to DSDMP for complete list of mitigation measures. Refer to Chapter 12, *Environmental Management Program* for Proposed BPPH Management OBCs. Design: Diffusers will be utilised during offshore dredge material placement via the CSD.	4	2	**Medium**	**Reasonable to High** Modelling conducted but calibration shows occasional aberration from occurrences. Excellent survey data.	Not applicable.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Placement of dredge material onshore							
	Indirect impact on mangroves due to groundwater seepage and exceedence of acceptable levels due to increased turbidity and light attenuation from decant water discharge.	Refer to DSDMP for complete list of mitigation measures. Refer to Chapter 12, *Environmental Management Program* for Proposed BPPH Management OBCs and Proposed Mangrove and Estuarine Habitat Management OBCs. Design: Placement site location selected to reduce risks to BPPH where practicable. Design: Discharge of decant water from the onshore dredge material placement site will be via a controlled point which will include the use of a weir box to control water height. Design: The onshore dredge material will be contained in a bunded area to reduce the risk of an unconfined release of seawater and sediments. Mitigate: A drainage ditch (with sump and pump system) will be installed to collect and divert seepage away from the Ashburton River Delta system. Monitor: Monitoring of discharge water will be undertaken with the objective of complying with the maximum turbidity limit of 250 mg/L TSS. Monitor: A mangrove monitoring program will be designed and implemented to detect change to mangrove health and mangrove habitat condition. The monitoring program will include: • Mangrove tree species composition and density. • Mangrove tree health (canopy density and/or tree condition data) • Groundwater/soilwater salinity and water table depth. • Sediment heights and ground levels (Cont'd)	3	3	**Medium**	Reasonable to High Modelling conducted but calibration shows occasional aberration from occurrences. Excellent survey data.	Not applicable

		• Hydrocarbon and heavy metal concentration in mangrove sediments and selected mangrove-dependant fauna. • Diversity and abundance of mangrove-dependant fauna • Mapping of mangrove habitat distribution and coastline movements. Refer to Chapter 9, *Terrestrial Risk Assessment and Management* for groundwater monitoring information.					
Nearshore Construction Activities							
Construction of PLF and rock placement for MOF breakwater walls							
	Indirect disturbance to the seabed from increased turbidity, sedimentation and light attenuation leading to loss of BPPH in exceedence of acceptable levels.	Design: MOF and PLF location selected to reduce the risk of loss of BPPH where practicable. Mitigate: Use graded rock material with low fines content. Mitigate: MOF and PLF mitigation covered under the CEMP.	6	1	**Low**	**Reasonable** Available information is adequate.	Not applicable.
Trunkline trenching and stabilisation							
	Indirect disturbance to the seabed from increased turbidity, sedimentation and light attenuation leading to loss of BPPH in exceedence of acceptable levels.	Design: Trunkline route location selected to reduce risks to BPPH where practicable. Mitigate: Use engineered rock material with low fines content.	4	2	**Medium**	**Reasonable** Available information is adequate.	Not applicable.
Trunkline shore crossing by trenching							
	Disturbance of mangrove habitat.	Mitigate: Maintain tidal flows to eastern end of lagoon by use of temporary gap in sand spit. Mitigate: Contain sediment within rock groyne structures to reduce the risk of potential sediment smothering impacts on mangroves. Mitigate: Disturbance area to be landscaped with the objective of re-instating to former topography. Mitigate: Use engineered rock material with reduced fines content. Mitigate: A DSDMP specific to trunkline trenching activities will be developed.	4	1	**High**	**Reasonable** Available information is adequate.	Not applicable.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Trunkline shore crossing by microtunnelling							
	No impact predicted.	No management or mitigation measures required	6	2	**Low**	**Reasonable** Available information is adequate.	Not applicable.
Onshore construction activities							
Construction of LNG plant and associated infrastructure							
	Direct loss of intertidal BPPH in excess of EPA Guidelines	Refer to DSDMP for complete list of mitigation measures. Refer to Chapter 9, *Terrestrial Risk Assessment and Management* for complete list of mitigation measures Refer to Chapter 12, *Environmental Management Program* for Proposed BPPH Management OBCs and Proposed Mangrove and Estuarine Habitat Management OBCs. Design: Nearshore infrastructure location selected to reduce the risk of disturbance to BPPH where practicable. Mitigate: In the event of sediment deposition, erosion, dust deposition, or groundwater alterations in mangrove habitat during construction activity exceeds background levels implement mitigation measures as defined in the DSDMP, Coastal Processes Management Plan (CPMP) and CEMP. Mitigate: If clearing exceeds permitted area of disturbance of mangrove habitat: • Immediately cease clearing in mangrove areas. • Confirm mangrove habitat losses by survey and redefine clearing boundaries. • Investigate options for rehabilitation of mangrove habitat. (Cont'd)	3	2	**High**	**High** Excellent survey data.	Not applicable.

		• Identify the cause of excessive clearing, review work procedures and amend as necessary to reduce the risk of further exceedence of permitted clearing. Monitor: A monitoring program will be implemented in order to monitor both the health of mangroves and the key factors maintaining the mangrove habitat.					
Impacts from onshore operations							
Indirect impacts to the Ashburton River Delta mangrove system							
	Indirect impacts to the Ashburton River delta mangrove system.	Refer to DSDMP for complete list of mitigation measures Refer to Chapter 12, *Environmental Management Program* for Proposed BPPH Management OBCs and Proposed Mangrove and Estuarine Habitat Management OBCs. Refer to Chapter 9, *Terrestrial Risk Assessment and Management*. Design: Nearshore outfall location selected to reduce risks to BPPH where practicable. Design: The following measures will be used during drilling activities to reduce the risk of a subsea blowout: • Provision of numerous primary and secondary barriers (subsea safety valves, Production Master Valve, Swab Valve, Tree Cup, Production Shutdown Valve, Production Wing Valve etc) • Well bore stability modelling for reservoir and overburden formations • Specific and approved controls for work-over or re-entry operations • Exclusion zone around wellheads with no anchoring in exclusion area gazetted and on navigational charts Mitigate: Manage discharges by taking into account the threshold limits of the ANZECC/ARMCANZ guidelines. Monitor: Monitoring to confirm applicable water quality targets at mixing zone boundary.	6	2	**Low**	**High** Excellent survey data.	Not applicable.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Offshore construction activities							
Construction of the WP and well head(s) and deep water pipelay activities							
	Direct disturbance to the seabed.	Design: Nearshore infrastructure location selected to reduce the risk of disturbance to BPPH where practicable.	6	1	**Low**	**High** Excellent survey data.	Not applicable.
Discharges from Onshore Construction							
Nearshore discharge from the accommodation village, stormwater run-off and reverse osmosis brine							
	Increased metals and other contaminants. Increased turbidity, salinity, nutrients and algal blooms leading to loss of or damage to BPPH in exceedence of acceptable levels.	Refer to Chapter 12, *Environmental Management Program* for Proposed BPPH Management OBCs, Proposed Mangrove and Estuarine Habitat Management OBCs and Proposed Operational Marine Water and Sediment Quality Management OBCs. Design: Nearshore outfall location selected to reduce risks to BPPH where practicable. Mitigate: Manage discharges by taking into account the threshold limits of the ANZECC/ARMCANZ guidelines. Monitor: Monitoring to confirm applicable water quality targets at mixing zone boundary.	6	1	**Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	Not applicable.
Discharges from Onshore Operations							
Nearshore discharge of wastewater, process wastewater, contact stormwater and reverse osmosis brine							
	Increased metals and other contaminants. Increased turbidity, salinity, nutrients and algal blooms leading to loss or damage to BPPH in exceedence of acceptable levels. Toxicity to BPPH.	Refer to Chapter 12, *Environmental Management Program* for Proposed BPPH Management OBCs, Proposed Mangrove and Estuarine Habitat Management OBCs and Proposed Operational Marine Water and Sediment Quality Management OBCs. Refer to Chapter 9, *Terrestrial Risk Assessment and Management* for surface water management and mitigation measures. Design: End of pipe diffuser located at the PLF. Design: Mixing zone location selected to reduce risks to BPPH where practicable. (Cont'd)	6	1	**Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences. Available information is adequate.	Not applicable.

		Mitigate: Manage discharges by taking into account the threshold limits of the ANZECC/ARMCANZ guidelines. Mitigate: Mixing zone boundaries to be established and monitoring to achieve applicable water quality targets at mixing zone boundary.					
Discharge of PW from the LNG plant							
	Toxicity to BPPH	Refer to DSDMP. Refer to Chapter 12, *Environmental Management Program* for Proposed BPPH Management OBCs, Proposed Mangrove and Estuarine Habitat Management OBCs and Proposed Operational Marine Water and Sediment Quality Management OBCs. Design: Nearshore outfall location selected to reduce risks to BPPH where practicable. Design: Selection of outfall location and diffuser design for adequate dilution and dispersion of PW. Design: The Proponent will determine PNEC for PW discharge. Mitigate: Treatment of PW with the objective of meeting the requirements of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 as they apply for time to time. Monitor: Monitor PW concentrations prior to discharge. Monitor: Confirm adequacy of diffuser design and size of mixing zone.	6	2	**Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences. Available information is adequate.	Not applicable.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Discharges from offshore construction and operations							
Routine discharges from offshore production (PW, MEG, drill cuttings, mud, sludges and sands, CW)							
	Turbidity and sediment changes. Toxicity to biota. Potential contamination with TPH and MEG. Increased turbidity, smothering, reduced dissolved oxygen (DO). Bioaccumulation of chemicals and trace metals in species / food chain. Exceedence of Commonwealth Regulations on TPH.	Design: The Proponent will determine PNEC for PW discharge. Mitigate: Compliance with Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009. Mitigate: Treatment in compliance with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78, Annex IV) (ref) Mitigate: Treatment of PW with the objective of meeting the requirements of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 as they apply for time to time. Mitigate: Controlled release of hydrotest water to reduce potential for toxicity impacts. Monitor: Monitor PW concentrations prior to discharge.	6	2	**Low**	**High** Excellent survey data.	Not applicable.
Leaks and spills							
Offshore spills							
	Loss of well control resulting in loss/damage of BPPH.	Design: The following measures will be used during drilling activities to reduce the risk of a subsea blowout: • Provision of numerous primary and secondary barriers (subsea safety valves, Production Master Valve, Swab Valve, Tree Cup, Production Shutdown Valve, Production Wing Valve etc) • Well bore stability modelling for reservoir and overburden formations • Specific and approved controls for work-over or re-entry operations • Exclusion zone around wellheads with no anchoring in exclusion area gazetted and on navigational charts (Cont'd)	5	5	**Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	Not applicable.

		Design: Implementation, where practicable, of relevant Australia Standards and Codes in the initial design integrity, process and utility equipment, materials handling and operating and maintenance procedures with the objective of reducing spills. Design: A DMP approved MOPP will be implemented and relevant personnel will be trained in accordance with the MOPP. Mitigate: Clean up and remediation methods will be implemented in the event of a spill. Monitor: Monitoring of discharge water will be undertaken with the objective of complying with the maximum turbidity limit of 250 mg/L, TSS. Monitor: A mangrove monitoring program will be designed and implemented to detect change to mangrove health and mangrove habitat condition. The monitoring program will include: • Mangrove tree species composition and density. • Mangrove tree health (canopy density and/or tree condition data) • Groundwater/soilwater salinity and water table depth. • Sediment heights and ground levels • Hydrocarbon and heavy metal concentration in mangrove sediments and selected mangrove-dependant fauna. • Diversity and abundance of mangrove-dependant fauna • Mapping of mangrove habitat distribution and coastline movements. Refer to Chapter 9, *Terrestrial Risk Assessment and Management* for groundwater monitoring information.					

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Nearshore spills							
	Mortality of BPPH due to refuelling work boats at the MOF, condensate spill during loading at PLF.	Design: Implementation, where practicable, of relevant Australia Standards and Codes in the initial design integrity, process and utility equipment, materials handling and operating and maintenance procedures with the objective of reducing spills. Design: A DMP approved MOPP will be implemented and relevant personnel will be trained in accordance with the MOPP. Mitigate: Clean up and remediation methods will be implemented in the event of a spill. Monitor: as for Offshore spills above.	1	5	**Medium**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	Not applicable.
Onshore spills entering the marine environment							
	Mortality of BPPH in Hooley Creek resulting from leak or spill from LNG plant.	Design: Implementation, where practicable, of relevant Australia Standards and Codes in the initial design integrity, process and utility equipment, materials handling and operating and maintenance procedures with the objective of reducing spills. Mitigate: A DMP approved MOPP will be implemented and relevant personnel will be trained in accordance with the MOPP. Mitigate: Clean up and remediation methods will be implemented in the event of a spill. Monitor: as for Offshore spills above.	4	5	**Very Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	Not applicable.
Ship movements during construction and operation							
Ship movements							
	Toxicity effects of anti-foulants on BPPH. Introduction of marine pests.	Mitigate: All vessels under the control of the Proponent will comply with the International Convention on the Control of Harmful Anti-fouling Systems on Ships as monitored by AQIS.	5	3	**Low**	**High** Several expert investigations/ studies.	Not applicable.

Discharge of ballast water							
	Adverse impacts on the marine environment. Introduction of marine pests.	Mitigate: All vessels under the control of the Proponent will comply with AQIS ballast water discharge requirements (Australian Ballast Water Management Requirements V4 2008).	5	3	**Low**	**High** Several expert investigations/ studies.	Not applicable.
Additive Effects							
All construction and production activities							
	The sum of all potential Project-attributable impacts from all Project phases and aspects.	See above for proposed management/mitigation measures. *NB: The risk ranking for Additive Effects is determined by the highest risk ranking for the BPPH section.*	3	2	**High**	**Low** No modelling conducted on additive effects.	Not applicable.

8.3.8 Predicted Environmental Outcome

The most significant loss of BPPH will occur due to the construction of onshore infrastructure and access roads, resulting in the loss of substantial areas of intertidal algal mats and samphire habitat from the Hooley Creek – Three Mile Creek system. Additionally, the dredged volumes required in the construction phase of the Project exceed many previous dredging projects in WA, and involves the dredging and placement of material containing a high proportion of fines. Dredging is likely to cause elevated turbidity in nearshore waters. Turbidity plumes are predicted to disperse to approximately 50 km to the east of the dredge area in summer and to the west in winter.

It is not anticipated that any whole coral reefs or coral shoals will be permanently damaged by the dredging program, and it is expected that the 'hard substratum' habitat will remain intact. However, up to 50 per cent of corals at Saladin Shoal, End-of-Channel Shoal and a small reef northwest of Ward Reef may experience mortality, due to their location close to the dredge area. These corals are unlikely to recover within five years, however recovery in the long term (>five years) is likely as many adult coral colonies will survive and larvae will continue to arrive from unaffected source reefs up-current. Severe coral damage, defined as damaged coral assemblages unlikely to recover within five years, will be restricted to reefs and shoals closest to the dredge area.

A reduction in abundance of seagrasses is anticipated in some seagrass beds to the west and to the east of the dredge area, although rapid recovery is predicted once the dredging program ceases. A moderate proportion of the macroalgae-dominated habitat in the Project area is predicted to be severely damaged as a results of the dredging works, but long-term recovery is predicted and the habitat type is widespread throughout the region.

The aspects described above have the potential to impact BPPH in an additive manner. The conservative additive residual environmental risk to BPPH as a result of Project-attributable impacts was assessed as being "High" – of "Moderate" consequence, arising from the combined effects of construction and maintenance dredging, placement of dredge material, construction and operation of onshore, nearshore and offshore infrastructure, discharges to the marine environment, movement of vessels and potential leaks or spills of hydrocarbons, and "Almost Certain" likelihood .

A DSDMP (Appendix S1) will be developed and finalised prior to the commencement of Project construction. This Plan will, in part, provide a high level indication of how impacts to BPPH will be managed. Additionally, it will specify the management and mitigation measures which will be implemented to limit Project-attributable impacts to BPPH. A DSDMP for the installation of the trunkline may also be developed, prior to construction occurring.

The Proposed Benthic Primary Producer Habitat Management OBCs and the Proposed Mangrove and Estuarine Habitat Management OBCs have been developed for BPPH, and are presented in Chapter 12, *Environmental Management Program*.

The DSDMP (Appendix S1) and the OBCs should be read in conjunction with the summary management measures and residual risk table above (Table 8.48) for a complete understanding of potential management and mitigation measures under consideration for the Project.

8.4 Marine Fauna

8.4.1 Management Objectives

The EPA Act (WA) and EPBC Act (Cth) management objectives that will be applied to the Project for the environmental factor, marine fauna are:

- To maintain the abundance, diversity, geographic distribution and productivity of marine fauna in the region through the reduction of risk of adverse impacts that could arise from construction and operational activities
- To provide for the protection of the environment, especially matters of NES and to conserve Australian biodiversity
- To be consistent with all relevant legislation and guidance.

The following sections present the assessment of impacts on marine fauna from the Project, taking into account design modifications and management and mitigation measures applied to reduce impacts.

8.4.2 Description of Factor

This section provides a summary of the marine fauna groups and species potentially at risk from impacts associated with the Project that have been considered during the risk assessment process. Detailed information on marine fauna distribution, critical fauna habitats, including known feeding, migratory and breeding areas, is provided in Chapter 6, *Overview of Existing Environment*.

This information has been collated from the following field and desktop studies:

- Matters of NES search for marine fauna species listed under the EPBC Act (Cth) that could occur within, or migrate through, the Project area.
- Desktop study on marine mammals potentially occurring in the Project area (URS 2009i, Appendix O7).
- Aerial surveys of the abundance and distribution of Humpback Whales, Dugongs, dolphins, Whale Sharks and turtles in the Project area (12 month dataset), undertaken by the Centre for Whale Research (CWR; CWR 2010a, Appendix O4).
- Underwater acoustic surveys of whales and other marine fauna in the Project area (12 month dataset), undertaken by the Centre for Marine Science and Technology (CMST; CMST 2010, Appendix O2).
- Turtle nesting survey of mainland and island beaches in the vicinity of the Ashburton North SIA (January / February 2009) (Pendoley Environmental 2009, Appendix O8).
- Vessel-based survey of foraging marine turtles in the vicinity of the Ashburton North SIA (July / August 2009) (RPS 2010a, Appendix O11).
- Preliminary results of the satellite tagging study of nesting and juvenile turtles in the vicinity of the Ashburton North SIA (RPS 2010a, Appendix O11).
- Compilation of the results of Pendoley Environmental (2009, Appendix O8), RPS (2010a, Appendix O11) and the Project light emissions report (URS 2009n, Appendix D1), to give an estimate of which mainland and island beaches may be subject to light spill (URS 2010a, Appendix O1).
- Field survey and report on the intertidal habitats of the Onslow coastline (URS 2009f, Appendix N11).
- Fish survey of the lagoon and creeks in the vicinity of the Ashburton North SIA (URS 2010i, Appendix O5).
- Survey and report on migratory waterbirds present in the vicinity of the Ashburton North SIA (Bamford Consulting Ecologists 2008; 2009).

Marine flora and fauna field studies are ongoing. The Supplementary EIS/ERMP will report on the results of these ongoing field studies, detail the findings, and also include an analysis of the importance of the project footprint and surrounding area to marine flora and fauna species, in particular sawfish, the Humpback Whale, coastal dolphin species, marine turtles, Dugong and seagrass species. The Supplementary EIS will also consider the availability of alternative habitat, should these species be displaced by the Project.

This impact assessment has focussed on "key receptors"; species of conservation or ecological significance, especially those considered migratory, vulnerable or endangered, that occur in the areas likely to be affected by the Project (Table 8.38). The key receptors were selected from the inventory of marine fauna whose distributions overlap the Project area and have been assessed by their:

- Spatial distribution within the Project area
- Spatial distribution within the regional context
- Temporal distribution within the Project area
- Dependence on critical habitats or foraging areas within the Project area
- Presence within the Project area during sensitive life history stages
- Interaction with aspects of the Project.

In addition to the key receptors, species of lower conservation significance and significant species less likely to be affected by the Project were risk assessed as "other receptors" (Table 8.38).

Table 8.39 summarises the sensitivities of marine fauna key receptors including their likely exposure to impacts from the Project and the potential for Project activities to adversely affect them. These are the main data used in the assessment of the consequences of impacts associated with the Project.

Table 8.38: Marine Fauna, Including Key Receptors, Considered in the Risk Assessment

Key Receptor	Reason for selection as a "key" receptor
Humpback Whale *Megaptera novaeangliae*	High conservation significance. Present in coastal waters during southward migration, cows (adult females) and calves may rest within the Project area in spring.
Indo-Pacific Humpback Dolphin *Sousa chinensis*	High conservation significance. Likely to be present in coastal waters (< 20 m deep) throughout the year.
Bottlenose Dolphin *Tursiops* sp.	High conservation significance. Likely to be present in coastal waters throughout the year.
Dugong *Dugong dugon*	High conservation significance. Present in coastal waters adjacent to the Project area.
Flatback Turtle *Natator depressus*	High conservation significance. Nests and forages in coastal waters of the Project area.
Green Turtle *Chelonia mydas*	High conservation significance. Nests and forages in coastal waters of the Project area.
Hawksbill Turtle *Eretmochelys imbricata*	High conservation significance. Nests in region encompassing Project area.
Loggerhead Turtle *Caretta caretta*	High conservation significance. Nests in region encompassing the Project area.
Sawfish (*Pristis* sp.)	High conservation significance. Sawfish have been observed in Hooley Creek and the North East Ashburton Lagoon, both with the Project area.
Other Receptors	**Reason for selection as "other" within**
Baleen Whales (other than Humpback Whales)	High conservation significance. Present or migratory in low numbers in offshore waters, highly mobile.
Toothed Whales (e.g. Sperm Whales)	High conservation significance. May be present or migratory in low numbers in offshore waters, highly mobile.
Southern Giant Petrel *Macronectes giganteus*	High conservation significance. Southern distribution means they are unlikely to be present in the Project area.
Seabirds (various species)	Some species of high conservation significance. Nest and roost on islands (including Nature Reserves) in the Project area.
Sea Snakes (various species)	Conservation significance. However, these species are generally widespread in the region and no critical habitats are known.
Whale Shark *Rhincodon typus*	High conservation significance. Migratory in offshore waters, unlikely to be present within the Project area.
Other Sharks and Rays	Well represented within the regional context, highly mobile.
Syngnathids (various species)	High conservation significance. Well represented within the regional context, no restricted habitats known within Project area, regional populations unlikely to be affected by the Project.
Benthic invertebrates e.g. prawns	Commercial and ecological significance. Critical habitat is present within the nearshore area, but well represented within the regional context. Low diversity. Could be affected by the Project.
Demersal teleost fish (various species)	Commercial, recreational and ecological significance. Well represented within the regional context, mobile, likely to be affected by increased recreational fishing pressure related to the Project.

Table 8.39: Potential for Impact to Marine Fauna Key Receptors from Project Activities

Key Receptor	Potential Exposure	Potential Impact
Humpback Whale	• Migrate through the offshore waters of the Project area annually between June and November. • Exmouth Gulf is a recognised resting area for cow/calf pairs. However, the southward migration pathway through the Project area is not well known. Cow/calf pairs expected to be present from late September to early November. • Known to be present, although very rarely, inshore of the 50 m isobath during southward migration, with fewer than 5 per cent of whales surveyed between May and December 2009 recorded within 10 km of the shore.	• Cow/calf pairs susceptible to acoustic impacts from piling activities. • All whales susceptible to vessel strike when vessels are present in large numbers.
Indo-Pacific Humpback Dolphin / Bottlenose Dolphin	• Dolphins present throughout the Project area. • Indo-Pacific Humpback and Bottlenose dolphins are the most common species in the Project area. • The Indo-Pacific Humpback Dolphin generally inhabits shallow coastal waters, embayments and estuaries (< 20 m).	• Sensitive to habitat degradation and possible population fragmentation due to coastal developments. • Susceptible to acoustic impacts from piling activities in nearshore areas during the construction phase. • Susceptible to vessel strike when large numbers of fast-moving vessels are present in coastal areas.
Dugong	• Present throughout the year in coastal waters throughout the Project area. • Cow/calf pairs have been recorded within herds during aerial surveys in the vicinity of the Project area.	• Susceptible to acoustic impacts from piling activities in nearshore areas during the construction phase. • Susceptible to vessel strike when large numbers of fast-moving vessels are present in coastal areas.
Marine turtles (Green, Flatback, Hawksbill, Loggerhead)	• Marine turtles likely to be resident and foraging in coastal waters of the Project area throughout the year. • Predominantly Flatback nesting on islands near the Project area. Medium density nesting on Ashburton River Delta and Ashburton Island (approximately 4 km and 12 km from the Project area, respectively). • Very low density nesting of Flatback Turtles on the mainland beaches and nest success expected to be low due to tidal inundation of nest sites. • Peak periods of mating (October to December), nesting (October to February) and hatching (December to April). • Reef habitats surrounding the islands offshore from the Ashburton North SIA appear to be important foraging habitat for juvenile and adult Green Turtles.	• Potentially sensitive to the effects of dredging (e.g. entrainment). • Susceptible to acoustic impacts from piling activities in nearshore areas during the construction phase. • Susceptible to vessel strike when large numbers of fast-moving vessels are present in coastal areas.
Sawfish (unidentified pristid species)	• Present in coastal waters, including Hooley Creek and the north eastern parts of the Ashburton Lagoon areas (Cont'd)	• Susceptible to changes to hydrodynamics of lagoons and tidal creek systems.

Other Receptor	Potential Exposure	Potential Impact
Demersal teleost fish (various species)	• Recreationally and commercially targeted species inhabit reefs surrounding the islands and creeks and lagoons of the Ashburton River Delta and Hooley Creek.	• Overfishing resulting in a reduction in fish stock, decline in populations of targeted species, altered predator-prey interactions.
Seabirds (various species)	• Migratory bird species nest and/or roost on islands. • A number of species are likely to forage in coastal areas and nearshore waters.	• Disturbance during sensitive life history phases, including nesting, from increased recreational access to islands.

8.4.3 Assessment Framework

8.4.3.1 Relevant Legislation / Guidance

Commonwealth and state guidelines and legislation relevant to the assessment and management of potential impacts to marine fauna include:

Commonwealth

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act [Cth])
- EPBC Act (Cth) Policy Statement 1.1 Significant Impact Guidelines
- Commonwealth Fauna Recovery Plans and Action Plans:
  - Action Plan for Australian Cetaceans (Bannister *et al.* 1996)
  - Blue, Fin and Sei Whale Recovery Plan 2005-2010 (DEH 2005a)
  - Humpback Whale Recovery Plan 2005-2010 (DEH 2005b)
  - Southern Right Whale Recovery Plan 2005-2010 (DEH 2005c)
  - Recovery Plan for Marine Turtles in Australia (DEH 2003)
  - Whale Shark (*Rhincodon typus*) Recovery Plan 2005-2010 (DEH 2005).

State

- *Environmental Protection Act 1986* (EP Act [WA])
- *Wildlife Conservation Act 1950* (WC Act)
- *Guidance for the Assessment of Environmental Factors. Draft Environmental Noise. No. 8.* (GS 8; EPA 2007)
- *Environmental Protection (Noise) Regulations 1997*
- Draft Marine Turtle Recovery Plan for Western Australia 2009-2016. Wildlife Management Program No. 45 (DEC 2009a).
- *Draft Environmental Assessment Guidelines. No. 5: Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts* (EAG 5; EPA 2010).

The EPBC Act (Cth) and the EP Act (WA) outline the framework for assessment of marine fauna at Commonwealth and Western Australian (State) levels, respectively. Most marine mammals are protected under the EPBC Act (Cth). The EPBC Act (Cth) also established the Australian Whale Sanctuary, which encompasses the area of the Exclusive Economic Zone outside State waters and which generally extends 200 nm from the coast, but further in some areas to cover the continental shelf and continental slope.

All native Australian marine fauna, as well as those that periodically migrate to Australia, are protected in WA under the WC Act (WA). Under this Act, it is an offence to kill, capture, disturb, molest or hunt any protected or threatened fauna. The level of protection for a given species depends on its conservation status. Species requiring special protection are listed under one of the four following categories in the Wildlife Conservation (Specially Protected Fauna) Notice:

- Schedule 1 – fauna that are rare or likely to become extinct
- Schedule 2 – fauna presumed to be extinct
- Schedule 3 – birds that are subject to the agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in

danger of extinction (i.e. Japan Australia Migratory Bird Agreement [JAMBA])
- Schedule 4 – other specially protected fauna.

GS 8 (EPA 2007) stipulates a precautionary approach should be adopted in the assessment of potential impacts of noise and vibration on marine fauna. GS 8 initially requires the proponent to identify whether there is a population which may be at risk of noise impacts because of their need to hear signals clearly over ambient noise; their inability to escape from the noise; or their endangered status. The second stage of this process requires a risk assessment to be carried out to estimate the likelihood of adverse impacts.

The management strategies proposed to reduce the risk of impact to marine fauna associated with the Project will be consistent with the objectives of the species recovery and action plans.

The Action Plan for Australian Cetaceans identifies a number of threatening processes that relate to the proposed Project which will require specific management strategies to be developed as follows (Bannister *et al.* 1996):

- Immediate threats:
  - Injury or mortality
  - Entanglement
  - Shipping strikes.
- Intermediate threats:
  - Oil spills
  - Disturbance and harassment (i.e. acoustic disturbance)
  - Degradation of cetacean habitat (i.e. physical or biological modification)
  - Exposure to human wastes.
- Long-term threats:
  - Contamination of marine environments by chemical pollutants
  - Contamination of marine environments by plastic debris.

Recovery plans for Humpback Whales; Blue, Fin and Sei Whales; and Southern Right Whales (DEH 2005a, 2005b and 2005c) list identified and potential threats to these species, of which only habitat degradation is relevant to the proposed Project activities.

The WA State Draft Marine Turtle Recovery Plan (DEC 2009a) provides evidence for the higher relative importance of turtle rookeries on the Pilbara islands including:

- Productivity of WA mainland nesting beaches is under threat from egg predation by introduced animals, particularly foxes, while Pilbara islands are largely free from introduced predators.
- The area between North West Cape and Port Hedland has the highest incidence of artificial lighting on turtle nesting beaches in WA, the cumulative impacts of which have not been assessed.
- Turtles that nest on the mainland may be disturbed by tourists, whereas limited tourism occurs on islands.

The overall objective of the Commonwealth Recovery Plan for Marine Turtles (DEH 2003) is:

> *"To reduce detrimental impacts on Australian populations of marine turtles and hence promote their recovery in the wild".*

A number of specific objectives have been further defined in the plan which will require specific management strategies to be applied throughout the duration of the Project as follows:

- Prevention of accidental death (e.g. by boat strikes)
- Identification of information gaps
- Management of factors that affect successful nesting
- Identification and protection of critical habitats (natal beaches, mating areas, inter-nesting habitat, feeding areas and pelagic waters).

The Commonwealth Whale Shark Recovery Plan (DEH 2005c) identifies potential future threats to this species relevant to the proposed Project activities as follows:

- Pollution and marine debris
- Direct disturbance from interference.

8.4.4 Consequence Definitions

To enable the assessment of risks associated with the Project, specific consequence definitions have been developed. Table 8.40 provides the consequence definitions that have been used in the risk assessment of marine fauna.

Table 8.40: Consequence Definitions for Marine Fauna

Marine	1	2	3	4	5	6
	Catastrophic	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Marine Fauna-Other	• One or more species become extinct • Species conservation status declines i.e. becomes threatened – meets criteria for listing • Regional and irreversible impact to communities and populations	• Regional and long-term impact to communities and populations	• Regional medium term or local long-term impact to communities and populations	• Local medium term impact to communities and populations	• Local short-term impact to communities and populations • Does not threaten viability of community and population	• No detectable impacts to communities and populations
Marine Fauna-Protected	• Species of protected marine fauna becomes regionally extinct	• Species of protected marine fauna becomes locally extinct	• Loss of individuals/taxon leading to reduced viability of population in local area • Ecologically significant proportion of local population is lost.	• Local short-term decrease in abundance, no lasting effects on population	• No detectable decrease in abundance or lasting effects on population	• No detectable impacts to communities and populations

Long-term: *>10 years (2x construction period) |* ***Medium term:*** *5-10 years |* ***Short-term:*** *<5 years (construction period) |* ***Local:*** *Within the Project area |* ***Regional:*** *Outside the Project area.*

8.4.5 Impact Assessment and Management

Impacts to marine fauna will occur to some extent as a result of Project activities. The following sections summarise the aspects and activities that may directly and indirectly affect marine fauna in, and surrounding, the Project area. Chapter 7, *Impact Assessment and Methodology* contains the risk matrix used to assess the likelihood and consequence of the impacts occurring. The potential impacts and the management measures to be implemented to be implemented are discussed in detail. Table 8.48 in Section 8.4.7 provides a summary of the potential impacts, management and mitigation measures and residual risk to marine fauna as a result of Project activities. The aspects which are considered in this section are presented below in Table 8.41.

8.4.5.1 Physical Presence of Nearshore Infrastructure

Nearshore infrastructure will have an ongoing physical presence in the local marine environment. Such infrastructure can create barriers to fauna movements if it bisects restricted migration routes or narrows transit routes between habitats. The main elements of infrastructure that may affect marine fauna are described in Chapter 2, *Project Description*. A summary is listed below:

- MOF and PLF
- Trunkline
- Vessels (construction and operation)
- Proposed dredge material placement sites.

The highest risks of potential adverse impacts to marine fauna associated with the physical presence of marine infrastructure are:

- Disturbance of normal movements/migration
- Artificial habitat for fish aggregation.

Other impacts associated with indirect effects of the infrastructure, such as noise, lighting and provision of substrate for settlement for introduced marine pest (IMP) species are addressed in other sections relating specifically to these stressors.

Disturbance of Normal Movements/Migration of Protected Marine Fauna

Residual risk of physical presence of nearshore infrastructure causing disturbance of normal movements of marine fauna is	**Very Low**

The presence of marine infrastructure may cause some disruption to normal movements of marine fauna species along the coastline at the Ashburton North SIA. However, the scale of infrastructure is similar to natural features in the area, such as sand bars, islands and rocky headlands, and the presence of the infrastructure is not predicted to adversely affect fauna populations in the area.

Mobile fauna will readily swim around barriers in the sea and the larger marine fauna commonly cover great distances along the coast; minor deviations in course are not predicted to affect the local fauna populations. No narrow movement corridors or migration routes have been identified in the areas where infrastructure has the potential to form a barrier to established patterns of movement. Coastal species such as Dugongs, sawfish and Indo-Pacific Humpback Dolphins are expected to circumnavigate any obstructions in the nearshore areas like simular sized natural obstructions e.g. headlands. The species with broader or more offshore distributions, for example Humpback Whales and turtles, are unlikely to be affected beyond occasional avoidance behaviour by a few individuals.

The presence of subsea infrastructure offshore is not likely to disturb the northern and southern migration routes for the Humpback Whale as much of the infrastructure will be on the seabed in deep water. The majority of offshore infrastructure above the sea surface can be easily avoided by pelagic marine fauna species that may be present in the area.

It is possible that there may be localised, long-term displacement of marine fauna (including protected species such as Dugongs, dolphins and turtles) that swim along the coast. However, it is unlikely that this would lead to injury or result in effects at a population level as fauna will swim around the obstruction.

Table 8.41: Summary of Potential Impacts to Marine Fauna Associated with Key Activities for the Project

Aspect	Activity	Potential impacts
Physical presence of marine and terrestrial infrastructure	• Operational phase – permanent presence of offshore and onshore marine infrastructure	• Disruption of normal movements/migration in nearshore waters • Modification of marine fauna habitats under infrastructure • Provision of artificial habitats, e.g. pilings, boosting secondary production and promoting fish aggregation (Peterson *et al*. 2003) • Substrate for potential settlement for a range of marine pest species
Dredging and dredge material placement	• Construction dredging – channel, trunkline, berthing area • Maintenance dredging (during operations) • Placement of dredge material offshore • Placement of dredge material onshore • Vessel movements – dredges, barges	• Entrainment of fauna in dredge. • Loss of, or disturbance to, habitat critical to protected and other marine fauna • Disturbance to marine fauna (migration, foraging, breeding) through interaction with dredge vessels • Indirect impacts from degradation of marine water and sediment quality • Routine discharges from vessels • Leaks and spills from vessel collisions • Noise from dredge cutter head and vessel engines • Disturbance to marine fauna behaviours and coastal migratory routes due to lighting, spills and dredge plumes
Construction activities (marine)	• Construction of MOF, PLF • Trenching, jetting • Rock dumping • Trunkline installation • Piling and fixing to seafloor • Installation of the surface and seabed infrastructure at the offshore field	• Loss or disturbance to habitat critical to protected and other marine fauna • Disturbance to marine fauna behaviours and migratory patterns • Degradation of marine water and sediment quality
Vessel movements	• LNG and condensate ship transits • Dredge vessel movements while dredging and transporting dredge material to placement sites • Barges laying trunkline • Vessels towing platform and drilling rigs • Standby tugs • Other refuelling, support, accommodation vessels and crew transfer vessels and barges • Environmental monitoring vessel movements	• Injury or mortality due to vessel strike. • Disturbance to marine fauna from vessel movements • Indirect effects in the event of a leak / spill from condensate ship or smaller vessel • Disturbance to marine fauna behaviours and migratory routes due to lighting, spills, noise • Indirect effects through deterioration of water quality associated with resuspension of fine seabed sediments by propeller wash from vessels in shallow waters • Interference with nesting sea turtles and seabirds leading to reduced breeding success • Disturbance to nests and burrows leading to reduced breeding success. • Seabird abandonment of disturbed nesting sites

Aspect	Activity	Potential impacts
Increased recreational pressure associated with construction workforce and Onslow population growth	• Visiting islands • Fishing • Boating • Anchoring • Increased foot traffic on mainland beaches • Increased camping on islands	• Disturbance of nesting fauna on islands (e.g. birds and turtles) • Direct impacts to fish populations • Disturbance to Dugong and turtles from boating activity
Discharges	• Routine discharges from onshore infrastructure • Routine discharges from vessels • Routine discharges such as PW, MEG, drill cuttings, mud, sludges and sands, CW, sewage/grey water, hydraulic control fluids and process chemicals. • Sand blasting of subsea trunklines • Hydrotest water discharge • PW	• Toxicity effects to marine fauna from discharges • Indirect effects associated with degradation of coastal marine water and sediment quality • Disturbance to marine fauna behaviours and migratory patterns
Leaks and spills	• Nearshore infrastructure and trunkline • Offshore infrastructure and trunkline • Vessel refuelling and fuel storage	• Potential oiling of fauna (particularly seabirds) leading to injury or mortality • Loss or disturbance to habitat critical to marine fauna • Toxic effects to marine fauna
Acoustic emissions	• Pile driving • Dredging and trenching • Rock dumping • Pipelaying • Engine noise from vessels • Noise associated with valves and trunklines in operation	• Behavioural changes, injury or mortality to protected and other marine fauna • Disruption of acoustic hunting behaviour and communications between cetaceans • Physiological damage to fauna in close proximity to piling
Light emissions	• Flaring • Routine lighting of onshore, nearshore and offshore infrastructure • Navigation marker lighting • Vessel lighting	• Attraction of turtle hatchlings and interference with sea-finding behaviour • Increased mortality of disoriented turtle hatchlings due to dehydration and predation • Injury or mortality of juvenile seabirds attracted to lighting and flying into infrastructure • Modification of fauna foraging behaviour around nearshore infrastructure due to light spill on the water

NB: Hatchlings are said to be "disoriented" during sea-finding when they cannot orient in a constant direction (Witherington & Martin 2000).

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that the presence of nearshore infrastructure will result in the disturbance of normal movements or migrations of marine fauna. The residual environmental risk for this potential impact was assessed as being "Very Low" – of "Minor" consequence and of "Unlikely" occurrence, as a major of marine fauna will be able to navigate around the infrastructure.

Change in the Abundance and Diversity of Protected Marine Fauna from the Creation of Artificial Habitat causing Fish Aggregation

Residual risk of marine infrastructure providing artificial habitat that may lead to adverse changes in marine fauna community structure/abundance is	**Very Low**

The marine infrastructure will attract a wide variety of fish and other organisms that may utilise the artificial habitat for colonisation, aggregation, food and/or refugia. Any ecological effects of the colonisation of new habitat will be localised around the marine submerged structures. There may be local long-term increases in abundance of some taxa at these new habitats. Indeed the modified habitat may enhance the success of some populations in the local area. For example, some species of Syngnathids will colonise the PLF pilings in areas where previously the sandy substrate was unsuitable for them. In the event that the submerged structures are removed, it is highly likely that the original benthic community will return to pre-development levels and that the impact to marine fauna communities will be negligible. This is based on the assumption that the original habitat, subtidal sand, would not have been permanently impacted by the presence of the infrastructure.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that the presence of nearshore infrastructure will result in the aggregation of some fish species leading to adverse impacts on marine fauna community structure and abundance. The residual environmental risk for this potential impact was assessed as being "Very Low" – of "Neglible" consequence and of "Possible" occurrence.

8.4.5.2 Dredging

Potential impacts to marine fauna associated with dredging and dredge material placement activities include:

- Entrainment of fauna in dredge
- Loss of critical habitat due to dredging and dredge material placement
- Degradation of marine water and sediment quality.

Entrainment of Protected Marine Fauna in Dredge

Residual risk to protected marine fauna from entrainment in the dredge is	**Low**

Marine fauna are only at risk of being entrained in the dredge when they are directly beneath the drag-head (i.e. suction tube which is dragged over the seabed during dredging). The drag-head follows seabed contours, but is periodically lifted above the water for inspection and maintenance. While in general only fauna on the seabed are at risk of being entrained, if the drag-head is raised above the seabed, fauna in the water column may also be entrained if the pump continues to run while the head is lifted. The suction of the water pump drawing in the slurry of water and dredge material from the seabed can suck in marine fauna that are not strong enough to swim away from the intake current. Field observations indicate that there is very little suction around the edges of the drag-head beyond approximately 1 m (D Dickerson [US Army Corp of Engineers] 2009, pers. comm.; R Morton [Port of Brisbane Corporation] 2009, pers. comm.). Large fauna such as adult turtles are generally strong enough swimmers to escape the dredge suction and reduce their risk of entrainment.

The potential for a dredge to entrain marine fauna depends on the type of dredge, as the different types of dredges vary according to the speed at which they operate and the nature of the material they remove from the seabed. CSD move slowly because they are cutting rock and are generally noisy enough to cause fauna to move away. Very few fauna have been entrained in CSD dredging operations in the United States (D Dickerson [US Army Corp of Engineers] 2009, pers. comm.). TSHD can move faster than CSD because they suck in unconsolidated sediments. TSHD pose a greater risk of entrainment to marine fauna resting on, or partially buried in the seabed sediments. While large, strong swimming fauna, can escape the suction field around the drag-head, smaller species and individuals can become entrained in the slurry sucked into the drag-head.

These fauna are likely to suffer extreme physical trauma and often die. Simple measures such as turning the dredge suction off when the head is raised above the seabed can greatly reduce the risk of entrainment.

Sessile marine fauna associated with benthic habitats in dredge areas will be entrained in dredge intakes; their loss is assessed in relation to loss of the supporting habitat (Section 8.3) with the dredge as the mechanism. The representation of the supporting habitats has been used as an index of the distribution of the associated sessile fauna. It is assumed that the permanent loss of benthic habitat in dredged areas and dredge placement sites will lead to mortality of all associated sessile fauna.

Mobile fauna are generally able to move away from the dredged areas. However, their relocation will only be successful if there is sufficient habitat adjacent to the dredge areas to accommodate the displaced fauna. Increased intra- and inter-specific competition will reduce the productivity and survival rates of the displaced species. The potential loss of some smaller site-attached fauna, or fauna with low mobility, such as molluscs and crustaceans living in sediment of the proposed dredge area is an unavoidable consequence of dredging. The larger marine fauna in the area, including marine turtles, sea snakes, cetaceans and Dugongs, are more mobile and their home ranges are much larger. The relocation of these taxa to adjacent habitats is considered sustainable given the absence of critical habitats in the dredge areas and the major risk is associated with entrainment of individuals. Due to their protected status, these fauna are considered in terms of loss of individuals.

The protected marine fauna most at risk from entrainment in the TSHD dredge are those species and individuals that spend a significant amount of time on, or very near, the seabed. Marine turtles and sea snakes are at higher risk of entrainment than other protected marine fauna, because they rest and forage on the seabed. Juvenile and sub-adult sea snakes and marine turtles are at greater risk of entrainment than adults (D Dickerson [US Army Corp of Engineers] 2009, pers. comm.), most likely due to their weaker swimming ability. However, rates of entrainment are generally low, even when TSHD are in use (S McKinnon [Port of Brisbane Corporation] 2010, pers. comm.). Average turtle capture per year by the TSHD *Brisbane* since the 2001/2002 financial year is 1.8 turtles (14 in total) or 0.00099 turtles per dredge hour. The TSHD *Brisbane* operates year round, 24 hours a day, both in Brisbane and at other ports in Queensland.

No Dugong or Manatee deaths due to entrainment in dredges have been recorded during dredge program monitoring in the US and Brisbane (D Dickerson [US Army Corp of Engineers] 2009, pers. comm.; R Morton [Port of Brisbane Corporation] 2009, pers. comm.). Dugongs are therefore not considered to be at risk of entrainment during Project dredging. Cetaceans of all sizes are not at risk of entrainment due to their strong swimming capabilities and preference for supra-benthic habitats.

Juvenile turtles in the Project area predominantly occur around offshore reef habitats, including reefs around islands; the majority of these turtles are Green Turtles. While there are no offshore reef habitats within the proposed dredged shipping channel, there are islands surrounded by reef to the east, west and north (Direction Island, Ashburton Island and Thevenard Island, respectively) of the Project area. The movement of juvenile turtles outside of and/or between the offshore reef habitats is not well understood.

Despite their larger size, inter-nesting Flatback Turtles are also considered to be at risk of entrainment during Project dredging because they may rest on the seabed. Flatback Turtles nesting at Ashburton Island are known to spend at least part of the inter-nesting period in the area of the proposed dredged shipping channel (RPS 2010a, Appendix O11). Diving data are currently being collected for these turtles and will provide an indication of the proportion of their time that they spend on the seabed, and hence at higher risk of entrainment, and will be reported separately. Dive data for inter-nesting Flatback Turtles in Queensland and the Northern Territory indicates these turtles are likely to spend long periods on the seafloor (Sperling 2007).

Although Green Turtles also nest on islands in the vicinity of the Project area (RPS 2010a, Appendix O11), they generally stay within a few kilometres of their nesting beach during the inter-nesting period (Hays *et al*. 1999) and are not expected to be present in the proposed dredged shipping channel.

Densities of foraging marine turtles in the Project area are low and the juvenile turtles, which according to data from the US Army Corps of Engineers are most at risk from dredging, mainly aggregate around the offshore islands, rather than in the areas proposed to be dredged. It is considered possible that a small number of turtles may become entrained in the dredge in the course of the dredging program. The significance of these deaths to the local populations is uncertain at present.

Anecdotal evidence from other parts of the world suggests that marine turtles may use the sheltered habitats created by shipping channels and thus may be susceptible to entrainment during the maintenance dredging of the channels. However, given the low densities of turtles in the area, only a small proportion of the population would be affected. Maintenance dredging will occur over a shorter period and cover a smaller area and is considered to pose a lower risk to marine turtles than construction dredging. The risk ranking for construction has conservatively been applied to all dredging.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that entrainment of protected marine fauna in dredging equipment may occur, reducing the abundance of the entrained species. The residual environmental risk for this potential impact was assessed as being "Low" - of "Moderate" consequence and "Possible" likelihood.

Loss of Critical Habitat due to Dredging and Dredge Material Placement

Residual risk to protected marine fauna from loss of critical habitat from dredging and placement of dredge material is	**Very Low**

Dredging for the shipping access channel, turning basin and the trunkline route will take approximately three to four years and hence potentially affect the full range of life history stages for most marine fauna. Construction dredging will involve both CSD, in shallow water, and TSHD in deepwater. These processes engender different risks to marine fauna. Dredging and proposed dredge material placement activities are described in detail in Section 8.3.

Benthic habitat mapping of the broader area within which the proposed shipping channel and other infrastructure will be constructed, indicated that there are no rare or restricted benthic marine fauna habitats in the area. While the final alignment of the shipping channel and berths has not been determined, none of the alternative locations will directly affect critical foraging habitat for protected marine fauna.

Approximately 12 per cent of low-cover seagrass beds, situated in the west and in the east of the Project area, are predicted to experience partial mortality associated with dredging works (Section 8.3). Partial mortality of seagrass refers to the death of some of the above ground plant material (ranging from one to 50 per cent of the cover or biomass for a given area). These seagrass beds are dominated by the genus *Halophila*, which is seasonally abundant and known to recover rapidly from disturbance (Birch & Birch 1984; Lanyon & Marsh 1995; Rasheed 2004). Therefore the affected seagrass beds are predicted to recover rapidly following cessation of the disturbance. Seagrasses are the primary food source for Dugongs and are an important food source for Green Turtles (Section 6.3). The disturbance of a small proportion of this habitat in the Project area (Section 8.3) is unlikely to have population level effects on Dugongs or marine turtles, but it may have a short-term influence on the distribution of individuals while foraging. Fauna that forage on seagrass in the Project area may avoid feeding in disturbed seagrass areas until the meadows have recovered fully. Sparse seagrass beds are found throughout the Project area and most will not be disturbed by Project activities because of their distance from the dredge area (Figure 8.26). In terms of Dugongs, which also feed on the below ground part of seagrasses, the loss of only some leaf material due to dredging may not have a significant impact on the foraging potential of seagrasses exposed to the dredge plume. Fauna that feed on fish and invertebrates, for example Flatback Turtles and dolphins, may increase usage of the development area as the marine infrastructure will provide enhanced foraging habitat. These behavioural changes are not predicted to affect the abundance or population success of any species of protected marine fauna in the area. Some marine fauna are likely to avoid areas of very high turbidity during the dredging, particularly the predators that rely on visual cues. However their temporary displacement to nearby habitats is not expected to have any effect on their population. The shallow areas to the north of the Ashburton River, where dredging is proposed, will create turbid plumes in areas that experience naturally turbid conditions during flooding and cyclonic activity.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that habitat critical to protected marine fauna will be damaged by dredging and material placement activities. The residual environmental risk for this potential impact was assessed as being "Very Low" - of "Minor" consequence, as it is unlikely that this activity will cause a change in abundance of species, and of "Unlikely" occurrence.

Loss of Critical Habitat to commercially important fauna due to Dredging and Dredge Material Placement

Residual risk to commercial marine fauna from loss of critical habitat from dredging and dredge material placement is	Medium

There are seven prawn trawl fisheries in WA, with a total value in 2006 of $38 million. As noted in Chapter 6, *Overview of Existing Environment* and Chapter 10, *Social Risk Assessment and Management,* the OPMF is the most prominent fishery in the Project area and extends over an area of 39 748 km^2. The OPMF is a small fishery, with a 2006 value of $0.65 million (the catch was so low in 2007 that the value was not recorded). In comparison to the OPMF, other fisheries in the Onslow area are relatively small. While it is relatively small in size, the PFTIMF dominates the demersal scalefish landed by commercial fisheries in the Pilbara region. Smaller quantities of fish are taken by the Pilbara Trap Managed Fishery (PTMF) and wetline fishers. While the total catch is small, it is important as a substantial portion of the scalefish sold in Perth comes from Pilbara fisheries. It should be noted that the trawl and trap fisheries are not permitted to fish in inshore waters, where recreational fishers concentrate their effort. There are also small catches in other commercial fisheries such as mackerel, Blue Swimmer Crabs, pearl oysters (*Pinctada* spp.), specimen shells and aquarium fish. There is a substantial, but largely unquantified recreational catch in the Pilbara. This is discussed further in Section 8.4.5.5.

Prawns are benthic dwellers and generally have a high tolerance to turbidity in excess of 100 mg/L (Preston *et al.* 2005). Banana prawns are known to prefer muddy habitats and are commonly found in the Ashburton River Delta, where turbidity ranges above 50 mg/L (URS 2010a).

With the low productivity of oceanic waters in the Pilbara, fish populations are relatively small and are easily overfished. Current estimates by DoF are that fish in the region are currently fully exploited and are likely to be adversely affected by increased fishing pressure. Many coastal fisheries, including prawns, are reliant on estuary systems and mangrove habitats during critical stages of their life cycles. For example, the primary determinant of juvenile prawn population sizes in tropical Queensland estuaries was found to be the settlement of post-larvae from offshore and the greatest densities of larvae were in the upper reaches of small creeks, not in the major river systems (Vance *et al.* 1998). Subsequently, maturing juveniles emigrate from the creeks and estuaries to coastal and offshore habitats. In the case of the OPMF, the nearshore area adjacent to the Ashburton North SIA is in the middle of a recognised nursery ground of approximately 7450 ha extending approximately 8 km along the coast to Beadon Point (Figure 8.60). This, and areas further offshore form part of the OPMF. The potential impacts that could affect these fisheries life-cycle processes in the Project area were identified as impacts to water quality, benthic habitats and coastal processes.

Turbidity impacts on water quality during dredging operations will occur temporarily (Section 8.2) but are considered unlikely to significantly affect fisheries in the area. The fisheries are based on mobile species which are periodically exposed to natural extreme turbidity events due to catchment run-off, especially from the Ashburton River, and resuspension due to wind and waves. Proposed operational discharges and surface water run-off from storms will meet regulatory standards and the risk of these impacting fisheries is considered low.

Direct impacts to fishes and crustaceans from elevated turbidity were considered minor in a recent dredge impact study in Fremantle Western Australia (SKM 2008). A South Carolina dredge monitoring study, conducted in the vicinity of dredge material placement sites during and after dredging, found no decrease in nearby reef fish stocks over the five year monitoring period (Crowe *et al.* 2010).

Kailola *et al.* (1993) found that the Pearl Oyster (*Pinctada maxima*) inhabits a variety of substrates, from mud, sand, gravel and seagrass beds, to deep water 'reefs', living beside sponges, soft corals and whip corals. The habitats in which *P. maxima* is most abundant are generally characterised by substantial amounts of terrigenous sediments combined with high nutrient inputs (Gervis & Sims 1992). This habitat is similar to significant pearl oyster collection sites found north of the Project area in the Mary Ann Passage (I. LeProvost [LeProvost Environmental Consulting] 2010, pers. comm.). *P. maxima* is able to cope with high suspended sediment loads (up to between 30 and 40 mg/L), including substantial amounts of inorganic particles (Yukihira *et al.* 1999). *P. maxima* also have a long breeding season, extending from September to May, and their planktonic larval stage lasts from between 28 and 35 days (Fletcher *et al.* 2006). This suggests that successful spawning and settling would still occur as the planktonic stages would still exist in the water column during and after dredging and placement activities.

Dredging may impact marine fauna indirectly by affecting important habitat, however no habitats in the area are known to be critical for the ongoing success of marine fauna populations. Loss of some coral assemblages due to dredging will inevitably impact fish assemblages dependent on this habitat, but only at those reefs exposed to damaging levels of sedimentation (Section 8.3).

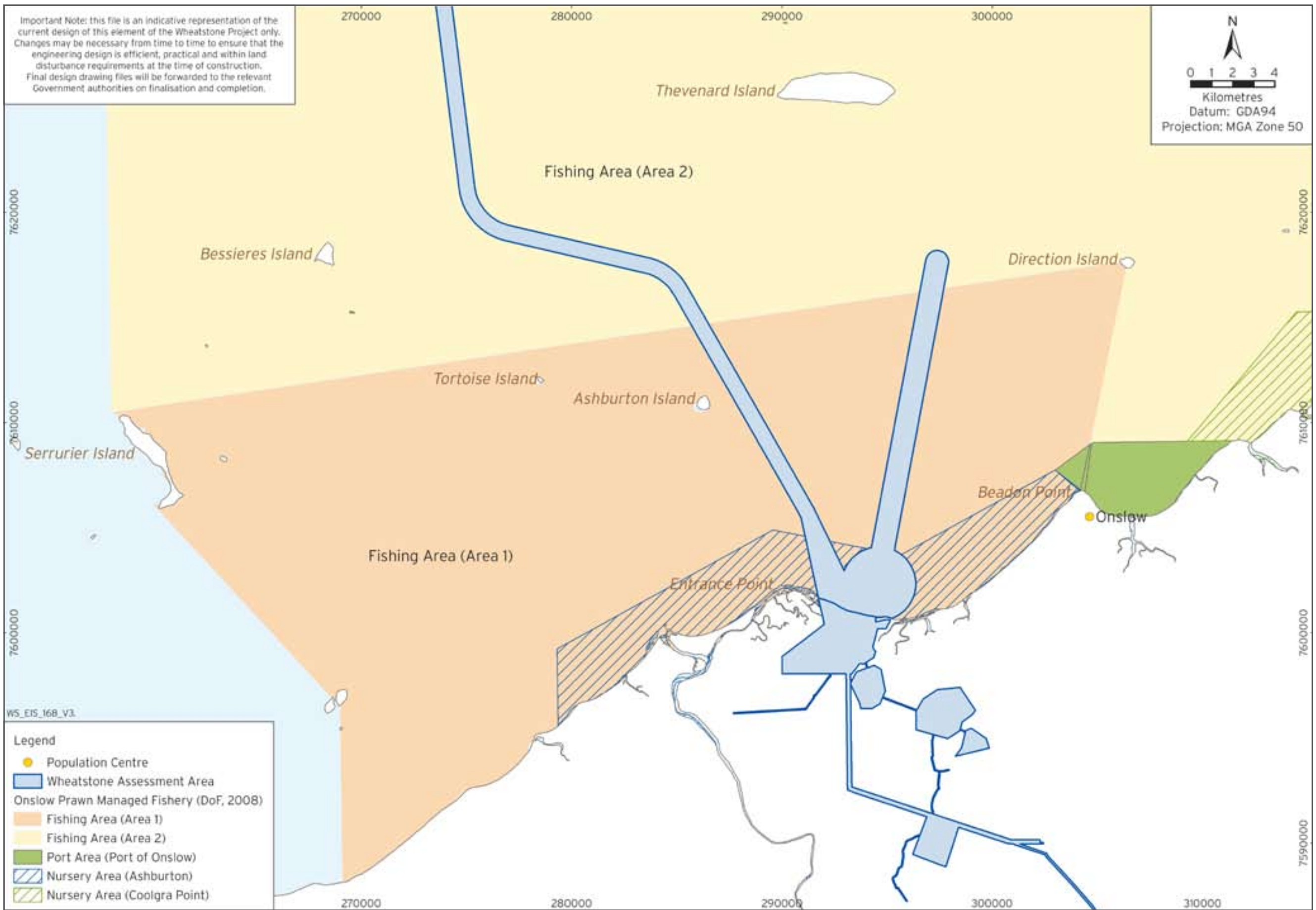


Figure 8.60: Boundaries of the Onslow Prawn Managed Fishery showing the Ashburton Nursery Area

Impacts could manifest as population declines in species dependent on corals for food and or shelter. Recovery of these populations should parallel recovery of the impacted coral assemblages once dredging has ceased. None of the coral-obligate fish species are known to be endemic to the Project area and affected populations will recover through recruitment from surrounding areas once the habitat has recovered. Populations of pelagic fish are likely to respond to the temporary impacts of dredging on water quality in the same way as they do to the annual, highly turbid discharges from the Ashburton River system.

In terms of benthic habitat, the anticipated potential permanent loss of the OPMF nursery ground, due to the development of the nearshore infrastructure, is less than four per cent of the total nursery ground area. Potential long-term loss of BPPH above guideline values due to plumes from dredging is not expected in the Project area with the adoption of mitigation measures outlined in the DSDMP. Temporary loss of macroalgae and seagrass beds is not considered to be substantial (Section 8.3). Proposed offshore dredge material placement sites do not support significant cover of BPPH (Section 8.3) and are not considered important BPPH. These areas are expected to recover through recolonisation by macroalgae and seagrass as was documented during ROV surveys of the Onslow Salt dredge material placement sites (URS 2009d, Appendix N9). The proposed loss of algal mats (241 ha or 24 per cent) and bioturbated mud flats (110 ha or 17 per cent) in Hooley Creek are above the CLGs and will contribute incremental regional loss of this habitat to fisheries. Potential impacts to the important Ashburton River delta system are unlikely (Section 8.3).

Although the proposed coastal marine infrastructure is likely to affect coastal processes, in particular the longshore sediment transport regime and the entrance regime of Hooley Creek (Section 8.5), management of these issues should mitigate this impact.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that a loss of habitat, critical for commercially and recreationally important marine fauna, may result as a consequence of degradation of marine water and sediment quality. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Moderate" consequence, as it is likely that this activity will cause a change in abundance of species, and of "Likely" occurrence.

8.4.5.3 Nearshore Construction Activities

Potential impacts to marine fauna associated with construction activities in the marine environment include:

- Loss of critical habitat due to construction of nearshore infrastructure
- Loss of critical habitat due to construction of offshore infrastructure
- Entanglement or ingestion of debris (assessed in Section 8.4.5.4).

Loss of Critical Habitat due to Construction of Nearshore Infrastructure

Residual risk to marine fauna from loss of critical habitat associated with construction of nearshore infrastructure is	Low

Construction of the MOF, PLF and channel will result in direct impact to seafloor sediment habitat, but not to habitat critical to marine mammals and turtles (Section 8.3). Potential direct impacts that may occur as a result of dredging have been addressed in the previous section and therefore are not considered further here. Indirect impacts through turbidity and sedimentation have also been addressed in Section 8.3.

Installation of the nearshore section of the trunkline is expected to cause localised disturbance to the filter-feeding communities on the sand/limestone pavement habitat between Bessieres Island Reef and Brewis Reef. The shallow portion of the trunkline will disturb soft sediment and limestone pavement habitat, the latter which may host algae and invertebrates that turtles may forage upon. There are no rare or critical habitats within the Project area and only a small proportion of habitat that is widespread within the region will be lost. This will have only a negligible effect on foraging habitats for turtles and Dugongs.

Construction of the proposed MOF and PLF will occur in shallow habitats where syngnathid fishes may be present. However, since their habitats are widespread in the shallower benthic areas along the coastline and around offshore islands, it is unlikely that habitat of particular importance to these fish species will be disturbed during onshore construction.

Nearshore construction is not predicted to affect any habitats critical for marine fauna. The coastal habitats are very well represented in the local and wider region and impacts will be limited to modification of areas in the immediate vicinity of the development. These changes are not predicted to affect marine fauna populations.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that a loss of habitat may result from construction of nearshore infrastructure, impacting on marine fauna. The residual environmental risk for this potential impact was assessed as being "Low" – of "Minor" consequence and of "Likely" occurrence.

Loss of critical habitat due to construction of offshore infrastructure

Residual risk to marine fauna from loss of critical habitat associated with construction of offshore infrastructure is	Very Low

The following activities associated with offshore construction for the Project may result in direct or indirect, (i.e. through removal of habitat, feeding grounds), disturbance to marine fauna:

- Drilling of wells
- Installation of subsea wells, manifolds and flowlines
- Installation of platform (may include release of ballast water during installation and ongoing use of ballast (e.g. rock or iron ore dump to maintain stability)
- Discharge of drilling fluids and muds (i.e. water based muds, non-water based muds [i.e. synthetic based muds or ester based muds], or a combination of these)
- Hazardous wastes
- Installation of trunkline.

Seabed disturbed during construction of the offshore infrastructure (i.e. WP, subsea wells, manifolds, flowlines and export trunkline) will not impact any protected marine fauna. Potential impacts may occur to other marine fauna groups through disturbance and modification of benthic substrates in the immediate vicinity of construction. Indirect affects through habitat modification have been addressed in Section 8.3.

Construction of the trunkline from the gas fields is expected to cause localised disturbance to the soft sediment communities over much of the route. Impacts to soft sediment communities are expected to be short-term. Possible changes in faunal communities along the trunkline route may occur where the trunkline creates an area of available hard substrate in an area where it is normally limited. No impact to ecosystem function or diversity is expected.

Offshore construction is not predicted to affect any habitats critical for marine fauna. Construction of the platform and subsea infrastructure is not predicted to affect the foraging or migratory range of any species of marine fauna. The modification of benthic habitats will be restricted to a very small proportion of widely represented habitats. These changes are not predicted to affect marine fauna populations.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that a loss of habitat may result from construction of offshore infrastructure, impacting on marine fauna. The residual environmental risk for this potential impact was assessed as being "Very Low" – of "Minor" consequence and of "Unlikely" occurrence.

8.4.5.4 Vessel Movements

Potential impacts to marine fauna associated with vessel movements during construction and/or operation include:

- Entrainment of marine fauna in the dredge (discussed in Section 8.5.2)
- Vessel collisions
- Disturbance to marine fauna behaviour from vessel movements
- Introduction of non-native marine species (pests).

Numerous vessels will have to operate throughout the Project area during the construction, operation and decommissioning phases of the Project. These vessels and the activities they will undertake include:

- Construction – dredging, support, refuelling/bunkering, towing platform, crew transfers, drilling rigs
- Operation – supply, standby tugs, maintenance dredging, crew transfers, LNG ships, condensate ships
- Decommissioning – removal of offshore platform (including legs/moorings), subsea wells, manifolds and flowlines, support.

Injury/Mortality and/or Disturbance to Protected Marine Fauna Behaviour due to Vessel Movements during Construction

Residual risk to protected marine fauna from vessel collision during construction is	**Low**

Marine megafauna aerial surveys carried out from May to December 2009 recorded a total of 691 vessels during a total of 17 surveys (Figure 8.61, CWR 2010a, Appendix O4). The number of vessels observed ranged from 9 up to 223, averaging approximately 46 (±13 SE) vessels per day. Vessel activity was highest within the immediate Project area during the survey period, indicating that marine fauna are already exposed to a relatively high existing level of vessel movements.

The greatest period of vessel movements will be during the construction phase, which will take approximately three to four years to complete, and require a large number of vessels which are summarised in Table 8.42. This will include vessels relating specifically to dredging and those relating to other construction work (e.g. PLF and MOF construction). Construction dredging will require the use of a CSD, TSHD and support vessels. A CSD will move at approximately an average of 0 - 0.5 m/s and, on the occasion it may have to move to a bunkering site, may be up to 3 knots. During the CSD operations (15 to 18 months) five barges will continually operate back and forth to placement site C at a speed of 8 to 10 knots with each trip lasting about 180 minutes. A TSHD will typically move at a speed of 1 to 3 knots during dredging and from 11 to 18 knots during transport of the dredge material which may occur twice up to six times a day. Supporting the dredge are a survey vessel which operates at around 2 to 3 knots and up to 10 knots while moving between locations and possibly bunker barges which move very slowly. Vessels assisting with the construction of the PLF and MOF will operate at variable speeds depending on the task. However, while in the construction areas speeds will be low to manage the risk of grounding and colliding with infrastructure. Areas anticipated to have highest construction and operation vessel activity is very limited when compared to current or background vessel activity shown in Figure 8.62.

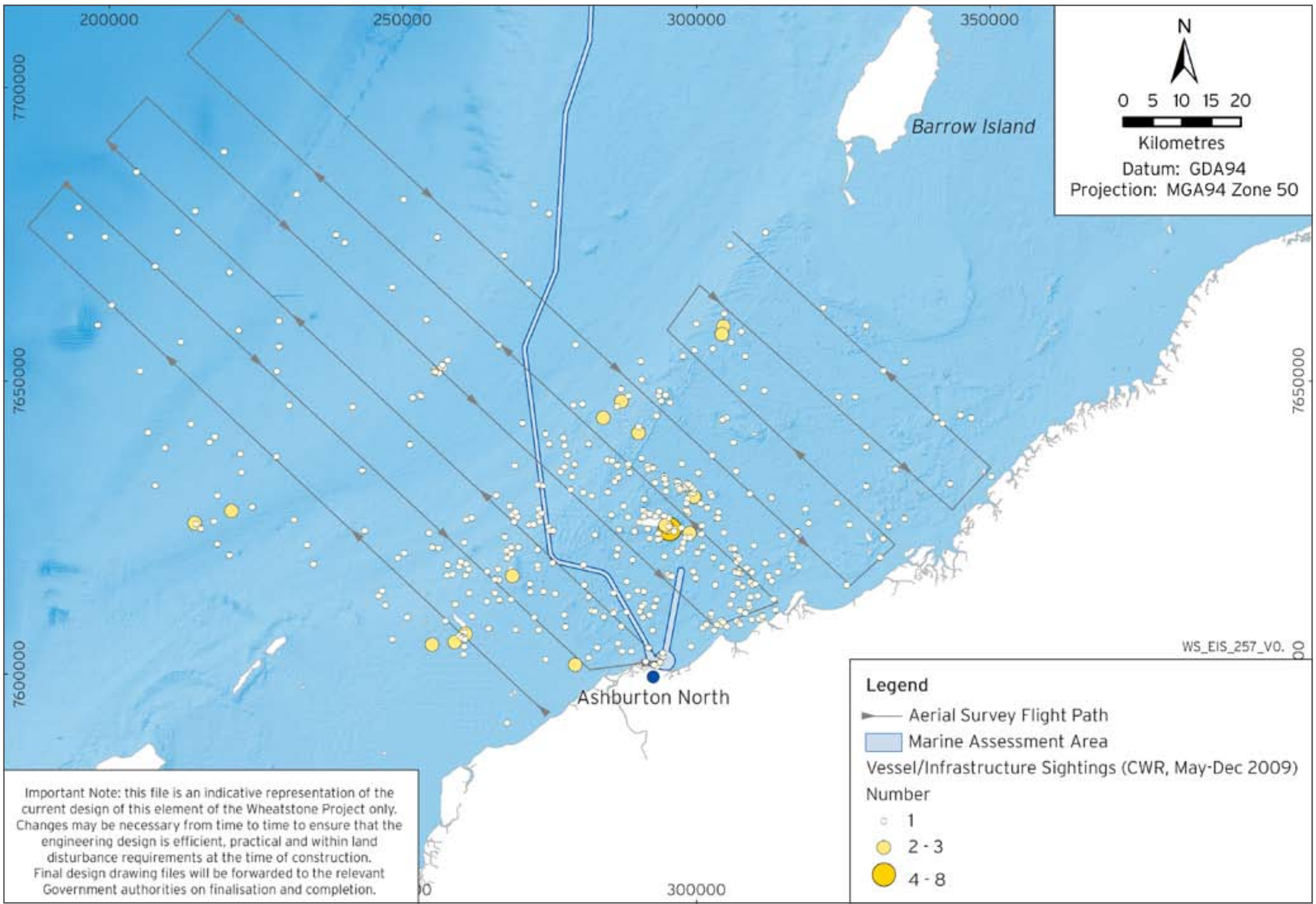


Figure 8.61: Distribution and Relative Abundance of Vessels and Man-made Structures Observed during Aerial Surveys from May to December 2009

Turtles, Dugongs and Humpback Whales inhabiting the area could be vulnerable to injuries or death from collisions with vessels due to their tendency to travel or rest on the sea surface. However, none of these fauna or their habitats have been found to be restricted to or concentrated within proposed areas of highest construction vessel activity. Figure 8.62 illustrates the areas of predicted highest Project (construction and operation) vessel movements in relation to areas that are thought to be seasonally important to these species.

The reef habitats support the highest densities of turtles during the non-nesting season. Nesting turtles are also out of the path of vessels, being restricted to islands and beaches outside the Project area. While turtles move throughout the Project area and surrounding areas between nesting events (RPS 2010a, Appendix O11), satellite telemetry data indicate that inter-nesting Flatback Turtles are not restricted to the high vessel activity area associated with dredge material placement site C.

Dugongs are distributed throughout the coastal waters out to the 20 m isobath, with most of the animals in the local area having been recorded east of the Project area. Only a very small proportion of potential seagrass habitat as recorded by URS (2010, Appendix N12) is within the area of high construction vessel activity, approximately 4 km south of proposed dredge material placement site C.

Based on the Humpback Whale surveys between May and December 2010 (CWR 2010a, Appendix O4), approximately five per cent of animals come within 10.5 km from the coast. As the area of highest construction vessel activity will be restricted to approximately 15 km from the coast, only a small proportion of the migrating whale population has the potential to be affected. The large construction vessels mainly produce low frequency sounds which propagate well through the water, giving the animals time to avoid them. Humpback Whales in New Caledonia display horizontal and vertical avoidance strategies in the presence of whale-watching tour operator boats, which may have a short-term behavioural impact (Schaffer *et al*, 2009).

Table 8.42: Summary Table of Project Vessel Movements During Construction

	Speed	Operation area	Frequency of movement	Duration
TSHD	1-3 kn (dredging) 11-18 kn (transit)	Dredge area and placement sites	6 times per day between dredge area and placement sites	3-4 years
CSD	0-0.5 m/s (<1 kn) <3 kn	Dredge area Bunkering site	Continuous	15-18 months
Barges	8-10 kn	Dredge area and dredge material placement site	Frequent	15-18 months
Survey vessel	2-3 kn or 10 kn when moving between locations	Dredge area, MOF and PLF; proposed anchorage area near Thevenard Island	Frequent	3-4 years
Support vessels	Variable speed; generally low to manage risk of grounding	Dredge area, MOF and PLF; proposed anchorage area near Thevenard Island	Frequent	3-4 years
Module and other delivery vessels	Variable speed; general low to manage risk of grounding	MOF and channel	Infrequent (2 vessels arriving and leaving per week)	3-4 years
Pilot vessels	Variable speed; general low to manage risk of grounding	MOF and channel	As above	3-4 years

Whilst avoidance of a vessel may require some additional energy expenditure, no lasting effects would be expected. Furthermore, unlike unmanaged tour operations, construction vessels will not target or purposely follow these animals, enabling them to move out of the way more easily.

Collisions between whales and dredge vessels have been previously reported (Best *et al*. 2001, Jensen & Silber 2004). It is unlikely that whales will be affected by vessel movements during the early part of the season, when the distribution is located offshore. Whales making their return journey southward from the calving grounds are, however, more likely to come close to shore. As such they are far more likely to encounter vessels associated with the dredging and construction of the Project. Calves spend longer at the surface and are usually accompanied during these surface intervals by their mothers (Laist *et al*. 2001) increasing the time that they are susceptible to a collision, but also increasing their visibility to vessel operators. Various responses, including mortality, have been described from the result of ships and whales colliding (Laist *et al*. 2001). Of 11 species known to be hit by ships, Fin Whale (*Balaenoptera physalus*) strikes have been recorded most frequently, with Right Whales (*Eubalaena glacialis* and *E. australis*), Humpback Whales, Sperm Whales, and Gray Whales (*Eschrichtius robustus*) strikes recorded less frequently (Laist *et al*. 2001). Previous studies have attributed 30 per cent of stranded Humpback Whales to collision with ships (Wiley *et al*. 1995). The high proportion of calves and juveniles among stranded Humpback Whale strikes indicates that young animals may be more vulnerable to being hit by ships and could also indicate that whales learn to avoid vessels as they mature (Laist *et al*. 2001). For whales which have learned to avoid vessels, the risk posed by additional vessels is much lower than the risk associated with introducing vessels into an area where the whales are not accustomed to their presence.

Vessel strike is unlikely to pose a major impact upon marine fauna due to most construction vessels moving at speeds less than 10 knots, at least 4 knots slower than the 'high risk' speed of 14 knots (Laist *et al*. 2001). The container vessels that will deliver plant and construction materials may have sufficient speed not to be detected by large cetaceans before collisions occur. In the case of large cetaceans, the probability of a lethal collision increases with speed, from 0.21 at 8.6 knots to 0.79 at 15 knots (Vanderlaan & Taggart 2007) and so not only are collisions more likely at these speeds, but they are far more likely to result in mortality (Laist *et al*. 2001). Whales usually are not seen beforehand or are seen too late to be avoided and most lethal or severe injuries involve ships 80 m or longer travelling ≥ 14 knots (Laist *et al*. 2001). Therefore, in the

Figure 8.62: Areas of Predicted Highest Project Vessel Movements in Relation to Important Areas for Turtles, Dugongs and Humpback Whales

event of a collision with a slow moving construction vessel, it is unlikely to result in death of the animal. While official records of interactions between dredges and marine fauna are not centrally located across Australia, an assessment of the issue (March 2010) across most major Australian ports failed to record any incident resulting in injury or death to marine mammals over the previous 10 years (W Young [DPA] 2009, pers. comm.). This is despite large dredging campaigns being undertaken in relatively high utilisation areas.

Whale Sharks are also at risk from vessel strikes (Speed *et al*. 2008). However, Whale Sharks are uncommon in the Project area (CWR 2010a, Appendix O4) and do not aggregate in this area as occurs seasonally off the Ningaloo Reef.

The most likely impact arising from the high level of vessel activity during construction is predicted to cause avoidance of the immediate vicinity of the construction area by larger fauna. Potential disruption of migratory behaviour will be limited to localised displacement of a very small proportion of the migrating populations but will not affect the success of the migrations. Marine fauna temporarily displaced from the Project area during construction are predicted to resume normal behaviours during the operational phase of the Project.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that injury or mortality of protected marine fauna may result through vessel collision following increased vessel movements during construction. The residual environmental risk for this potential impact was assessed as being "Low" – of "Moderate" consequence and of "Possible" likelihood.

Injury/mortality and/or disturbance to Protected Marine Fauna Behaviour due to Vessel Movements during Operation

Residual risk to protected marine fauna from vessel collision during operation is	**Low**

The operations phase will require significantly fewer vessels than the construction phase. LNG ships and condensate ships will arrive at the PLF at the Ashburton North SIA at varying frequencies, dependent upon the stage of operation of the Project (Chapter 2, *Project Description*) as summarised in Table 8.43 for 25 MTPA (frequency will be less for two trains). Additional support vessels will be required to support the LNG and condensate export activities. The speed of these vessels within the nearshore area will be dictated by harbour regulations. Within the navigation channel, LNG ship will travel at speeds ranging from 8 to 10 knots. For the approach to the navigation channel vessels will transit between 10 and 12 knots and will only reach cruising speed when in deep water (i.e. water depths greater than 20 m without hazards). The frequency of vessel arrivals will be approximately one LNG ship per day and three condensate ships per month (Chapter 2, *Project Description*). Figure 8.62 shows the Project area predicted to experience the highest vessel activity during the operation period. This area is very limited when compared to current or background vessel activity shown in Figure 8.61. Operational vessel activity will largely be restricted to the MOF, the PLF and the proposed navigation channel.

Figure 8.62 also illustrates the areas of highest Project vessel movements during the operational phase in relation to areas considered to be important to turtles, Dugongs and Humpback Whales on a seasonable basis.

Table 8.43: Summary Table of Project Vessel Movements During Operations (25 MTPA)

	Speed	Operation area	Frequency of movement	Duration
LNG ships	Channel 8-10 kn Approach 10-13 kn	Navigation and approach channel	2 transits per day (one in and one out)	Project life
Condensate ships	As above	As above	6 transits per month (3 in and 3 out)	Project life
Tugs	As above	As above	As above	Project life
Pilot vessels	As above	As above	As above	Project life

The proposed LNG departure routes do not intersect any known critical resting, feeding or breeding habitats of these species. Reef habitats have been found to support the highest densities of turtles during their foraging season. Most movements of inter-nesting satellite tracked turtles have been throughout coastal waters out to the smaller islands, with only one turtle traversing the 20 m isobath around the north coast of Thevenard Island (RPS 2010a, Appendix O11), around the general area of LNG departure route "alternative A". Dugongs have been found to be distributed throughout coastal waters, out to the 20 m isobath with most animals recorded east of the Project area and none recorded within the proposed LNG ship departure routes. Surveys to date have not detected any seagrass habitat within these areas; the closest patches of seagrass (with five per cent coverage) are more than 6 km away. Humpback Whales surveys between May and December 2010 (CWR 2010a, Appendix O4), showed that only approximately five per cent of animals come within 10.5 km of the coast. The vast majority (90 per cent) of whales are widely distributed between 10.5 km and 120 km from the coast so are therefore not concentrated near areas of high vessel movements. The known resting area (Exmouth Gulf) for migrating Humpback Whales with calves lies to the south-east of the Project area and is not bisected by the shipping route.

A detailed description of the potential for vessel strike is provided in Section 8.4.5.4 above. However, the potential for vessel strike to marine fauna is of a lower likelihood during Project operations than construction. This is due to fewer vessel movements, largely restricted to LNG and condensate ships in the areas frequented by migrating whales. These vessels emit low frequency sounds which cetaceans are able to hear and avoid.

The potential for disturbance, injury or mortality from increased boating associated with the Projects workforce during operations is discussed in Section 8.4.5.5.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that injury or mortality of protected marine fauna may result through vessel collision following increased vessel movements during Project operation. The residual environmental risk for this potential impact was assessed as being "Low" – of "Minor" consequence and of "Possible" likelihood.

Damage to Marine Biosecurity

Residual risk to marine fauna from IMPs is	Low

Australia is sensitive to the risks posed by IMPs, as they pose major ecological, economic and social risks to Australia. Non-native marine species may:

- Out-compete, predate upon or displace native species
- Alter natural ecological processes
- Harbour pathogens which can impact upon ecological or human health
- Degrade commercial fisheries and aquaculture enterprises, either through direct competition with target species or via the introduction of pathogens
- Cause problems for industrial infrastructure and navigation aids, for example, by blocking seawater intakes/outlets, impairing the operation of undersea valves, or causing buoys to sink
- Impose major maintenance and operational problems for vessels, and require them to undertake regular cleaning to keep underwater hull areas clear of fouling.

Marine pests are known to be introduced or translocated by a variety of vectors, including ballast water, biofouling, aquaculture operations, aquarium imports, marine debris and ocean current movements (Wells *et al.* 2009). IMP in Australia and overseas have caused many millions of dollars of damage to local economies and can require the expenditure of many more millions of dollars annually in control and remediation efforts (URS 2009j, Appendix R1). Once established, IMP can be difficult to eradicate, so prevention of transfer in the first instance is the best form of control.

Biosecurity can be defined as a set of practices that, when followed, may reduce the risk of the spread of disease, parasite and IMP from one location to another. As noted in Chapter 6, *Overview of Existing Environment*, none of the target list of 55 marine pest species of concern to Australia has been recorded in the Project area, or elsewhere in the Pilbara Nearshore or Pilbara Offshore bioregions.

The risks of introducing marine pests into WA via the Project were assessed as low for several reasons (URS 2009j, Appendix R1):

- The north coast of WA is part of the tropical Indo-West Pacific marine biogeographic region, and most of the species that could live in north-western Australia already occur there naturally. The exception is the Black-striped Mussel (*Mytilopsis sallei*), which is native to the tropical and subtropical waters of the eastern Pacific, the Gulf of Mexico and northern parts of South America (AQIS 2007).
- Mega-diverse tropical regions appear to have a natural resistance to introduced marine species becoming pests.
- Shipping movements in the Pilbara have been substantial for the last 40 years, but no marine pests have been recorded as introduced to Pilbara ports.
- There are a number of transmission vectors for reported introductions of marine bacteria, viruses and parasites. They are most readily translocated from one area to another in their hosts. This has most commonly been reported in operations related to aquaculture. Such activities will not be undertaken by the Project.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that increased vessel movements in the Project area during operation may result in an increase in the likelihood of introduction of marine pests, resulting in impacts to industry and commercially important marine species. The residual environmental risk for this potential impact was assessed as being "Low" – of "Massive" consequence, due to the risk of potential introduction of pest species impacting on fisheries, industry and natural biodiversity, and of "Remote" likelihood.

8.4.5.5 Increased Recreational Pressure Associated with the Project

Potential impacts to marine fauna associated with recreational fishing and use of the island Nature Reserves from construction workforce include:

- Change to fish abundance and population size structure
- Boat strikes to Dugong and turtles
- Disturbance to nesting birds and turtles on islands
- Entanglement or ingestion of debris (e.g. fishing lines).

Reduction in Fish Stocks due to Increased Recreational Fishing Associated with Construction Workforce and Onslow's Population Growth

Residual risk to fish abundance and trophic structure from increased recreational fishing is	Medium

Fishing has traditionally been part of Onslow's identity, with recreational beach and boat-based fishing undertaken by residents and tourists. A recent intercept survey, undertaken by Coakes Consulting (Chapter 5, *Stakeholder Consultation*), of fishers in Onslow found they generally fished for consumption; targeting carnivorous species such as trevally, tuskfish, Red Emperor and Coral Trout. Those with larger boats are able to fish in deeper waters around Thevenard, Direction, The Twin and Ashburton islands while those with smaller boats are restricted to nearshore waters and creeks.

There has been a noticeable increase in visitors from the "mining hinterland" including Tom Price and Pannawonica in recent years (A O'Halloran [Shire of Ashburton] 2009, pers. comm.). Between 2005 and 2020 Onslow's population is projected to increase by 271 per cent (PICC 2008), is in response to proposed and new developments including the Project. Accordingly, recreational fishing in Onslow is expected to increase greatly. Further information on Onslow's projected growth is provided in Chapter 6, *Overview of Existing Environment*.

Increased fishing pressure can lead to the depletion of local or regional fish stocks. Targeted fish species are often high order carnivores that are long lived and take many years to reach maturity, and so are vulnerable to overfishing. The depletion of large carnivorous fish has also been found to cause shifts in other levels of the food web. This effect is known as 'trophic cascade' and can occur when numbers of predatory fish are reduced, resulting in an increase in numbers of prey species such as smaller fish, urchins and sea stars (Westera, 2003). The impact of trophic cascade will vary between ecosystems but results in flow-on effects to lower trophic levels (Westera 2003; Pinnegar *et al*. 2000). Reef food webs are sensitive to the potential for trophic cascade as a result of overfishing (Pinnegar *et al*. 2000). Reef degradation has occurred in areas such as Kenya and the Caribbean, where intensive fishing has removed high order predators, resulting in increased urchin populations and their subsequent overgrazing of primary producers (Jennings & Kaiser, 1998 *cited in* Pinnegar *et al*. 2000).

It is difficult to assess the potential impacts from increased recreational fishing around Onslow as there is very little information available on current size of fish stocks, population health and current level of exploitation for key target species (DoF, 2005). Predator-prey interactions are largely unpredictable, making it difficult to predict the potential trophic cascade effects.

Summary

Onslow is currently experiencing an increase in recreational fishing pressure, particularly during the winter months (peak tourist period), and the Project workforce is likely to further increase recreational fishing pressure. If fishing pressure reaches unsustainable levels it may lead to depletion in populations of target species and may have trophic cascade effects on the marine ecosystem.

Uncertainty exists with regard to the management of increased recreational fishing associated with the Project. Furthermore, there are no permanent Fisheries Officers located in Onslow, there is a data deficiency in relation to local fish stock size and population health and there is difficulty in predicting trophic level effects. These limitations have been taken into account when assessing the environmental risk.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that increased recreational fishing pressure may damaged populations of target fish species. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Major" consequence, due to the anticipated increase in recreational fishers in the Onslow area, and of "Possible" likelihood.

Injury/mortality and/or disturbance to Dugongs and turtles due to Increased Recreational Boating

Residual risk to marine fauna from boat strikes to Dugongs and turtles is	**Medium**

Recreational vessel activity is likely to increase during the construction and operational phases as a direct result of increased workforce in the area. Data on current or projected boat ownership for Onslow is not available. However, the number of vessels registered within the Pilbara region has grown from 1362 in 1990 to 3920 in 2008, an approximate increase of 5 per cent per year (ABS 2009). This increase in recreational boating has been linked to an increase in population and in household incomes within the Pilbara as a result of increased resource sector activity. It is anticipated that these trends will continue.

Small recreational vessels pose a serious threat of injury to marine fauna because they can be difficult for the animals to detect and often have exposed propellers. Detection by animals is difficult due to the relatively small size, high speeds and high frequency sounds of these vessels. They can travel at a speed greater than 20 knots, depending on sea state (Hazel *et al*. 2007). They produce mainly high frequency sound which does not propagate very well underwater and speed boats often have unprotected propellers. Small fast moving vessels are a potential major source of injury and mortality to marine mammals and turtles. Haubold *et al*. (2006) reported that 25 per cent of all documented deaths to Florida Manatees (*Trichechus manatus latirostris*) were due to vessel collisions. Greenland and Limpus (2006; Cited in Hazel *et al*. 2007) noted that seven per cent of dead Dugongs reported from Queensland had been struck by vessels.

Limited information is available on avoidance responses of marine turtles to vessels. Vessel strike is responsible for around 65 turtle strandings in Queensland each year, which is approximately 14 per cent of total annual recorded turtle strandings in Queensland (Hazel & Gyuris 2006). However, specific details of the vessel strike incidents are largely unknown (Hazel & Gyuris 2006). A study undertaken in Queensland demonstrated that the majority (60 per cent) of Green Turtles were able to flee to avoid a 6 m vessel travelling at 4 km/h (2 knots) or less in shallow water (<five m depth), but that only 4 per cent actively avoided the vessel when it was travelling at 10 knots (Hazel *et al*. 2007). The Code of Practice for Sustainable Management of Vessel-based Dugong and Marine Turtle Tourism (Birtles *et al*. 2005) recommends that vessel speed limits of five knots be implemented in areas where there is a high risk of collision with turtles.

For most species, a decrease in abundance will be localised and short term, and offset by recruitment with no predicted population level impacts. However, for Dugongs, even a small increase in mortality could potentially lead to population level effects. Due to their low reproductive potential, Dugong populations are likely to decline if human-induced mortality exceeds one to two per cent of females (Marsh *et al*. 1994).

Summary

Uncertainty exists with regard to the management of increased recreational boat traffic associated with an increase in the anticipated population of Onslow. It is possible that boat strikes associated with increased recreational boating could cause a decline in local Dugong and turtle abundance.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that increased recreational boating traffic may result in a decline in the local population of turtles and Dugongs. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Major" consequence, due to the anticipated increase in recreational boat traffic in the Onslow area, and of "Possible" likelihood.

Disturbance to nesting birds and turtles on Islands due to Increased Recreation

Residual risk to marine fauna from potential increased recreational access to offshore islands is	Medium

Thevenard, Serrurier (Long) and Airlie Islands are protected under the *Conservation and Land Management Act (1984)* as Nature Reserves and are located to the north and north-west of the Ashburton North SIA (Figure 8.63).

These islands are vested with the Conservation Commission of Western Australia and managed by the DEC. By their isolated nature, islands provide refuge for indigenous flora and fauna, including nesting seabirds and turtles. A description of these and other local islands is provided in Chapter 6, *Overview of Existing Environment*.

The Onslow Structure Plan (2003) identifies the islands as important recreation areas for Onslow residents and tourists undertaking activities such as swimming, fishing and diving. Visitation by mine workers from towns within the Ashburton Shire has increased in recent years (A O'Halloran [Shire of Ashburton] 2009, pers. comm.) as has camping on some of the nearshore islands. Currently, visitor access to these Nature Reserves is largely unregulated due to a lack of management presence by DEC. Campers are expected to contact the DEC Exmouth District Office for permission to camp but it is not known whether this system is always followed. The biodiversity audit states that reserve management in this area is poor, because DEC's ability to actively manage these islands is

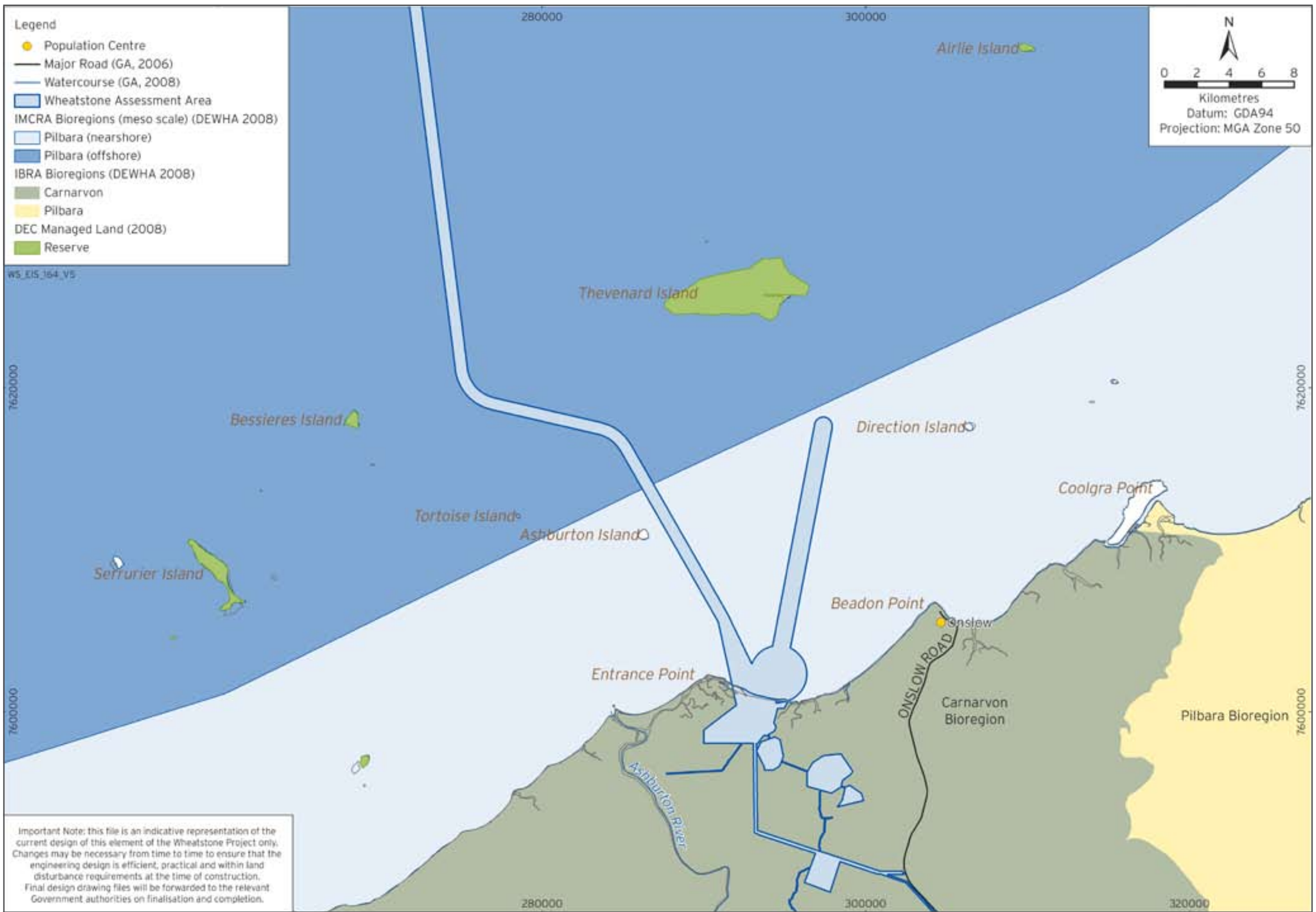


Figure 8.63: Location of Island Nature Reserves

constrained by a lack of funding and resources (May & McKenzie 2003). As a result, it seems that it would be very difficult for DEC to manage an increase in current visitation levels.

An increase of residents and visitors in Onslow during the operation phase may result in increased recreational usage in the Onslow marine environment as well as recreational visits to offshore island Nature Reserves. This may in turn threaten the conservation values of these islands. Uncontrolled recreational access to the offshore islands surrounding the Ashburton North SIA may affect the breeding success of marine turtles and seabirds on these islands.

Without management measures in place, such disturbance could conservatively be expected to affect a few individual nesting turtles, but without long-term effects on the population size or distribution.

Seabirds and shorebirds in this region are used to disturbances from cyclones and generally recover well in subsequent years. However continued and regular disturbance of roosting or nesting seabirds may affect their long-term breeding success. Seabirds that are disturbed during the pre-laying period when site attachment is low are more likely abandon their breeding attempt (Wooller *et al*. 1990). Depending on the species roosting birds may return to their roosts, or relocate to a nearby roost if disturbances are short-term. Birds that invest heavily in their breeding effort with a single large egg, such as the Wedge-tailed Shearwaters (*Puffinus pacificus*) that nest on Airlie Island and Serrurier Island, may show a greater variation in breeding success as a result of disturbances (Dunlop *et al*. 2002). Nesting birds may abandon their nests if disturbed by dogs or humans and if the disturbance is continual, long-term breeding success may be affected. A single dog could destroy most of a seabird rookery which would affect an ecologically significant proportion of the local population. While the population may recover through nesting the following year if dogs become a regular presence on these islands, birds are likely to be displaced.

Summary

Uncertainty exists with regard to the management of increased recreational use of islands near-by to Onslow. The potential exists to for disruption to occur to turtle nesting and bird rookery areas due to an increase in island access.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that increased recreational access of nearby islands may impact on turtle nesting and bird rookery areas. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Major" consequence, due to the anticipated increase in recreational access of the near-by islands, and of "Possible" likelihood.

Entanglement or Ingestion of Marine Debris related to Increased Recreational Boating and Fishing

Residual risk to marine fauna from entanglement in, or ingestion of, marine debris is	Low

Marine debris that may be harmful to marine fauna consists of plastic garbage, abandoned fishing gear, and solid non-biodegradable floating materials (such as plastics) disposed of by ships at sea. The presence of activity in the marine environment during construction and throughout operation of the Project will increase the potential for harmful marine debris entering the marine environment. No disposal of plastic waste to sea is planned for the Project; however, accidental loss of small volumes of plastic waste falling from vessels is possible. Potential increases in fishing activity will increase the likelihood of hooking or line entanglement of marine fauna, particularly juvenile turtles. Entanglement may also affect nesting seabirds that may forage between the islands.

Entanglement in marine debris can cause restricted mobility, starvation, infection, amputation, drowning and smothering. Marine turtles, whales and seabirds may be severely injured and even die after entanglement with fishing lines, fragments of trawl netting or plastic packing straps. Seabirds caught up in marine debris may lose their ability to move quickly through the water, reducing their ability to catch prey and avoid predators; or they may suffer constricted circulation, leading to asphyxiation and death. Fishing line debris, nets and ropes cut into the skin of whales or turtles, leading to infection or amputation of flippers, tails or flukes.

Marine fauna, such as turtles and seabirds, may also mistake plastic bags or rubber for prey and ingest them, which may cause a blockage in the digestive system, leading to injury and death.

Recreational fishing use of the general area is likely to lead to increased loss of fishing lines to the sea. However, these are much less likely to entangle fauna than fishing nets.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that increased recreational boating and fishing activity may result in increased likelihood of entanglement or ingestion of marine debris by marine fauna. The residual environmental risk for this potential impact was assessed as being "Low" – of "Minor" consequence and of "Possible" likelihood.

8.4.5.6 Discharges

The following discharges and wastes may be generated during the construction phase:

- Wash down water (for vehicles and equipment, waste areas, quarantine areas)
- RO brine
- Storm water
- Non-hazardous solid wastes
- Hazardous solid wastes
- Domestic waste streams such as sewage, grey water and food scraps
- Tail water from the onshore placement activities
- Hydrotest fluids (during construction)
- Concrete batch plant effluent
- Drilling muds and completion fluids
- Hazardous waste
- Construction and support vessel discharges
- Trunkline conditioning chemicals.

The proposed methods to dispose of, and manage wastewater, are discussed in Chapter 4, *Emissions, Discharges and Wastes*.

The planned marine discharges and waste that will be generated during routine onshore and offshore operations and could pose a potential impact to marine fauna are identified below:

- Process wastewater (nearshore)
- RO brine (nearshore)
- Storm water run-off (nearshore)
- Sludges and sands (nearshore)
- Drilling fluids/muds (nearshore and offshore)
- CW (offshore)
- PW (onshore and offshore)
- MEG (offshore)
- Hydrotest water (onshore and offshore)
- Deck drainage (offshore)
- Sewage and grey water (onshore and offshore)
- Putrescible wastes (offshore)
- Ballast water (offshore)
- Dredge material arising from maintenance dredging (offshore).

Potential impacts to marine fauna from routine discharges and waste generated in association with construction, operational and decommissioning activities are as follows:

- Toxic effects to marine fauna from nearshore and offshore discharges
- Indirect impacts to marine fauna from degradation of water and sediment quality (Section 8.4.5.2 Dredging Impacts)
- Increased nutrients in water leading to eutrophication
- Introduction of marine pests.

The potential environmental impacts on marine fauna from these discharges and wastes are discussed in the following sections. Management measures proposed to reduce identified potential impacts to marine fauna are presented in Table 8.48.

Toxic Effects to Marine Fauna from Nearshore Discharges

Residual risk to marine fauna from toxic effects from nearshore discharges is	**Very Low**

The types of ocean discharges expected to be produced at nearshore facilities at the Ashburton North SIA are described in Chapter 4, *Emissions, Discharges and Wastes*, and impacts to water quality given in Section 8.2. Discharge will be from at least 2 outfalls: at the PLF in 5 m of water and adjacent to the trunkline in approximately 20 m of water. The discharge of toxic substances to the marine environment can impact marine fauna indirectly through degradation of water and sediment quality. Toxic contaminants can bioaccumulate in water and in sediments which can affect the availability of suitable habitat, refugia and food. Marine fauna can also be affected by the direct ingestion of toxic substances which can result in injury and sometimes mortality.

Nearshore wastewater streams discharged are likely to contain contaminants that could be toxic to marine fauna if present in high concentrations or exposed for long periods. Given that the toxicity of a mixture depends on the total concentration of bio-available contaminants in the water, the potential toxic effects discussed in this section have been considered for each outfall location. Toxic effects to marine fauna will generally be managed by treating waste discharge according to government regulations. The sand/

silt substrate in the vicinity of the outfall at the PLF is well represented regionally and sensitive or protected marine fauna species are unlikely to be restricted to this location. Furthermore, the marine fauna that are likely to be present in the vicinity of the outfall on the PLF are considered widespread in the Pilbara region. Any toxic effects that do arise from the discharges will be localised to the area at or immediately surrounding the outfall location.

Trunklines will be hydrostatically tested (Chapter 4, *Emissions, Discharges and Wastes*). During commissioning of plant, the majority of the hydrostatic test water will be discharged offshore at the platform location. Discharge to the nearshore will be limited to low volumes of water from pigging and from contingency dewatering volumes required during emergency conditions (i.e. in the event of an approaching cyclone or harsh weather). The approximate volume of hydrotest water for the Trunkline and infield lines, to cover the range of contingency flooding, dewatering and final hydrotest requirements, is anticipated to be approximately 956 000 m^3. The export trunkline and infield production lines may also require swabbing with MEG to remove residual water prior to commissioning. Hydrotest water may result in short-term localised oxygen deprivation of biota exposed to the plume during mixing with seawater.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that discharges into the nearshore marine environment may have toxic effects on marine fauna. The residual environmental risk for this potential impact was assessed as being "Very Low" – of "Minor" consequence and of "Unlikely" occurrence, as all discharges will be treated to within acceptable limits prior to discharge.

Increased Nutrients in Water Leading to Eutrophication

Residual risk to marine fauna in the coastal marine environment from eutrophication is	**Very Low**

The types of nutrient discharges from nearshore facilities are described in Chapter 4, *Emissions, Discharges and Wastes* and Section 8.2. Elevated levels of nutrients in the water column can stimulate the growth of marine primary producers such as phytoplankton and algae, leading to blooms that can be toxic to local marine fauna. Increased algal growth on the leaves of seagrasses and other marine plants can also restrict photosynthetic ability with subsequent indirect impacts on grazers such as Dugongs and turtles.

Sewage and grey water will be treated according to statutory requirements and discharged to the marine environment via an ocean outfall (Chapter 4, *Emissions, Discharges and Wastes*). The potential impacts to marine fauna arising from the discharge of sewage and grey water are considered minor and are likely to be localised to the vicinity of the outfall.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that discharges into the nearshore marine environment may increase nutrients in the water, resulting in eutrophication. The residual environmental risk for this potential impact was assessed as being "Very Low" – of "Minor" consequence, as increases in nutrients in the water will limited to localised areas adjacent to the outfall locations, and of "Unlikely" occurrence.

Toxic Effects to Marine Fauna from Offshore Discharges

Residual risk to marine fauna from toxic effects from offshore discharges is	**Very Low**

The types of ocean discharges from offshore facilities are described in Chapter 4, *Emissions, Discharges and Wastes* and Section 8.2. In assessing the effects of discharges from offshore facilities it is important to highlight that the platform is more than 140 km from the mainland and approximately 45 km from the nearest island. The discharge of drill cuttings (and drilling fluids/muds that adhere to the cuttings) can increase turbidity in the water column as the cuttings are released overboard. As the cuttings fall to the seabed, the formation of a cuttings pile has the potential to smother marine benthic communities and can alter the marine sediment composition in the immediate area. The impacts of cutting to marine benthic fauna will be restricted to areas unlikely to exceed 500 m from the well (Dann & Mulder 1996, Currie & Isaacs 2005) and are therefore considered localised. There may be a restriction of oxygen transfer to underlying sediments for some time depending on water depths and currents; however currents should disperse and degrade the cuttings pile over time. The benthic fauna that are likely be affected by the discharge of drill cuttings are generally widespread throughout the Pilbara region.

Depending on the volume discharged, some sludges and sands could settle on the seabed and therefore have the potential to smother marine benthic communities and alter the marine sediment composition within an area unlikely to exceed 100 to 500 m from the well (Dann & Mulder 1996, Currie & Isaacs 2005). This would have a similar effect to cuttings piles described above, in that anoxic conditions in underlying sediment layers may result, until sludges and sands are degraded and dispersed. The impacts to marine benthic fauna from the discharge of sludges and sands would be restricted a relatively small area surrounding the well and are therefore considered localised.

Both water based and synthetic based drilling fluids ("muds") will be used during the drilling campaign (Section 4.6). These will be brought to the surface through separation equipment (shale shaker) where the fluids and cuttings are separated. Synthetic based fluids will be pumped to a vessels storage tanks and transported to shore for re-use or disposal (Section 4.6). Drilling fluids can have toxic effects to marine fauna, however only small volumes of drilling fluids that are attached to drill cuttings will be discharged to the marine environment. The concentration of drilling fluids that would be discharged will generally be too low to elicit a toxic response. Any toxic effects that do occur will be generally restricted to the vicinity of the wells and can therefore be considered localised. The marine fauna that are likely be affected by the discharge of drilling fluids that adhere to drill cuttings may include benthic invertebrates, marine plankton and fish that come into contact with drill cuttings that are contaminated with drilling fluids. The marine fauna present in the vicinity of Petroleum Titles WA-253-P, WA-16-R, WA-17-R and WA-356-P are representative of those found in similar habitats throughout the Pilbara region.

Hydrotest water that is discharged in deep offshore waters will most likely be discharged at the platform; however it will quickly be diluted in the deep water environment (Section 8.4.5.6).

PW and MEG discharges from the offshore platform are described extensively in Section 8.2. The PW from trains 1 and 2 will be treated, most likely using hydrocyclones and a degasser, prior to discharge as discussed in Chapter 4, *Emissions, Discharges and Wastes*. Following discharge, offshore currents are expected to quickly reduce PW concentrations in the receiving environment to levels below toxic thresholds. Any toxic effects that arise in marine fauna will be localised to the immediate area surrounding the central processing platform. Given the location and nature of the discharge, toxic effects to marine fauna from the discharge of PW are likely to be minor. Large volumes of MEG will be periodically discharged into the marine environment (Chapter 4, *Emissions, Discharges and Wastes*). MEG is used as a hydrate inhibitor. It is required to prevent formation of hydrates, a crystal structure of water and hydrocarbons. MEG is rapidly broken down in the marine environment and is believed to have low toxicity (ANZECC/ARMCANZ 2000).

CW discharge from the offshore platform is described extensively in (Chapter 4, *Emissions, Discharges and Wastes*). CW can contain biocides or contaminants which can degrade water and sediment quality. The discharge temperature will most likely differ from that of the surrounding marine environment which also reduces water quality. Indirect impacts to marine fauna from the discharge of CW are considered minor since the water will be rapidly dispersed on entry to the marine environment. Mixing and dispersion will reduce the temperature of the water and dilute any biocides or contaminants present.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that discharges into the offshore marine environment may have toxic effects on marine fauna. The residual environmental risk for this potential impact was assessed as being "Very Low" – of "Minor" consequence and of "Unlikely" occurrence, as most discharges will be significantly diluted in the deep water environment.

8.4.5.7 Hydrocarbon Leaks and Spills

This section describes the potential impacts from accidental condensate and diesel spill events associated with the Project, on marine fauna. A leak is defined as the escape, entry, or passage of oil through a breach or flaw in a pipe or tank. A spill is defined here as a layer of oil floating on water or covering the shoreline of a body of water. Oil spill modelling has been undertaken for a number of oil spill scenarios that could have a potential impact to marine fauna as follows:

- Nearshore facilities and trunklines:
  - PLF – surface spill of condensate during loading
  - MOF – fuel spill.
- Offshore facilities and trunklines:
  - Subsea spill of condensate during production (loss of well control)
  - Surface spill of diesel from WP
  - Subsea spill of condensate from punctured trunkline.

The modelling results for these oil spill scenarios, the likely fate and transport of released hydrocarbons and potential impacts to critical habitat for marine fauna have been discussed in Section 8.3.

For the purpose of this assessment the modelled spills have been grouped into nearshore and offshore spills. Potential impacts to marine fauna that may occur as a result of a leak or spill in either marine environment are as follows and are further discussed below:

- Loss of, or disturbance to, habitat critical to marine fauna
- Toxic effects to marine fauna
- Smothering and/or oiling of marine fauna leading to injury and/or mortality.

Loss of, or Disturbance to, Nearshore Habitat Critical to Marine Fauna

Residual risk from loss of, or disturbance to, habitat critical to marine fauna due to a leak or spill in the nearshore marine environment is	**Low**

Physical impacts to marine fauna from a leak or spill in the nearshore Project environment may result indirectly through loss of critical habitat for a species, e.g. coating of beaches important for marine turtle nesting or nesting birds and disturbance or damage to seagrass habitat important for Dugong and as a nursery habitat for prawns. The spills modelled in the nearshore marine environment are diesel spills at the MOF and condensate spills at the PLF. It is important to note that these spill plots represent "worst-case" because they do not factor in any mitigation measures to reduce the extent and duration of the actual spill. The effects of these spills on marine fauna will depend on the season, location of the spill, prevailing conditions and success of contingency response measures.

The oil spill model indicates that the spill largely follows the coastal currents in a predominantly easterly direction along the coastline during summer and predominantly westerly direction during winter. The modelled spill scenarios for the nearshore environment and the probability of impact to BPPH in the area are discussed in Section 8.3.5.14. Given that the proportion of total seagrass habitat that could be affected is small and that seagrass can recover quickly from large smothering events (Kenworthy *et al*. 1993), marine fauna associated with this habitat are unlikely to be severely impacted. Given the patchy distribution of seagrass within the Project area it is not likely to be utilised by the majority of faunal populations. However, the nearshore area designated as a nursery area for prawns for the OPMF could suffer impacts if hydrocarbons become entrained in the benthos. Protected marine fauna, such as Dugongs, are unlikely to be indirectly impacted due to lack of critical habitat affected by a spill (Section 8.3).

Although the model boundary does not include the mainland beach west of Entrance Point where low density turtle nesting has been recorded, it is unlikely that turtles nesting on this beach would suffer long-term effects as nests are built above high tide and the likelihood of a spill stranding on the beach or penetrating above the high water mark is low.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that a leak or spill of hydrocarbon into the nearshore marine environment may result in loss of, or damage to, habitat critical to marine fauna. The residual environmental risk for this potential impact was assessed as being "Low" – of "Moderate" consequence, arising from the potential for smothering of fauna, associated habitat and nesting beaches, and of "Unlikely" occurrence.

Loss of, or Disturbance to, Offshore Habitat Critical to Marine Fauna

Residual risk from loss of, or disturbance to, habitat critical to marine fauna due to a leak or spill in the offshore marine environment is	**Low**

For larger offshore spills (e.g. loss of well head control or trunkline rupture) there is more potential for contaminants to persist in the marine environment long enough to come into contact with habitats critical for marine fauna. The oil spill modelling indicates that a large spill of condensate in the offshore environment would travel in a north-easterly direction during summer and in a south-westerly direction during winter (Section 8.3). This slick is predicted to travel in the order of hundreds of kilometres from the spill source and though generally remains in deeper water; the spill does contact North West Cape coastline during transitional season conditions (Section 8.3). This could result in an impact on known turtle nesting beaches either in the vicinity of the offshore islands or along North West Cape. As the evaporation rate of condensates in tropical waters is quite rapid and the model predicts that the slick would take two to three weeks to reach North West Cape, it is likely that much of the spill could evaporate in calmer conditions before reaching nesting beaches. However, if driven by strong winds then it is possible that a portion of the spill could reach these beaches. Again it is unlikely that the slick would penetrate up the shoreline past the high water mark other than in the event of high tidal surge.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that a leak or spill of hydrocarbon into the offshore marine environment may result in loss of, or damage to, habitat critical to marine fauna. The residual environmental risk for this potential impact was assessed as being "Low" – of "Moderate" consequence, arising from the potential for smothering of fauna, associated offshore habitat and nesting beaches, and of "Unlikely" occurrence.

Toxic Effects to Marine Fauna

Residual risk of toxic effects to marine fauna due to a leak or spill in the nearshore marine environment is	**Low**
Residual risk of toxic effects to marine fauna due to a leak or spill in the offshore marine environment is	**Low**

Marine fauna surfacing in a slick may suffer lethal and/or sub-lethal effects due to inhalation or ingestion of hydrocarbons. Other potential impacts include irritation and damage to the more sensitive membranes of the eyes and mouth in marine mammals and turtles. However, this latter effect would be limited to the period immediately following the spill while the aromatic compounds were evaporating.

In general, whales and dolphins are considered to have the ability to detect and avoid oil slicks. Numerous studies have been conducted on dolphins regarding their detection abilities, and in all instances, the representative test animals were able to identify the presence of the pollutant and actively avoided contact with surface slicks (NOAA 1992 in Pidcock *et al*. 2003). Extensive studies carried out by Geraci (1990, cited in USEPA 2000) determined that direct surface fouling poses little if any problem to these cetaceans due to their extraordinarily thick epidermal layer which is highly effective as a barrier to the toxic, penetrating substances found in petroleum. However, it should be noted that Humpback Whale cow (adult female)/calf pairs would be more vulnerable due to the presence of these individuals in greater numbers in the nearshore Project area during their southward migration and also due to the greater amount of time spent at the surface than in adults.

There is little information available documenting sensitivity of Dugongs to hydrocarbons spills. However, it is likely they would be affected in a similar way to whales and dolphins, directly through toxicity via inhalation and ingestion, with juveniles being the most at risk. In the event of a large offshore spill of condensate, the very high evaporation rates of condensate in tropical environments will tend to reduce the extent of effects with concentrations of aromatic compounds likely to be significantly reduced by the time they reach sensitive areas such as offshore island nature reserves in the vicinity of the Project area and North West Cape. It is anticipated that large marine fauna such as Humpback Whales, dolphins, Dugongs and turtles will exhibit avoidance behaviour when in close proximity to a slick, particularly in the offshore waters of the Project area, where natural dispersion will also aid in reducing the exposure of aromatic hydrocarbons to marine fauna.

Small diesel spills in confined, shallow water such as in the nearshore Project area would pose a greater impact than a similar size spill in open water, where it would be rapidly diluted. Shellfish and prawns in the nearshore Project area may bioaccumulate the hydrocarbons and may also affect reproduction and feeding. Sawfish that may be present in and around Hooley Creek at that time could suffer toxicity if hydrocarbon components contaminate their food source. The affect of an oil spill would be elevated in shallow embayments such as Hooley Creek and the coastal area that the sawfish may be utilising around the creek, where the effectiveness of natural dispersion is less so than in open water. However, the minimum arrival time of low concentrations of oil to the creek is 6 hours (Section 8.3) and oil spill contingency measures would be employed within that time, reduce the likelihood of spill reaching the creek (DHI 2010e, Appendix Q2).

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that a leak or spill of hydrocarbon into the nearshore or offshore marine environment may result in marine fauna experiencing toxic effects. The residual environmental risk for this potential impact was assessed as being "Low" – of "Major" consequence, arising from the potential for lethal or sub-lethal impacts to marine fauna, and of "Unlikely" occurrence.

Smothering and/or Oiling of Marine Fauna

Residual risk from smothering and/or oiling of marine fauna due to a leak or spill in the nearshore marine environment is	**Low**
Residual risk from smothering and/or oiling of marine fauna due to a leak or spill in the offshore marine environment is	**Low**

Whales and dolphins have smooth skin and are hairless, hence hydrocarbons do not adhere to the skin. It is therefore unlikely that they would be sensitive to smothering or oiling effects from a spill. Also, as already discussed, it is anticipated that large marine fauna such as Humpback Whales, dolphins, Dugongs and turtles will exhibit avoidance behaviour when in close proximity to a slick, particularly in the offshore waters of the Project area, where natural dispersion will reduce the risk of exposure of a slick to marine fauna.

The greatest potential impact by direct smothering and/or oiling would be to seabirds nesting on the offshore islands in the Project area, if they were to come in contact with spilled oil as whilst on the surface of the sea and on foreshores while searching for food. Oil-coated birds can suffer hypothermia, dehydration, drowning and starvation and can become easy prey (AMSA 2002). These effects would be elevated in the event that a larger spill reached offshore islands of the Project area and/or North West Cape, where seabirds protected under the EPBC Act (Cth) may nest. However, the persistence of both diesel and condensate at the sea surface is low and it is predicted by the model that the slick would take two to three weeks to reach sensitive areas such as North West Cape.

Sawfish present in and outside of Hooley Creek may be affected in the event that the oil spill comes into contact with their gills, smothering them. However, as discussed above it is likely that oil spill contingency measures would be employed within time (Table 8.47) to reduce the likelihood of a spill reaching the creek.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that a leak or spill of hydrocarbon into the nearshore or offshore marine environment may result in smothering and/or oiling of marine fauna. The residual environmental risk for this potential impact was assessed as being "Low" – of "Major" consequence, arising from the potential for lethal or sub-lethal impacts as a result of smothering or oiling of EPBC Act (Cth) listed marine fauna and seabirds, and of "Unlikely" occurrence.

8.4.5.8 Noise and Vibration

The potential noise and vibration generating activities that may be associated with the Project are as follows:

- Pile driving
- Dredging and trenching
- Rock dumping
- Pipelaying
- Vessel movements
- Trunkline operation
- Vertical Seismic Profiling (VSP).

Noise and vibration can have the following potential adverse physiological impacts on marine fauna:

- Temporary or permanent injury or mortality
- Stress response
- Behavioural changes
- Attraction to the noise source
- Avoidance of the immediate area
- Disruption to underwater acoustic cues for navigation, foraging and communication.

The noise generating activities and their locations are summarised in Table 8.44, along with the marine fauna that could be affected by the noise and vibration associated with the activities. Noise generated by the Project (Chapter 4, *Emissions, Discharges and Wastes*) will be mainly concentrated in the nearshore marine environment. Of the sound generating activities, pile driving, dredging and trenching, and rock dumping only occur in the Pilbara Nearshore Region (PIN). Note that the proposed platform will be gravity based so no piling is currently planned during the installation and operation of this structure. Drilling activities are only anticipated in the offshore waters of the NWS Region, whilst vessel movements, pipelaying and trunkline operations will occur in all marine regions associated with the Project. The extent of the impacts to marine fauna from these activities depends on factors such as proximity, frequency, intensity and duration of the noise source. The level of the impacts also depends on the likelihood that the marine fauna are present in the areas that will be ensonified (Huson & Associates 2009).

The Project area does not contain significant habitat for marine fauna, which suggests that general avoidance impacts and stress responses will have negligible effects on the marine fauna populations in the area. Furthermore, if such activities do disturb marine fauna and cause them to leave the area, there are suitable marine habitats in the waters surrounding the Project area in which the effects are likely to be lower or absent and where affected fauna can move. Most individuals are expected to be only temporarily displaced and to return to an area once the noise ceases.

Construction Noise Sources

Piling

Construction of the proposed PLF will involve driving piles into the seabed (pile driving). Several hundred strikes are generally required to completely drive each pile into the seabed. These strikes can generate noise levels similar to those emitted during seismic activities and marine blasting, and can generate intense pulses of noise that have been observed to injure fishes that are very close, and have the potential to elicit a startle response in cetaceans (Vagle 2003; Parvin *et al*. 2007; URS 2009l, Appendix O9). Pile driving during the Project may therefore present a risk to marine fauna present in the immediate vicinity of the activity.

The proposed PLF will extend approximately 2.5 km offshore, remaining in waters less than 10 m deep. Pile driving will be conducted only during the construction phase of the Project, and involves short, intense pulses of noise, rather than a more continuous noise output (Chevron 2005). Two pile drivers will be operating concurrently and it will take approximately 14 months to complete the work (Section 4.5). Diesel engine noise from the pile driver mostly propagates in the air above the water column, and generally only influences the water column within a radius of <20 m (Huson & Associates 2009). Huson and Associates (2009) state that the dominant sound source from pile driving is caused by vibration of the pile in the water column during and after impact by the drop hammer (a strike). The peak pressures for pile driving vary for each strike and are dependent on pile diameter and substrate, but are approximately 170 dB re 1μPa on average (Nedwell *et al*. 2002). The intensity of the sound decreases with distance from the source (McCauley *et al*. 2002). For example, recent field measurements of impact pile driving at Gellibrand Pier, Port Philip Bay in Victoria showed noise levels ranging from 186 dB re 1μPa at 39 m to 165 dB re 1μPa at 258 m from source (URS 2009l, Appendix O9; CMST 2009). Noise from vibratory pile driving in the same area ranged from 172 dB re 1μPa at 49 m to 150 dB re 1μPa at 213 m (URS 2009l, Appendix O9; CMST 2009).

Pile driving source levels can vary between 220 and 230 dB re 1μPa; however, the frequency bandwidth for most of the energy in pile driving sounds is concentrated in lower frequencies, typically below 1000 Hz (Kent & McCauley 2006), but will also contain some high frequencies at lower energy levels. Dolphins and Dugongs are likely to be the only species in close proximity to the piling and are present year round. They are therefore likely to be exposed to the sounds from piling. However, they are not as sensitive to low frequencies as are large whales, and high frequencies do not travel as far underwater as low frequencies. The area in which dolphins and Dugongs would potentially be affected is therefore a smaller area than the area in which sounds from piling could be detected.

Sounds dissipate quickly in water that is shallow relative to the frequency. Low frequencies of 100 Hz or less cannot propagate across water that is shallower than a few metres. As the proposed PLF is located in waters of up to 10 m depth, it is likely that sound propagation will occur during the majority of piling events. However, as the coastal region in which the proposed Project lies has a high tidal range, there may be times when piling is conducted at low water and therefore sounds associated with piling may not propagate through the water.

Studies on the impacts to marine fauna from pile driving have been conducted for other developments in Australia. Table 8.45 summarises some of the impact zones that have been determined from other studies, and the management zones applied by other projects during pile driving activities. All projects applied a buffer zone of 200–500 m from the piling site within which marine megafauna were considered at risk. Since the noise emitted during each pile driving event is intermittent rather than continuous, and will only occur during the construction phase, the impacts to marine fauna are expected to be short-term in nature but extended over a period of 14 months. Potential impacts, including 'startle response', will be localised to the immediate vicinity of pile driving activity, concentrated around the pile, and are likely to be less severe as the distance from the pile increases.

Dredging

Dredging and trenching differ from pile driving as they result in a more continuous noise output. The sound levels emitted vary depending on the type of dredge used and the activity being undertaken. Sound levels from some large TSHDs operating in rocky areas have been recorded in excess of 150 dB re 1μPa at 1 km, while large CSDs can emit noise audible 20-30 km away (Richardson *et al*. 1995; Dames & Moore 1996). A TSHD operating in Port Phillip Bay in Victoria generated underwater noise levels of

143 to 154 dB re 1µPa at a distance of 100 m (Huson & Associates 2009). However, underwater noise levels from self-propelled hopper barges engaged in transferring dredge material can often be higher than the noises from the dredge itself, particularly during the loading and dumping operation of rocky material (URS 2009l). Dredging will mostly occur during the construction phase; however, some maintenance dredging will also be conducted during the operations phase. Whilst the sound emitted during dredging will be less intense than that generated during pile driving, it is expected to be more widespread, occurring for a longer time and over a greater area. Impacts to marine fauna will be localised to the areas where the dredges and the hopper barges are operating and are likely to result in avoidance of the immediate area by most marine fauna, with the exception of fish which may be attracted to the disturbance of sediment (Huson & Associates 2009).

Rock Dumping

Rock dumping will be conducted in the marine environment during the construction phase of the Project. Noise associated with the dumping, movement and settling of the rocks would probably be low frequency broadband (URS 2009l). The intensity and duration of the noise would be influenced by factors such as the amount, size and mass of rocks dumped, the depth of water in which they were dumped and the type of surface upon which they landed and settled. Rocks released underwater by a hopper would be expected to produce less noise as no splash would be generated. The use of fall pipes would also produce minimal splash but increased noise would occur from the banging and clatter of rocks inside the pipe (URS 2009l). Impacts to marine fauna from the noise and vibration associated with rock dumping are likely to be short-term and localised to the immediate vicinity of the activity.

Pipelay

Pipelaying activities will occur in offshore areas from the gas fields to the mainland shore crossing. Noise from marine pipelaying will vary in intensity and character with most of the noise caused by the operation of the pipelay and support vessels, particularly if dynamic positioning vessels are employed, and allied construction tasks such as trenching and rock armour dumping (Shapiro & Associates 2004). Some noise will be generated by the movement and placement of the pipe, but this is likely to be transitory, and will depend on the size and type of pipe and method of placement (URS 2009l). The noise generated during pipelaying activities will be less intense than that associated with pile driving, but will be widespread as the pipelaying vessels will traverse a large area.

Drilling

Drilling will be conducted offshore in the NWS region during the Project. Most of the source of noise during drilling is from the rig tenders, rather than the drilling rig or drilling operation itself (URS 2009l). Drilling noise is generally low level, low frequency and continuous, with most below 1 kHz. Richardson *et al*. (1995) reported that near field measurements from four bottom-founded drilling platforms were in the order of 119 dB re 1µPa to 127 dB re 1µPa. Studies have found that noise levels at 2 km from a drilling rig exceeded 120 dB re 1µPa for only 2 per cent of the time and estimated that significant effects of underwater noise would be confined to within 3 km of the rig (APPEA 2005).

Vessels

Noise and vibration associated with vessel movements will occur in all marine areas during all phases of the Project. Vessel numbers are expected to be greatest during the construction phase in the nearshore marine waters surrounding the proposed PLF, where a number of marine construction activities are planned. Vessels present during the construction phase will be of various types and sizes and will include dredging vessels, drilling rigs, various support vessels (for crew transfers, refuelling, etc.) and accommodation barges.

Vessel noise can be separated into two categories; noise from nearby ships and that from distant traffic. Surface shipping is the most widespread source of low frequency (<1000 Hz) marine anthropogenic noise (Richardson *et al*. 1995; Simmonds & Hutchinson 1996; Popper *et al*. 1998). Ships generate substantial broadband noise from their propellers, engines, auxiliary machinery, gear boxes and shafts, plus their hull wake and turbulence (URS 2009l). Sound levels were recently measured for ships operating in Port Phillip Bay, Victoria (Huson & Associates 2009). The maximum short-term sound emission level was generally 149 dB re 1µPa at a distance of 100 m (Huson & Associates 2009). In general, the larger the ship, the louder the source level ('near field noise') and the lower its tonals ('far field noise'). For example, the key noise spectrum from merchant ships is typically 20-500 Hz, with tonal peaks at approximately 50–60 Hz, often referred to as "far field noise".

Diesel engines produce more noise than steam or gas turbines, but most long distance, low frequency noise is generated by the propeller. The level of vessel noise in deep water is generally higher than in shallow waters as low frequency sound tends to be attenuated in shallow water (Nedwell *et al*. 2002). Barges are considered to have lower noise emissions than ships and other vessels, due to their lower powered engines (Huson & Associates 2009). Although it has been identified that noise from shipping and vessel movement can disturb marine fauna (such as cetaceans), they are generally tolerant of such noise as evident from the continued presence of marine mammals in this region with the existing moderate levels of vessel activity.

The frequency of vessel movements will decrease when the Project moves from the construction phase to the operations phase. The vessels to be used during the operations phase will include LNG and condensate ships, as well as tugs and support vessels associated with LNG and condensate export activities. The vessels will generally be sources of low frequency noise (<1000 Hz) which will be transitory because the vessels are moving point sources.

Recreational vessel activity, and therefore small scale noise outputs, will increase during the operational period as a result of an increased workforce in the area. High speed craft such as recreational speed boats and jet skis produce high frequency sounds which do not propagate well through water. Such craft are therefore not heard from a large distance and have the potential to startle marine fauna that come into close proximity. Although the quantum of increase in recreational vessels is not known at this stage, the potential effects to marine fauna will be limited to the immediate vicinity of the vessels.

Trunkline Noise

Trunkline operations will involve the movement of gas or fluids through a trunkline which generates noise that is radiated into the water column beyond the pipe (URS 2009l). Such noise is a function of several factors, such as the type of fluid, its physical characteristics, velocity through the pipe, internal diameter of the pipe, pipe length and the material from which the pipe was made. These factors, as well as any covering over the pipe, such as rock armour or bottom sediment, influence both the transmission of vibration through the pipe and its acoustic coupling with the water. For example, Marko (2003) considered sound propagation through bare and concrete coated steel plates and longitudinal pipe sections (URS 2009l, Appendix O9). It was demonstrated that a concrete coating on a pipe acts as an acoustic insulator and reduces radiated noise (Marko 2003).

The noise radiating from a 250 mm, epoxy coated, high-pressure, marine natural gas trunkline in Georgia Strait in the north-east Pacific, was measured at 60–72 dB re 1µPa (Birch *et al*. 2000; URS 2009l, Appendix O9). This can be lower or equal to the background sea noise emanating from wind, water movement, fauna and other sources (Richardson *et al*. 1995). Further modelling and analysis concluded that the larger diameter gas trunkline proposed for Georgia Strait would have a lower frequency for any given operating pressure than a smaller diameter line, with an estimated radiated noise equal to or lower than 30 dB re 1µPa at frequencies of 16 kHz and above (Shapiro & Associates 2004). The noise generated during operation of the proposed trunkline is expected to be low frequency and will persist for the duration of the Project.

PLF Noise

There will be vehicle movements and thermal expansion of metallic structures including trunklines delivering products to the terminal. These will create continuous (vehicle) and impulse (trunkline expansion shunts) noises that are likely to transfer to the marine environment. While these are unlikely to produce sounds at levels that would ordinarily disturb marine fauna, they will be associated with a new structure and coupled with movements of personnel and vehicles along the PLF, could create a barrier for the movements of sensitive marine mammals and in particular Indo-Pacific Humpback and Spotted Bottlenose Dolphins. It is also possible that Dugongs may be affected in the same manner. These three species are known to undertake seasonal migration movements along the coast, generally in shallow waters of the continental shelf. While it is unknown whether these three species will avoid the PLF for the reasons stated, it is also unknown whether they will also habituate to the presence of the PLF and the activities that will occur thereon.

Offshore Platform

Construction of the offshore platform is likely to generate the most significant noise in this area. Underwater acoustic emissions during construction, operation and decommissioning activities will be influenced by water depth, characteristics of the seabed, characteristics of the noise source (pressure, frequency and duration), background noise levels and thermoclines in the water column. Operations on the offshore platform will include noise sources such as flaring, power generation, mechanical noise/vibration from pumps and vessel blowdowns. Given the platform is elevated above sea level, little above surface noise is transmitted underwater.

Vertical Seismic Profiling

Vertical seismic profiling (VSP) is an activity to take measurements in a vertical wellbore using geophones inside a wellbore and a seismic energy producing source at the surface near the well. VSPs vary in the well configuration, the number and location of sources and geophones, and how they are deployed.

Table 8.44: Location of Sound Generating Activities and Marine Fauna that may be Impacted by Acoustic Emissions

Noise Generating Activity	Noise Level Range/Frequency	Marine Fauna	Humpback Whales	Blue whales	Dolphins	Dugong	Turtles	Whale Sharks	Bony Fish	Prawns
		Auditory Ranges	200 Hz - 10 kHz	200 Hz - 10 kHz	900 Hz up to 105-150 kHz	400 Hz - 46 kHz	400 Hz - 1 kHz	20 Hz - 800 Hz	up to 3 - 4 kHz	100 Hz - 3 kHz
		Location	PIN, PON, NWS	NWS	PIN, PON	PIN, PON	PIN, PON	PON, NWS	PIN, PON	PIN
Construction Phase										
Pile Driving	172 dB at 49 m to 150 dB at 213 m (vibratory piling) 186 dB at 39 m to 165 dB at 258 m (impact piling) CMST (2009)	PIN	●		●	●	●		●	●
Dredging and trenching	143 dB to 154 dB at 100 m from the source (Huson & Associates 2009)	PIN	●		●	●	●		●	●
Rock dumping	below 1 kHz (URS 2009l)	PIN	●		●	●	●		●	●
Pipelaying	n/a	PIN, Pilbara Offshore Region (PON), NWS	●	●	●	●	●	●	●	●
Drilling	below 1 kHz (URS 2009l)	NWS	●	●				●		
Vessel movements	below 1 kHz (URS 2009l)	PIN, PON, NWS	●	●	●	●	●	●	●	●
Operations Phase										
Trunkline operation	250 mm diameter pipe 60-72 dB (Birch et al. 2000)	PIN, PON, NWS	●	●	●	●	●	●	●	●
Vessel movements	below 1 kHz (URS 2000l)	PIN, PON, NWS	●	●	●	●	●	●	●	●

Table 8.45: Noise Impact Zones and Management Exclusion Zones for Marine Fauna during Pile Driving Activities

	Cape Lambert	Gladstone LNG	Port Of Melbourne	Gunn Pulp Mill	Gorgon Project
Whales	• Observation zone of 2.5 km (Sinclair Knight Merz [SKM] 2009) • Marine fauna exclusion zone of 500 m (SKM 2009) • Suspension zone of 100 m (SKM 2009)	N/A	• 200 m from marine based pile driving rig (Port of Melbourne (PoM) 2008) • 600 m from hydrohammer (PoM 2008)	• Serious hearing impairment zone 50 m (McCauley & Salgado Kent 2008) • Temporary impairment zone 100 m (McCauley & Salgado Kent 2008)	• Exclusion zone of 2000 m (Chevron 2008)
Dolphins	• Observation zone of 2.5 km (SKM 2009) • Marine fauna exclusion zone of 500 m (SKM 2009) • Suspension zone of 100 m (SKM 2009)	• 350 m from piling activity in water depth >3 m (Huson & Associates 2009) • 150 m from piling activity in water depth <3 m (Huson & Associates 2009)	• 200 m from marine based pile driving rig (PoM 2008) • 600 m from hydrohammer (PoM 2008)	• Serious hearing impairment zone 50 m (McCauley & Salgado Kent 2008) • Temporary impairment zone 100 m (McCauley & Salgado Kent 2008)	• Exclusion zone of 500m (Chevron 2008)
Dugongs	• Observation zone of 2.5 km (SKM 2009) • Marine fauna exclusion zone of 500 m (SKM 2009) • Suspension zone of 100 m (SKM 2009)	• 350 m from piling activity in water depth >3 m (Huson & Associates 2009) • 150 m from piling activity in water depth <3 m (Huson & Associates 2009)	N/A	N/A	• Exclusion zone of 500m (Chevron 2008)
Turtles (adults and juveniles)	• Physical injury zone from 20-30 m (SVT Engineering Consultants (SVT) 2009) • Avoidance zone from 300-400 m (SVT 2009)	N/A	N/A	N/A	• Exclusion zone of 500 m (Chevron 2008) • Suspension zone (stop-work) of 100 m (Chevron 2008)

Turtles (hatchlings)	• Physical injury zone from 40-70 m (SVT 2009)	N/A	N/A	N/A	• Exclusion zone of 500 m (Chevron 2008) • Suspension zone (stop-work) of 100 m (Chevron 2008)
Fish	• Zone of potential injury 140-320 m around each pile (SVT 2009)	N/A	N/A	• Serious physiological impact zone 10 20 m (McCauley & Salgado Kent 2008) • Physiological impact zone 20 300 m (McCauley & Salgado Kent 2008) • Behavioural impact zone 0 500 m (McCauley & Salgado Kent 2008)	N/A

Note: Grey shaded boxes indicate the management zones that have been developed for other similar scale projects.

Most VSPs use a surface seismic source, which is commonly an air gun in marine environments. An airgun is used as a source of seismic energy by releasing highly compressed air into water. Air-gun pulses are composed predominantly of low frequencies (< 300 Hz).

Behavioural Changes, Injury or Mortality to Protected Marine Fauna

Residual risk to protected marine fauna from changes to behaviour, injury or mortality from acoustic emissions during construction is	**Low**
Residual risk to protected marine fauna from changes to behaviour, injury or mortality from acoustic emissions during operation is	**Low**

Marine Mammals

Noise generated during the construction and operational phases of the Project may interfere with the acoustic perception and communication of protected marine mammals and can result in startle responses and avoidance behaviour (URS 2009l, Appendix O9). As shown in Table 8.44, the protected marine mammals that are considered at risk of impact from sound generating activities are the Humpback Whales, Pygmy Blue Whales, dolphins and Dugongs.

The auditory ranges for the protected marine mammals listed in Table 8.44 varies from 200 Hz (whales) to a maximum of up to 105-150 kHz (dolphins). Baleen whales (such as the Humpback Whale and Blue Whale) vocalise in the low to mid range, with the larger rorquals producing low to very low (infrasonic) frequencies (Richardson *et al.* 1995). Mathematical functions used to estimate frequency sensitivity of the Humpback Whale suggested a 200 Hz to 10 kHz auditory range with maximum sensitivity of 2-6 kHz (e.g. Houser *et al.* 2001). Dolphins and other toothed whales typically produce most of the higher frequency (< 5 kHz) calls, whistles and echolocation pulses. The greatest sensitivity for Bottlenose Dolphins is thought to occur in the frequency range of approximately 15 kHz to 50 kHz (McCauley & Salgado Kent 2008). Little information is available on the auditory systems of Dugongs, however the sensitive parts of Dugongs auditory range appear to be restricted to the middle frequencies (1–18 kHz) (URS 2004).

During the construction phase, Pygmy Blue Whales may be affected by noise and vibration from pipelaying, drilling and vessel movements occurring in deeper, offshore waters during their migratory periods. During the operations phase, vessel movements and trunkline operations could have minor impacts during the migratory periods through the Project area, although vessel movements will substantially decrease, and primarily occur around the PLF rather than further offshore. Blue Whale migration is expected to occur in deep waters offshore and over the continental shelf edge from the Project area between May and August (northward) and October and January (southward). Aerial surveys conducted in the Project area to date have recorded very few Blue Whales, suggesting that numbers are relatively low in the area (CWR 2010, Appendix O3; CWR 2010a, Appendix O4). Noise impacts to Blue Whales are therefore anticipated to be minor and short-term, and are therefore unlikely to have an effect on population viability.

As indicated in Chapter 6, *Overview of Existing Environment*, Humpback Whales travel northward offshore of the Ashburton North SIA during the winter months, and then return southward, offshore towards the end of spring, after they have calved (CWR 2010a, Appendix O4). Results of aerial surveys detected differences found between the distance of pods from the coast, based on direction of travel, with the mean distance of whales further offshore during their northbound than southbound migration (49 and 36 km offshore, respectively) (CWR 2010a, Appendix O4). This species may be affected by noise and vibration generated from all of the activities identified in Table 8.41, particularly if the activities coincide with their southward migratory period.

There is evidence that whales on their southern migration come closer to shore than on their northern migration. At the beginning of the season, whales were sighted no closer than 30-50 km offshore, coming to within 10 km during the August peak and then sighted less than 10 km and often less than 5 km offshore during the rest of the southward migration (CWR 2010a, Appendix O4). Analysis of distance from shore and direction of travel from the early part of the season (June – August) support the conclusion that whales found closer to shore are on their southward migration (CWR 2010, Appendix O3; CWR 2010a, Appendix O4).

Pile driving will be associated with construction of the PLF, which extends 2.5 km offshore. The majority of noise associated with pile driving will be generated at least 2.5 to 7 km away from the southern migratory path, and at least 50 km from the northern migratory route. Whilst pile driving has relatively intense noise levels compared to other construction activities, the impacts to Humpback Whales are expected to be minor, since noise levels will dissipate over this large distance. Since pile driving is a temporary noise source, impacts to Humpback Whales are anticipated to be short term, and mostly limited to the months during their peak southward migration through the nearshore Project areas, when cow/calf pairs are expected to come to within 5 to 10 km of the coast. Lastly, piling is predicted to last only about 14 months, and thus will occur over one, possibly two, Humpback Whale migration periods. Figure 8.64 illustrates the spatial extent of potential noise impact/management zones associated with the proposed piling location and in relationship to where megafauna have been recorded during aerial surveys (CWR 2010a, Appendix O4). The 2009 aerial survey data suggests Humpback Whales do not occur in depths (<6 m) characterised by the proposed piling location, and Dugongs and turtles occur only in very low densities at these depths. Indicative noise impact/management zones are proposed based on modelling studies for similar projects Australia wide, including Cape Lambert (Table 8.45). Marine mammals and turtles within 100 m of an active pile hammer (the suspension zone) are potentially at risk from hearing injury. Marine mammals and turtles within 500 m (observation zone) are at risk from behavioural responses. These indicative noise-impact management zones will be modified prior to piling based on a site specific underwater noise modelling study that will be presented in a supplementary report.

Dredging and trenching activities during construction are anticipated to occur over approximately three to four years. After construction dredging is complete, maintenance dredging (Section 8.3) will be required, but will be of smaller scale than construction dredging. The noise generated during these activities has the potential to impact Humpback Whales over a longer period compared to other construction activities; however, the most intense period of activity will be during the construction phase. Whilst the noise generated during dredging and trenching is considered more widespread, it generates less intense sound frequencies than an activity such as pile driving (URS 2009l). The majority of dredging will occur in relatively shallow waters in the vicinity of the PLF, but will also extend into the proposed shipping channel. Impacts from noise are anticipated to result in avoidance behaviour and may be more severe during the Humpback Whales' peak migration periods. As Humpback Whales will only pass through the Project areas for relatively short periods, and as they will be distant from the majority of dredging and trenching activities, noise impacts to Humpback Whales are expected to be minor.

Noise generated during pipelaying and rock dumping activities during construction will vary in intensity and character, but is generally continuous, low level, low frequency broadband (URS 2009l). No pipelaying or rock dumping is required during operations. The impacts to Humpback Whales will most likely be minor and short-term since pipelaying and rock dumping are transitory activities, which will only be in the PIN and PON areas for a relatively short period, before moving further offshore.

Dolphin species rely heavily on echo-location because they often forage in highly turbid waters. Increased noise at higher frequencies may mask hunting ability and communication between groups. Of the activities listed in Table 8.44, those with the potential to generate higher frequency noise levels are pile driving and vessel movements, both of which will be concentrated in relatively shallow waters in the vicinity of the PLF and harbour during construction. Pile driving will not be required during the operational phase, and whilst vessel movements will continue, a decrease in vessel numbers and therefore noise output is expected. The Indo-Pacific Humpback Dolphin in particular is a coastal species that is known to be sensitive to development. Dolphins have been recorded during aerial surveys, with the highest densities present between the 10 to 20 m depth contours. Therefore impacts from noise generated during construction activities in the vicinity of these contours pose the greatest threat. The most intense noise levels will be associated with pile driving during the construction phase, and are therefore considered short-term. Dolphins are not considered restricted to the nearshore waters that constitute the Project areas. Furthermore, dolphins are highly mobile and would be expected to avoid an area in response to intense noise levels. Impacts are likely to be minor since the marine environment surrounding the Project area contains widespread suitable habitat for foraging.

Dugongs have been recorded mostly within shallow coastal waters that coincide with areas where seagrass has been mapped (Chapter 6, *Overview of Existing Environment*). It is considered likely that Dugongs are resident in the vicinity of the Project area year round but with some seasonal variation in densities. Whilst there are many anecdotal reports of Dugongs avoiding areas with high boat traffic, there has been little research undertaken to investigate the sensitivity of Dugongs to noise. The sensitive parts of Dugongs auditory range appear to be restricted to the middle frequencies (1-18 kHz) (URS 2004). This may indicate that activities such as pipelaying, rock dumping, drilling and vessel movements (which are generally <1 kHz) will not result in adverse noise impacts to Dugongs. Anecdotal observations suggest Dugongs may temporarily move from an area following blasting, which may suggest the same behaviour could be expected in response to the noise intensive activities such as pile driving. There are no significant Dugong seagrass habitats that are restricted to the Project area. Impacts to Dugongs from pile driving are likely to result in avoidance behaviour and relocation to nearby seagrass beds in the region. Impacts to Dugongs are therefore expected to be minor since it is unlikely that the population will be affected by noise generated during construction and operations. Impacts are also expected to be short-term since they will generally be restricted to the construction phase of the Project.

It is assumed that Indo-Pacific Humpback Dolphins, Bottlenose Dolphins and Dugongs would spend most of their time in waters several kilometres off of the Project coastline. As the PLF will only extend 2.5 km from the mean high water mark, it is predicted that all three species will continue to move along the coast, passing offshore of the PLF, if they are deterred from passing under or near the structure by noise or other factors.

VSP activities produce significantly less energy than large scale offshore seismic surveys, so therefore the potential effects on marine fauna and fish are considered to be much lower than those for typical offshore 3D seismic surveys. Offshore seismic surveys generally consist of up to 20 air guns, each operating at around 2,000 psi and expelling a volume of air of 4,000 cubic inches (cui) (Appendix O9). At the source, pulses are between 220-240 dB, typically reducing to 170 180 dB within one km and approximately 150 dB within 10 km. This compares to VSP, which is undertaken in a well and may only use a two to three airgun cluster. Each airgun in VSP operates at around 2,000 psi, but only expels approximately 150 cui, creating a far smaller pressure pulse. The airgun cluster will typically be fired at intervals of six 10 seconds, generating a sound of approximately 190 dB, with a frequency typically centred around 200 Hz. Baleen whales have inner ears that appear to be specialised for low frequency hearing and thus are at most risk to low frequency noise produced during VSP (Appendix O9). Potential impacts to whales and other marine mammals can be characterised as physical, perceptual or behavioural effects (DEWHA 2008). McCauley *et al.* (2000) observed that migrating Humpback Whales tended to avoid operating seismic sources when the received sound levels were greater than 157 164 dB. For general VSP activities, it is anticipated that levels will be below 150 dB at distances greater than 500 m from the source, and therefore present minimal risk of disturbance to whales. DEWHA has developed guidelines (EPBC Act (Cth) Policy Statement 2.1 – Interaction between offshore seismic exploration and whales) to minimise impacts to whales from seismic activities. The DEWHA guidelines will be considered during the development of mitigation measures to limit impacts to whales if VSP is required during the Project.

In summary, the potential noise impacts are considered minor for large cetaceans, that are more likely to be present offshore, and also for dolphins, due to their likely avoidance behaviour and due to the short-term nature of pile driving. Furthermore, although pile driving activities may be undertaken 24 hours a day, it is reasonable to assume that not all of this time will actually be spent driving piles, with periods of respite between operations. The Project area does not contain significant habitat for protected marine mammals (URS 2009l). It is concluded that activities generating noise and vibration during the Project will not result in long-term impacts to the populations of protected marine mammals in the region.

Marine turtles

Electro-physical studies have indicated that the best hearing range for marine turtles is in the 100 to 700 Hz range (McCauley 1994). Behavioural response trials have demonstrated that adult marine turtles may begin to show behavioural changes to an underwater noise source at a received level of approximately 166 dB re 1μPa, and avoidance responses at 175 dB re 1μPa (McCauley *et al*. 2000).

Modelling of underwater acoustics conducted for the Cape Lambert Port B Development determined zones of physical injury and zones of avoidance for adult and hatchling marine turtles in response to pile driving (SVT 2009). The zone of physical injury or hearing damage from pile driving for adult and juvenile turtles ranged from 20 m close to shore, to 30 m at the end of the PLF. The zone of avoidance ranged from 300 m to 400 m. For turtle hatchlings, the zone of physical injury or hearing damage ranged from 40 m close to shore to 70 m at the end of the PLF.

It is unlikely that marine turtles would be significantly affected by piling activities during PLF construction as the closest important marine turtle nesting beach is on the Ashburton River Delta, which is approximately 4 km west of the Ashburton North SIA (RPS 2010a, Appendix O11). Aerial surveys suggest that the proposed PLF location and adjacent waters support a low density of turtles compared with deeper water locations (Section 6.3). In addition, although the reef habitats surrounding the islands offshore from the Ashburton North SIA appear to be important foraging habitat for juvenile and adult Green Turtles, it is likely that once piling commences, they will move away from the source of the noise, which would likely dissipate within a 400 m radius in accordance with modelling carried out by SVT (2009a). Hatchlings are also likely to move away from the noise source as once they leave the nesting beaches they are likely to travel offshore to deep-water areas, without being exposed to piling noise. However, attraction of hatchlings to light sources on the mainland could expose these to noise levels that could cause physical damage and is discussed in terms of the cumulative impact of stressors in Section 8.4.5.9.

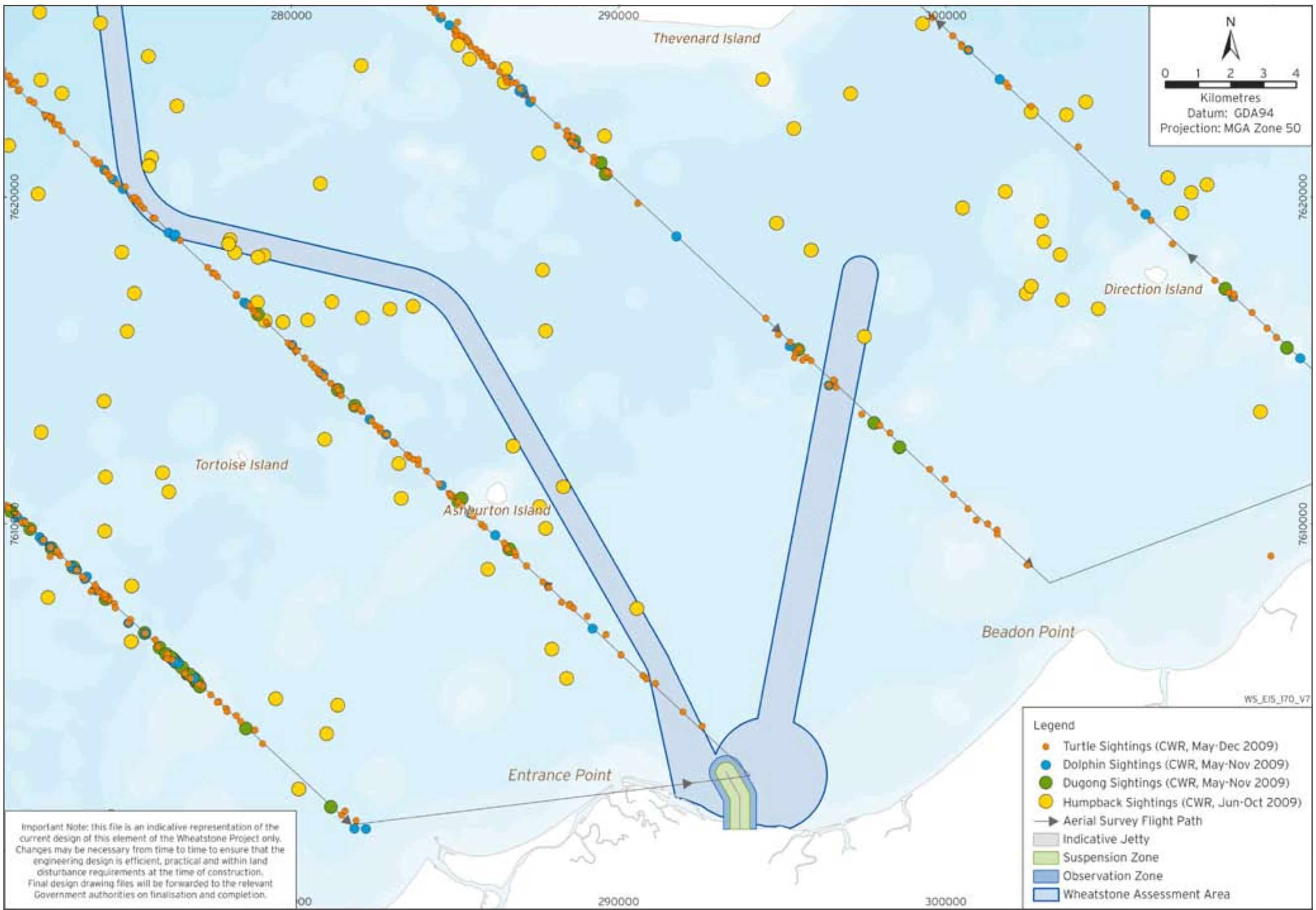


Figure 8.64: Indicative Pile Driving Noise Management Zones in Relation to Megafauna Sightings in 2009

Whale Sharks and sawfish

There appears to be no specific information available on the hearing abilities of the Whale Shark or sawfish; however, it is reasonable to assume that these elasmobranchs (a class of fish) have similar hearing abilities as rays (URS 2009l). The best hearing sensitivity of rays is in the low frequency range of 20 Hz to 800 Hz. Myrberg (2001) noted that many species of sharks and rays have hearing which is highly sensitive to irregularly pulsed, low-frequency sounds, especially in the range of 20 to 400 Hz (URS 2009l).

The noise generating activities that coincide with the locations of Whale Sharks is generally low level, low frequency and continuous, with most levels below 1 kHz (Table 8.44). It is therefore possible that Whale Sharks present in close proximity to activities such as drilling, pipelaying or in the vicinity of areas with a high density of vessel movements, could experience adverse noise impacts, particularly for noise that is irregular and in the range of 20-40 Hz. However, there are no areas of upwelling or restricted habitat in the Project area and the nearest known aggregation site is at Ningaloo Reef, approximately 100 km west. Therefore, while Whale Sharks could be impacted by noise generating activities in the PON and NWS areas, noise impacts are anticipated to be minor and of short duration, since they will most likely result in avoidance behaviour and relocation to other offshore areas, and will be mostly restricted to the construction phase.

Sawfish are more likely to be exposed to high noise levels in the nearshore waters surrounding the PLF. Sawfish are not restricted to the nearshore waters of the Project area and being highly mobile are expected to avoid any areas in response to intense noise levels.

Birds

If noise or vibration levels are sufficiently high, then nesting birds on the island Nature Reserves may relocate to similar habitat on other nearby islands, either prior to the commencement of the nesting season or abandoning existing nests. Those birds that do not relocate may lay eggs with reduced hatching success due to vibration.

However, the scale of potential impact is considered sufficiently small to not cause a detectable decrease in abundance or any lasting effects on the local population.

The noise generating activities that may take place in the vicinity of nesting islands is most likely restricted to general vessel movements and vessels associated with pipelaying and rock dumping during the construction phase. These activities are temporary and of relatively short duration and would only have minor noise effects on seabird populations nesting in the area. During the operations phase, vessel movements and trunkline operations would have a negligible effect on seabirds that nest on nearby islands.

Summary

The greatest risk of impact to protected marine fauna from construction noise is associated with the intense noise levels generated during pile driving activities in nearshore areas, if they are required. Pile driving has the potential to result in avoidance of the area in the vicinity of the PLF by protected marine fauna, particularly marine turtles, dolphins and Dugongs which are known to occur from time to time in these areas. However, these species are not restricted to the nearshore infrastructure area, and these areas do not contain habitat that is critical to the long-term survival of their populations. Indeed, megafauna sighting data in 2009 suggest that marine mammals and turtles occur in very low densities in the area of the proposed piling area. Operational noise is predicted to cause temporary displacement of protected marine fauna during vessel movements and maintenance dredging. The noise levels associated with these activities are predicted to be low relative to construction noise levels, and the potential for fauna mortality is low. Marine fauna will be displaced for only a short time and will move back into the area once the noise associated with the activity has subsided. No population level effects are predicted.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that behavioural changes, injury or mortality to protected marine fauna may occur as a result of acoustic emissions generated by nearshore construction activities. The residual environmental risk for this potential impact was assessed as being "Low" – of "Moderate" consequence, arising from the potential for lethal or sub-lethal impacts as a result of acoustic emissions to protected marine fauna, and "Possible" likelihood.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that behavioural changes, injury or mortality to protected marine fauna may occur as a result of acoustic emissions generated by nearshore operational activities. The residual environmental risk for this potential impact was assessed as being "Low" – of "Moderate" consequence, arising from the potential for lethal or sub-lethal impacts as a result of acoustic emissions to protected marine fauna, and "Possible" likelihood.

Behavioural Changes, Injury or Mortality to other Marine Fauna

Residual risk to other marine fauna from changes to behaviour, injury or mortality due to noise and vibration during construction is	**Low**
Residual risk to other marine fauna from changes to behaviour due to noise and vibration during operation is	**Low**

Bony Fish

The range of sensitivity to sound among bony fishes is immense, and partly due to the diversity of anatomical structures involved in sound detection (Popper & Fay 1999). However, all fish tested to date appear capable of performing the same basic hearing functions as other marine vertebrates, such as discriminating between sounds, determining sound direction and filtering biologically relevant signals in the presence of ambient noise (Popper *et al*. 2003).

Fish that have morphological adaptations to link their otoliths (hearing organs) to their swim bladders or have gas filled bullae are considered "hearing specialists". Audiograms of hearing specialists show high sensitivity to sound levels as low as 60 dB across a broad frequency range. Fish of the family Clupeidae, which includes Herring (i.e. *Clupea harengus*) and Anchovy *(Engraulis australis)*, are examples of hearing specialists and have highly specialised auditory systems (Blaxter 1980; Nedwell & Howell 2004). Hearing specialists are thought to be able to detect signals up to 3–4 kHz, with thresholds that are 20 dB or more lower than the generalists (Popper & Hastings 2005).

Many fish have a swim bladder that is physically linked to the inner ear. The swim bladder is a gas filled cavity that can transfer an impinging sound waves pressure information to the otolith (Popper & Fay 1993). Fish with bullae generally have higher sensitivity to noise than those with a swim bladder, and those with a swim bladder in turn usually have greater sensitivity than fish without a swim bladder (Nedwell & Howell 2004).

Bony fish are likely to be present in the vicinity of the majority of marine construction and operational activities and are therefore at risk of impacts from the generation of noise from these activities (Table 8.44). The exception is offshore drilling in deep waters at the gas field, where the numbers of bony fish are expected to be lower than those in other areas. Construction activities such as pile driving, dredging, trenching, pipelaying and vessel movements have the potential to impact fish in the immediate vicinity of the source, though the effects of the noise will be spatially limited.

Raised underwater noise can result in changes to the behaviour in fish species, such as stress and avoidance of the area. As pelagic species are highly mobile, they are likely to move away from the source if the sound levels become uncomfortable. Benthic fish species may be less inclined to move away from sound sources than pelagic species due to territorial behaviour and site fidelity (Wardle *et al*. 2001).

Despite the potential for avoidance behaviour, physical damage, including that to hearing structures, in hearing specialists, is likely to occur only as a result of prolonged or intense exposure. Furthermore, mortality has not been observed with fish exposed to continual close range discharges (Parvin *et al*. 2007). Impacts to bony fish are not likely to be widespread or significant since the substrate within which the proposed PLF is located is largely sand and silt and will likely have a relatively low abundance of fish species compared to other habitats in the region. There are no known critical habitats or known aggregation areas for bony fish in the Project area. Impacts to bony fish from noise generating activities during construction and operations are likely to be restricted to the immediate vicinity of the noise source. The affected areas will most likely be subsequently recolonised from surrounding habitats. No long-term effects on the viability of local populations of bony fish are predicted.

Prawns

The hearing abilities of the Common Prawn (*Palaemon serratus*) have been studied by Lovell *et al*. (2004). Demonstrated hearing abilities include low frequency sounds ranging from 100 Hz to 3 kHz, indicating that prawns may have a similar hearing acuity to that of a generalist fish (Lovell *et al*. 2004). Noise generated during construction and operation activities may propagate beyond the Project area therefore, prawns in the area adjacent shallow, nursery habitats may experience noise impacts. These impacts are most likely to result in avoidance behaviour, with prawns moving away from the noise source. The impacts are likely to be minor in comparison to the physical disturbance of prawn habitat during the construction phase of the Project. During the operational phase of the Project, it is unlikely that trunkline operation, vessel movements and maintenance dredging will result in noise impacts to prawns.

Summary

Construction activities, including pile driving, dredging, trenching, pipelaying and vessel movements, have the potential to impact bony fish and prawns in the immediate vicinity of the acoustic emission source, though the effects of the noise will be spatially limited. Anticipated impacts may include avoidance behaviour, potentially injury and mortality to bony fish and prawns. However no long-term impacts to these marine fauna are predicted.

Operational activities are predicted to result in acoustic emissions that may cause temporary displacement of bony fish and prawns during vessel movements and maintenance dredging. Noise generated during trunkline operation is not expected to have an effect on these marine fauna. The noise levels associated with vessel movements and maintenance dredging is predicted to be low relative to construction noise levels, and the potential for fauna mortality is low. Bony fish and prawns are expected to be temporarily displaced and will either relocate to nearby surrounding areas, or move back into the area once the noise associated with the activity has subsided. No population level effects are predicted.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that behavioural changes, injury or mortality to other marine fauna may occur as a result of acoustic emissions generated by construction activities. The residual environmental risk for this potential impact was assessed as being "Low" – of "Negligible" consequence, as injury and mortality are not anticipated as a result of acoustic emissions, and of "Likely" occurrence.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that behavioural changes, injury or mortality to other marine fauna may occur as a result of acoustic emissions generated by operational activities. The residual environmental risk for this potential impact was assessed as being "Low" – of "Negligible" consequence, as acoustic emissions will be minimal during the operational phase, and of "Likely" occurrence.

Behavioural Changes, Injury or Mortality to Marine Fauna Associated with Blasting

Residual risk to marine fauna from underwater blasting is	**Very Low**

Underwater blasting is not currently considered to be part of construction activities for the Project. However, a lack of detailed geotechnical data in some areas of the Project indicates that blasting may be an option in the future. Underwater blasting is generally used to remove or fracture rock or other hard substrates. Surface and confined blasting are the two main techniques used. Surface blasting involves charges being placed directly on to the seabed or rock surface. Confined blasting, also known as the "drill and blast" method, involves drilling small holes within the rock, placing small charges in the holes and firing the explosive as part of a pattern.

Blast waves in an underwater environment cause a pressure drop over a very short duration (short rise time) and are relatively broadband in frequency. At close range the noise, and associated shock-wave of an underwater blast, can cause mortality or significant physical injuries to marine fauna (Lewis 1996). Gas filled structures, such as swim bladders, are the most common sites of injuries. Behavioural changes may also occur. Effects may be temporary or permanent. There are several zones surrounding the blast source within which different effects may be expected. Beyond the zone of mortality or acute physical injuries, a permanent threshold shift (PTS) in hearing sensitivity may occur. Temporary Threshold Shifts (TTS) occur outside the zone of PTS, with a zone of avoidance and behavioural changes occurring beyond this impact zone (Southall *et al*. 2007).

The likelihood of these effects occurring is dependent on the characteristics of the charge, environmental conditions at time of blasting, the proximity of the receptor and the anatomical characteristics of the receptor animal (Southall *et al*. 2007). Christian (1973) modelled damage zones of underwater explosions and found that proximity of fish to a detonation locus in waters of depth less than 15 m varied as a function of the square root of depth and derived a simple formula to approximate the radius of impact for charge weights up to 450 kg. An example of the latter is provided in Todd *et al*. (1996), who reported that Humpback Whales off Newfoundland did not alter their residency period, movement or general behaviour as a result of construction related detonations. However, it was inferred that detonations may have shifted their hear sensitivity threshold. In contrast, a study by McCauley *et al*. (2000) reported that caged turtles exhibited increased swimming behaviour when exposed to sounds of 155 dB re 1 μPa^2-s, and erratic behaviour at 164 dB re 1μPa^2-s.

Heggies (2009) modelled pressure and sound resulting from 20 and 50 kg confined shots in 13 m of water and derived predicted impact ranges for a variety of marine fauna assuming acoustic properties of the seabed and seawater. If blasting was required for the Project, it would occur in similar or shallower water depths as that used in Heggies' calculations (i.e. 13 m). The differences in impacts between 0 and 13 m water depth are negligible. Heggies (2009) found the predicted ranges and associated potential impacts for marine fauna varied from an 80 m radius for organ trauma to Humpback Whales, dolphins, Dugongs and turtles to 1 150 m radius from the detonation site for maximum expected extent of Temporary Threshold Shift (TTS) to Humpback Whales and turtles. A 1 150 m exclusion zone around the detonation site was therefore recommended for the Hay Point Coal Terminal Expansion Project during blasting activities as a result of this analysis (Heggies 2009). Approval conditions set by DEWHA required marine fauna observers and a 2 km exclusion zone for cetaceans and a 1 150 m exclusion zone for turtles and Dugong (EPBC 2009/4759). A similar impact domain could be expected for the Project if blasting were to occur along the dredge footprint. As noted in previous sections, no critical habitats for marine protected fauna in the Project area are considered to occur in this proximity to the dredge footprint (pending finalisation of flora and fauna studies). Measures to mitigate impacts to megafauna would be adopted within the Blasting Environmental Management Plan (BEMP) using a comparable exclusion approach if blasting were to occur. A Draft BEMP will be included in the Supplementary EIS/ERMP if blasting remains a possible activity that will be undertaken.

With the exception of a seagrass bed north of Ashburton Island, the trunkline route and navigation channel dredge area are located in habitats characterised by unvegetated, subtidal sand (Chapter 6, *Overview of Existing Environment*). Unvegetated sand habitat, unlike habitats dominated by coral reefs and macroalgae, does not support high densities of fishes nor provides important feeding habitat for marine mammals or turtles. Similarly, there is no known critical resting or calving habitats for marine mammal and turtles along the trunkline route or the proposed navigation channel. Furthermore, almost all reefs and associated organisms are located several kilometres from the proposed trunkline route and proposed navigation channel. For these reasons, fauna at primary risk from a blasting event along the trunkline route and proposed navigation channel would be marine mammals, turtles and or pelagic species of fishes migrating through the area.

If blasting is required during Project construction, a number of targeted management actions may be undertaken and may include:

- Scheduling blasting outside whale migration periods
- Scheduling blasts for daylight hours only to allow for effective visual monitoring
- Using sequential explosive charges to manage cumulative impacts of the explosions, as opposed to less frequent, larger blasts
- Using small, warning charges to encourage animals to move away from the construction area prior to a blast
- Physically removal of turtles from the blasting zone prior to blasting operations subject to approval from regulators
- Using marine observers on a vessel to confirm that marine fauna are not present in the blasting zone and designed buffer zone before blasting is initiated
- Developing a BEMP (to be included in the Supplementary EIS/ERMP if blasting is to be required).

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that behavioural changes, injury or mortality to marine fauna may occur as a result of blasting activities. The residual environmental risk for this potential impact was assessed as being "Very Low" – of "Moderate" consequence, as the water depth at which blasting may occur does not propagate noise and vibration well, and "Remote" likelihood, as blasting is not anticipated to be required at this stage of Project development.

8.4.5.9 Light Emissions

The main potential impacts to marine fauna from Project light emissions are interference with nesting marine turtle behaviour, attraction of marine turtle hatchlings, and attraction of seabirds.

Sources of light emissions from the Project are described in Chapter 2, *Project Description* and Chapter 4, *Emissions, Discharges and Wastes*; those that may affect marine turtles and/or seabirds include:

- Lighting of plant, coastal and offshore facilities during operation
- Flaring during LNG plant commissioning and operational emergencies
- Construction lighting.

Light emissions can manifest as direct light spill or sky glow. During the LNG plant commissioning phase, the extent, intensity and location of light emissions is likely to vary, depending on the stage of construction (Section 4.3.4). Onshore flaring at the Ashburton North SIA will occur over approximately 12 days during commissioning. During the operations phase, maintenance flaring will be scheduled for plant shut-downs, with emergency flaring occasionally required to dispose of slugs of gas. A flaring event is considered to have equal probability of occurring during the day or during the night.

Flaring at the offshore production facilities (Chapter 4, *Emissions, Discharges and Wastes*) will occur intermittently during commissioning (other than purge/pilot and minor process wastes), with the intensity and duration likely to vary depending on the activities. Flaring (other than purge/pilot and minor process wastes) during the operations phase will occur during plant shutdown or flowline shut-downs (to prevent hydrate formation and possible blockages), with emergency flaring occasionally required to dispose of slugs of gas. The platform is more than 140 km from the mainland and more than 45 km from the nearest island. The platform location is not near any known critical aggregation areas for turtles or birds.

Construction of the MOF and PLF will take approximately three years to complete and during peak periods will occur 24 hours per day. For safety reasons, night time construction will require high lighting levels. Construction lighting typically comprises bright white lights (metal halide, halogen, mercury vapour, fluorescent).

Installation of the trunkline will require construction and support vessels to be lit at night, however this activity will occur only once, and be of short duration at any given location.

To predict the effect of light emissions on hatchlings and nesting turtles, illumination (light spill or sky glow) originating from the whole plant; the dry/wet flare and marine flare were modelled in relation to the closest nesting beaches (URS 2010a, Appendix O1). To provide context to the modelled light emissions (expressed as Lux) from the plant, a comparison of light levels emanating from common lighting situations and natural ambient lighting phenomena is presented in Table 8.46. Lux is defined as a unit of illumination equal to one lumen per square metre. A lumen is the SI unit of luminous flux, a measure of the power of light perceived by the human eye.

Table 8.46: Natural Ambient Lighting Phenomena

Illuminance (Lux)	Source
0.0001	Light from Sirius; the brightest star in the sky
0.01	Quarter moon
0.27	Full moon on a clear sky
1	Full moon overhead in tropical latitudes
400	Sunrise or sunset on a clear day

Attraction of Marine Turtle Hatchlings

Residual risk to marine turtle hatchlings from attraction to light is	Low

Attraction to artificial lighting has the potential to affect marine turtle hatchling behaviour through interference with sea-finding behaviour and/or open-ocean finding ability. The closest nesting in the vicinity of the Ashburton North SIA is by Flatback Turtles at the Ashburton River Delta beach and Ashburton Island (approximately 4 km and 12 km from the Ashburton North SIA, respectively). It is hatchlings that emerge on these beaches that are at greatest risk from Project light emissions.

Hatchling "sea-finding" behaviour involves using horizon elevation and profile together with light gradients to locate the ocean after night-time emergence from the nest (Witherington & Martin 2000; Salmon & Witherington 1995). Hatchlings have a strong tendency to orient towards the brightest direction, with brightness being a function of light intensity, wavelength and hatchling spectral sensitivity (Pendoley 2005). When light is polarised in one direction and of sufficient intensity, for example an artificial light source on a beach, light gradients become a more important cue than horizon elevation in sea-finding behaviour and may result in disorientation or misorientation of hatchlings. Hatchlings are said to be "misoriented" during sea-finding when they move constantly in the wrong direction (Witherington and Martin 2000). Hatchling disorientation and misorientation increase the potential for predation, exhaustion, entrapment in debris and dehydration.

Lighting cues become less important to orientation as hatchlings enter the water and begin to swim toward the open ocean. Once they are in the sea, hatchlings are thought to use wave direction cues to make their way offshore (Lohmann *et al*. 1997). However, lights from vessels and offshore structures do attract hatchlings at sea, possibly more so in areas where the wave fronts are less noticeable, causing a conflict between light and wave cues. When hatchlings are attracted to a light source in the water, they will aggregate around this light source where they may be more vulnerable to predation from large fish (Witherington & Martin 2000).

Marine turtle hatchlings may be attracted to both light spill, and sky glow, caused by overall increases in light in an area. It has been suggested that hatchlings may disregard distant point sources of light but are subject to misorientation from even low intensity sky glow (Pendoley Environmental 2004; 2007).

The Flatback Turtle is the species most at risk from Project light emissions because this species nests within 4 km of the Ashburton North SIA. Flatback Turtle hatchlings are able to see light between wavelengths of 450 nm and 700 nm (Pendoley Environmental 2007). Whilst generally unable to differentiate between lights with a difference in wavelength of < 30 nm, they can differentiate between 550 nm and 570 nm light (Pendoley Environmental 2007). When given the option of two light sources of varying wavelength, Flatback Turtle hatchlings exhibit a strong attraction to blue/green light (500 nm), even at very low intensities and appear to be either disoriented or repelled by orange light (650 nm) (Pendoley Environmental 2007).

Light spill modelling (URS 2010a, Appendix O1) of operational plant lighting demonstrates that, during normal operation (including the pilot light on the flare), the islands in the vicinity of the Ashburton North SIA will not be directly illuminated above levels of ambient starlight during a new moon. Sky glow from the Ashburton North SIA may be visible up to 50 km offshore, which includes all islands and mainland beaches between the mainland and Flat, Thevenard and Twin islands, but the expected luminance levels are very low.

Hatchlings emerging from nests on the southern side of Ashburton Island may be attracted to the sky glow emanating from the Project area; however the orientation of these hatchlings will be toward the ocean. Once the hatchlings reach the ocean, the light will become less visible and natural navigational cues, such as wave direction and alongshore currents are expected to over-ride potential attraction to sky glow.

Sky glow from the Ashburton North SIA may be visible at the Ashburton River Delta nesting beach, however hatchlings on this beach are not expected to be attracted to sky glow as the intensity of light is expected to be less than 0.001 Lux (Figure 8.65, URS 2010a), which is below the level demonstrated to affect Green Turtle hatchling behaviour (0.05 Lux) (Pendoley Environmental 2005). No such level is known for Flatback Turtle hatchlings. Additionally, the dune system on the Ashburton River Delta beach reaches up to 10 m which shields a large section of the nesting beach from illumination. Lastly, experiments conducted on Barrow Island suggest that hatchlings are not attracted to elevated sky glow (e.g. light visable from over the top of a dark sand dune) (Pendoley Environmental 2008).

It is possible that some hatchlings at the Ashburton River Delta beach, upon reaching the water, will be attracted to the PLF or ships. However, this beach forms a shallow bay that shields the view of the PLF and the far eastern end of the beach (closest to the Project area) gradates into a mangal that is unsuitable for nesting.

Flaring is expected to occur periodically during operations (Chapter 4, *Emissions, Discharges and Wastes*). Light spill modelling undertaken within the Project area indicates that, under worst-case conditions, light from the dry/wet flares could be perceived by a turtle approximately 8 km away as an object equivalent to the moon, although the risk of attraction to the flare increases during periods of low natural lighting (e.g. new moon) (Pendoley 1999). Hatchlings on Ashburton Island will be beyond the known range of effect for flaring light (Pendoley 1999).

The nesting area on the Ashburton River Delta beach is expected to be subject to flare light at intensities of up to 0.07 Lux or less from the dry/wet (and marine flare) because the first dune crest is of sufficient height to shield the area from direct light (Figure 8.66). This level of light is unlikely to affect turtle hatchlings on the beach.

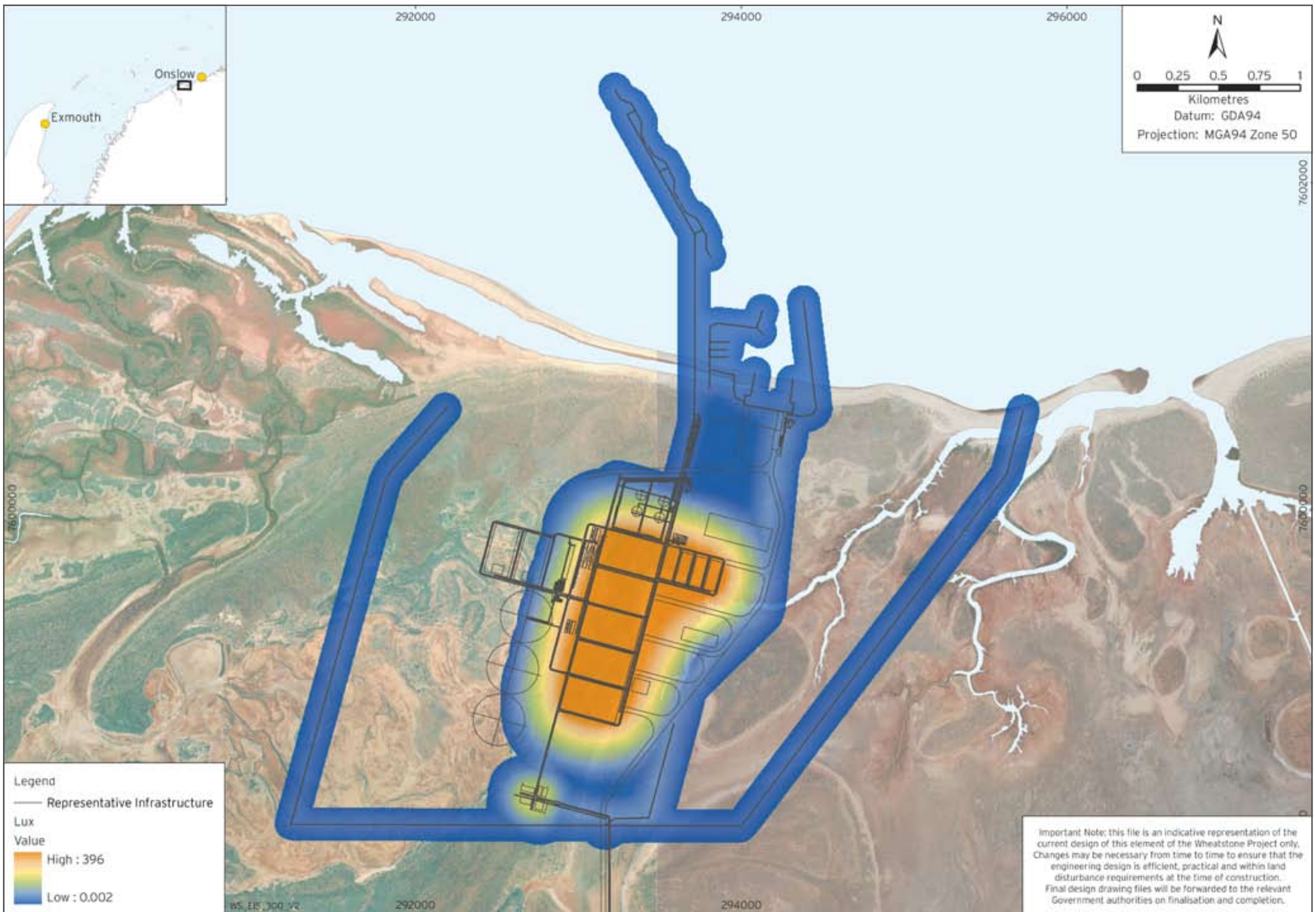


Figure 8.65: Lux Contours Emanating from the LNG Plant

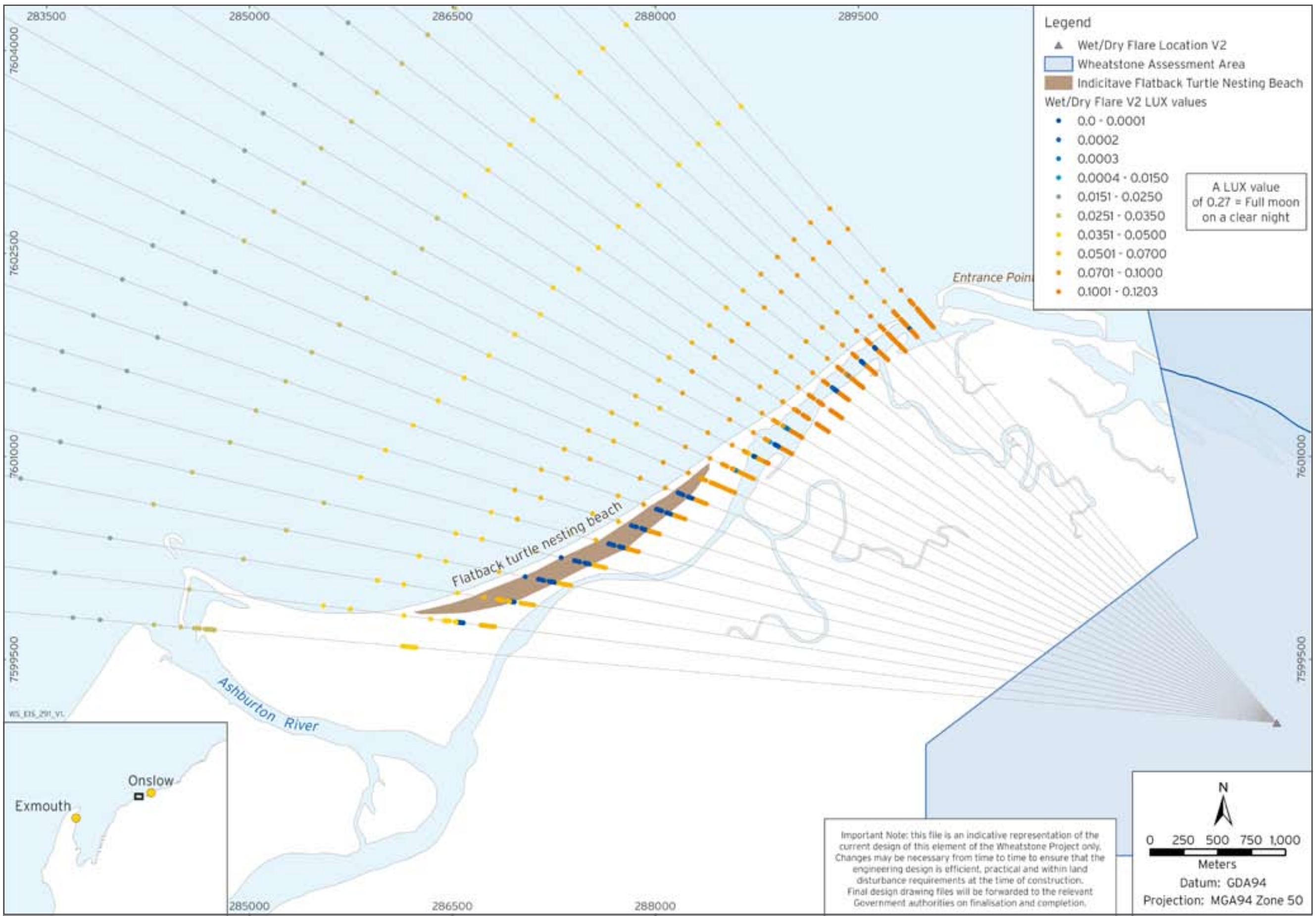


Figure 8.66: Dry/Wet Flare Lighting Intensity in Relationship to the Ashburton Delta Nesting Beach

Experiments on Barrow Island have shown that Flatback Turtle hatchlings are influenced by metal halide and fluorescent lights at lower intensities (0.05 Lux, Pendoley Environmental 2005), however the spectral characteristics of flare light (i.e. higher wavelengths) means it is less attractive to Flatback Turtle hatchlings than metal halide and fluorescent lights (Pendoley Environment 2005). Additionally, experiments conducted on Thevenard Island indicated that Green Turtle hatchlings were not attracted to a flare at a distance of 400 m from the flare (Pendoley 1999), and the Ashburton River Delta nesting beach is approximately 4 km from the flare.

Of potentially greater concern than direct light spill to turtles is sky glow. Sky glow occurs when artificial light reflects off clouds and atmospheric particles such as dust and water vapour, causing a "scattering" effect. Different light sources will produce different amounts of sky glow from the same amount of light being sent into the atmosphere. A simple metric for this phenomenon is known as the Rayleigh Scatter Index, which indicates that HPS lamps produce roughly one-third to one-half of the sky glow than typical metal halide lamps, based on the same amount of light entering the atmosphere (URS 2010a, Appendix O1). Airborne particles, cloud elevation, and sea conditions will all considerably affect the level at which sky glow is perceived from an observer, located some distance from the Ashburton North SIA. Maximum Lux perceived as a result of sky glow by a turtle hatchling in the modelled domain occurs at a point approximately 3.4 km from the flare. This would reach the nearshore area of the Ashburton River delta beach. The maximum intensity of the sky glow is computed as being approximately 0.00001 Lux (URS 2010a, Appendix O1). This is one order of magnitude less than the light produced by Sirius and thus will not affect hatchlings or nesting adults.

Light emissions from the pipelay vessels are likely to be visible on the northern, eastern and southern beaches of Ashburton Island while the vessels are working within 5 to 10 km of the island. However, given that pipelaying in the vicinity of Ashburton Island will be of short duration, light emissions from the trunkline laying vessels are not expected to have a significant impact on hatchlings at Ashburton Island.

Summary

The attraction of marine turtle hatchlings to Project light spill is predicted to have only a short-term, localised impact on a local population of Flatback Turtle (EPBC Act (Cth) listed marine fauna) hatchlings. Although light spill will be managed through facility design and mitigation, the proximity of the Ashburton River Delta nesting beach to the Ashburton North SIA means that Project light spill may have an impact on marine turtle hatchlings behaviour.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that Project light spill may impact on a local population of Flatback Turtle hatchlings, potentially causing behavioural changes. The residual environmental risk for this potential impact was assessed as being "Low" – of "Moderate" consequence, arising from the disruption in behaviour of an EPBC Act (Cth) listed marine fauna species, and "Possible" likelihood.

Interference with Nesting Marine Turtle Behaviour

Residual risk to marine turtles from disturbance to behaviour and/or migratory patterns from light emissions is	**Low**

Marine turtles can be discouraged from emerging from the water to nest by artificial lighting on nesting beaches (Mortimer 1995), however the presence of artificial light does not always dissuade turtles from nesting (Pendoley 2005). Nesting turtles that are disturbed by artificial lighting may be displaced to adjacent beaches, which may be less suitable for nesting and/or egg development (Lutcavage *et al*. 1997; Witherington & Martin 2000).

The majority of nesting in the vicinity of the Project area is by Flatback Turtles at Ashburton Island and at the Ashburton River Delta. Green Turtles have not been recorded in large numbers on any of the islands in the Project area or on mainland beaches near the Project facilities.

Light spill modelling suggests that islands in the vicinity of the Ashburton North SIA will experience only very low level luminance from plant operational lighting (URS 2010a, Appendix O1) and turtles are not expected to be deterred from nesting on this island by plant operational lighting.

Some light spill during plant operations can be expected on the Ashburton River Delta beach; however, the intensity is expected to be less that 0.001 Lux (Figure 8.65). Some nesting turtles may be displaced from the lower-dune area to the higher-dune area of this beach, resulting in higher density turtle nesting in the higher-dune area. This displacement and associated increase in the density of nesting is unlikely to affect the productivity of the Ashburton River Delta beach as nesting densities on this beach are much lower than other beaches in the region, such as at Barrow Island (Pendoley Environmental 2008) and it is unlikely to have reached its carrying capacity for nesting and egg development.

Light emissions from the trunkline laying vessels are likely to be visible on the northern, eastern and southern beaches of Ashburton Island. However, pipelaying in the vicinity of Ashburton Island will be of short duration. Given the shape of Ashburton Island (round), and that nesting has been observed on all of the islands beaches (RPS 2010), any nesting turtles that are disturbed from the vessel lights could potentially relocate to nest on another part of the island that is protected from the light spill.

Summary

Although it is possible that displacement of nesting turtles from the Ashburton River Delta beach to other beaches, as a result of light spill from the Project, may occur, it is not expected to have impacts at a population level.

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that Project light spill may impact on a local population of Flatback Turtles, potentially causing changes in nesting behaviour. The residual environmental risk for this potential impact was assessed as being "Low" – of "Moderate" consequence, arising from the disruption in behaviour of an EPBC Act (Cth) listed marine fauna species, and "Possible" likelihood.

Attraction of Seabirds

Residual risk to seabirds from attraction to light emissions is	**Low**

Project light emissions have the potential to attract seabirds and extend their foraging time. This could also stimulate population growth and could result in increased levels of competition with, and predation of, protected fauna.

Silver Gulls (*Chroicocephalus novaehollandiae*) are often attracted to plant lighting as it increases the availability of prey; insects are also attracted to the lights, and fish are attracted to light spilling onto the sea surface. The increased availability of prey and the ability of the birds to extend their foraging time through the night are likely to result in increased numbers of Silver Gulls, which may have flow on effects for other seabirds and for marine turtles, through competition for breeding habitat and predation of turtle eggs and hatchlings, respectively.

The mainland beaches in the vicinity of the Ashburton North SIA are not recognised as being important for nesting seabirds, but support roosting seabirds. These populations may learn to forage in the areas of light spill.

The islands offshore from the Ashburton North SIA development site, including Airlie, Serrurier and Thevenard Islands, are all Nature Reserves that support nesting birds. Light spill modelling for the plant facilities indicates that, during normal operation, the islands in the vicinity of the Ashburton North SIA will not be directly illuminated at levels above natural light (i.e. from the moon and stars). Sky glow from the Ashburton North SIA may be visible up to 50 km offshore, which includes all islands and mainland beaches between the mainland and Flat Island, Thevenard Island and Twin Islands, but the luminance levels would be low. Therefore seabirds are not expected to be attracted to the Ashburton North SIA by plant operation lighting.

Seabirds may be attracted to lighting of the trunkline laying vessels, however pipelaying in the vicinity of Ashburton Island will be of short duration and long-term behavioural changes are unlikely. Therefore it is not anticipated that seabirds attracted to the lighting of trunkline laying vessels will have a significant impact on nesting seabirds or on turtle eggs and/or hatchlings at Ashburton Island.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.48, it is possible that Project light spill may impact on local populations of roosting seabirds, potentially causing changes in foraging behaviour which may impact on marine turtle hatchlings. The residual environmental risk for this potential impact was assessed as being "Low" – of "Moderate" consequence, arising from the disruption in behaviour of seabirds and the potential for additional impact to turtle hatchlings, and "Possible" likelihood.

8.4.6 Implications for Matters of National Environmental Significance

Matters of NES exist in relation to the presence of marine fauna in the Project area. Matters of NES relevant to marine fauna are defined as:

- Listed threatened species and ecological communities
- Migratory species protected under international agreements
- The Commonwealth marine environment.

Table 8.47 provides a summary of matters of NES that may be potentially affected by Project activities. The table details the species that has the potential to be impacted, their listing under the EPBC Act (Cth), potential impacts to the taxa, the residual risk ranking (after implementation of management and mitigation measures), and details on which the risk assessment was based.

Management and mitigation measures proposed for marine fauna will carefully consider species categorised as matters of NES.

Table 8.47: Summary of Residual Risk Analysis for Matters of NES

Common Name	EPBC Act (Cth) Listing Category	Key Potential Impact	Residual Risk Ranking	Basis of Risk Assessment
Mammals				
Humpback Whale *Megaptera novaeangliae*	Vulnerable, Migratory	• Behavioural changes, injury or mortality during construction (Noise and Vibration) • Behavioural changes during operations (Noise and Vibration)	Low Low	Present in coastal waters during southward migration, cows and calves may rest within the Project area. Noise may interfere with acoustic perception and communication however impacts are expected to be temporary, short-term and localised.
		• Toxic effects from leaks and spills (Leaks and Spills) • Potential smothering and/or oiling leading to injury or mortality (Leaks and Spills)	Low Low	Present in offshore and coastal waters, with cow/calves present in greater numbers during the southern migration (spring). Short resurfacing intervals may expose individuals to spill; however, it is likely that most whales temporarily exposed to hydrocarbons would not suffer significant effects. A condensate spill would tend to evaporate quickly and therefore risk of exposure would be reduced. Impacts anticipated to be minor and short term and unlikely to have an effect on population viability.
		• Injury or mortality due to vessel collision (Vessel Movements)	Low	Highly mobile and quick avoidance response, possible impacts limited to period of southern migration when cow/calves present in high numbers.
		• Disturbance from vessel movements (Vessel Movements)	Low	Potential disruption will be limited to localised displacement of a small proportion of the migrating populations and is not likely to affect the success of the migrations.
		• Entanglement or ingestion of debris (Construction Activities – marine)	Low	Conservation and awareness programs to educate construction and operational workforce in responsible waste disposal, particularly during recreational boating.
		• Disturbance of normal movements/migration (Physical Presence of Marine Infrastructure)	Low	Possible disturbance limited to small numbers of individuals in close proximity to coast during southern migration. The majority of offshore production facilities will be located on the seabed. Structures above the sea surface can be easily avoided.
		• Toxic effects from discharges (Discharges)	Very Low	Mixing and dispersion in deep offshore waters will dilute any contaminants present in discharges from the offshore installation.

Common Name	EPBC Act (Cth) Listing Category	Key Potential Impact	Residual Risk Ranking	Basis of Risk Assessment
Blue Whale *Balaenoptera musculus intermedia* (includes the Pygmy Blue Whale, *B. musculus brevicauda*)	Endangered, Migratory	• Behavioural changes, injury or mortality during construction (Noise and Vibration) • Behavioural changes during operations (Noise and Vibration) • Toxic effects from leaks and spills (Leaks and Spills) • Potential smothering and/or oiling leading to injury or mortality (Leaks and Spills) • Injury or mortality due to vessel collision (Vessel Movements)	**Low** **Low** **Low** **Low** **Low**	Blue Whales are only present in the deep offshore waters of the Project area and on a seasonal basis. May be affected by noise and vibration from pipelaying, drilling and vessel movements occurring in deeper, offshore waters during their migratory periods. Surveys to date have not recorded any Blue Whales in the area which suggests that numbers are relatively low. Impacts anticipated to be minor and short term and unlikely to have an effect on population viability.
Antarctic Minke Whale *Balaenoptera bonaerensis*	Migratory	• Toxic effects from leaks and spills (Leaks and Spills) • Potential smothering and/or oiling leading to injury or mortality (Leaks and Spills) • Injury or mortality due to vessel collision (Vessel Movements)	**Low** **Low** **Low**	Unlikely to occur in surrounding offshore waters (colder water species), highly mobile, unlikely to be affected by Project activities.
Bryde's Whale *Balaenoptera edeni*	Migratory	• Toxic effects from leaks and spills (Leaks and Spills) • Potential smothering and/or oiling leading to injury or mortality (Leaks and Spills) • Injury or mortality due to vessel collision (Vessel Movements)	**Low** **Low** **Low**	Temporarily present when migrating in surrounding offshore waters, highly mobile, unlikely to be affected by Project activities.

Southern Right Whale *Eubalaena australis*	Endangered, Migratory	• Toxic effects from leaks and spills(Leaks and Spills) • Potential smothering and/or oiling leading to injury or mortality (Leaks and Spills) • Injury or mortality due to vessel collision (Vessel Movements)	**Low** **Low** **Low**	Unlikely to occur in surrounding offshore waters (colder water species), highly mobile, unlikely to be affected by Project activities.
Sperm Whale *Physeter macrocephalus*	Migratory	• Toxic effects from leaks and spills (Leaks and Spills) • Potential smothering and/or oiling leading to injury or mortality (Leaks and Spills) • Injury or mortality due to vessel collision (Vessel Movements)	**Low** **Low** **Low**	Temporarily present when migrating in surrounding offshore waters, highly mobile, unlikely to be affected by Project activities.
Killer Whale *Orcinus orca*	Migratory	• Toxic effects from leaks and spills (Leaks and Spills) • Potential smothering and/or oiling leading to injury or mortality (Leaks and Spills) • Injury or mortality due to vessel collision (Vessel Movements)	**Low** **Low** **Low**	Seldom occur in surrounding offshore waters (colder water species), highly mobile, unlikely to be affected by Project activities.

Common Name	EPBC Act (Cth) Listing Category	Key Potential Impact	Residual Risk Ranking	Basis of Risk Assessment
Indo-Pacific Humpback Dolphin *Sousa chinensis*	Migratory	• Behavioural changes, injury or mortality during construction (Noise and Vibration) • Behavioural changes during operations (Noise and Vibration)	**Low** **Low**	Likely to be present in coastal waters. Occur in discrete, geographically localised populations. Ongoing degradation of the species' habitat is anticipated to be the primary factor negatively affecting populations throughout their range. Frequencies of whistles and broad band clicks coincide with frequencies often found emanating from vessel traffic. Known to be sensitive to development. Most intense noise is associated with pile driving which is short-term. Temporary displacement expected during vessel movements and maintenance dredging.
		• Toxic effects from leaks and spills (Leaks and Spills) • Potential smothering and/or oiling leading to injury or mortality (Leaks and Spills)	**Low** **Low**	Present in coastal waters and unlikely to be exposed to spill scenarios from ruptured trunkline offshore and loss of well control. Potential exposure to diesel/condensate spills in the nearshore environment at the MOF and PLF. If temporarily exposed to hydrocarbons there may be individual mortalities. A condensate spill would tend to evaporate quickly and therefore risk of exposure would be reduced. Impacts anticipated are to be minor, short-term and unlikely to have an effect on population viability.
		• Disturbance of normal movements/migration (Physical Presence of Marine Infrastructure)	**Low**	Population fragmentation is not anticipated, may cause some disruptions to normal movements.
		• Injury or mortality due to vessel collision (Vessel Movements) • Disturbance from vessel movements (Vessel Movements)	**Low** **Low**	Likely to be present in coastal waters, sensitive to habitat destruction and degradation and vessel traffic. Frequencies of whistles and broad band clicks coincide with frequencies often found emanating from vessel traffic.
		• Entanglement or ingestion of debris (Construction Activities – marine)	**Low**	Conservation and awareness programs to educate construction and operational workforce in responsible waste disposal, particularly during recreational boating.
		• Toxic effects from discharges (Discharges)	**Very Low**	Nearshore wastewater streams discharged via piped ocean outfalls will be treated according to government regulations.

Spotted Bottlenose Dolphin *(Arafura/ Timor Sea populations)* *Tursiops aduncus*	Migratory	• Behavioural changes, injury or mortality during construction (Noise and Vibration)	**Low**	Likely to be present in coastal waters around the Project area. Sensitive to noise. Noise associated with construction will be temporary and localised.
		• Behavioural changes during operations (Noise and Vibration)	**Low**	
		• Toxic effects from leaks and spills (Leaks and Spills)	**Low**	Present in coastal waters and unlikely to be exposed to spill scenarios from ruptured trunkline offshore and loss of well control. Potential exposure to diesel/condensate spills in the nearshore environment at the MOF and PLF. If temporarily exposed to hydrocarbons there may be individual mortalities. A condensate spill would tend to evaporate quickly and therefore risk of exposure would be reduced. Impacts anticipated are to be minor, short-term and unlikely to have an effect on population viability.
		• Potential smothering and/or oiling leading to injury or mortality (Leaks and Spills)	**Low**	
		• Injury or mortality due to vessel collision (Vessel Movements)	**Low**	Highly mobile species, however susceptible to strikes by small high-speed recreational boats.
		• Disturbance from vessel movements (Vessel Movements)	**Low**	
		• Entanglement or ingestion of debris (Construction Activities - marine)	**Low**	Conservation and awareness programs to educate construction and operational workforce in responsible waste disposal, particularly during recreational boating.
		• Toxic effects from discharges (Discharges)	**Very Low**	Nearshore wastewater streams discharged via piped ocean outfalls will be treated according to government regulations.

Common Name	EPBC Act (Cth) Listing Category	Key Potential Impact	Residual Risk Ranking	Basis of Risk Assessment
Dugong *Dugong dugon*	Migratory	• Behavioural changes, injury or mortality during construction (Noise and Vibration)	Low	Present in coastal waters. Uncertainties surround the structure of the local Dugong population and distribution (collation of dataset is underway). Limited data available on the sensitivities of Dugongs to noise. The auditory range of Dugongs appears to be restricted to the middle frequencies (118 kHz) (URS 2004), which may indicate that activities such as pipelaying, rock dumping, drilling and vessel movements (which are generally <1 kHz) may not result in adverse noise impacts to Dugongs. Impacts will be short term.
		• Behavioural changes during operations (Noise and Vibration)	Low	
		• Injury or mortality due to vessel collision (Vessel Movements)	Low	Susceptibility to strikes by small high-speed recreational boats, the ownership of which is expected to greatly increase. A conservative risk ranking has been based on uncertainties regarding residency or migration patterns of Dugongs recorded during aerial surveys.
		• Disturbance from vessel movements (Increased recreational pressure)	Medium	
		• Toxic effects from leaks and spills (Leaks and Spills)	Low	Present in coastal waters and unlikely to be exposed to spill scenarios from ruptured trunkline offshore and loss of well control. Potential exposure to diesel/condensate spills in the nearshore environment at the MOF and PLF. If temporarily exposed to hydrocarbons there may be individual mortalities. A condensate spill would tend to evaporate quickly and therefore risk of exposure would be reduced. Impacts anticipated to be minor and short-term and unlikely to have an effect on population viability.
		• Potential smothering and/or oiling leading to injury or mortality (Leaks and Spills)	Low	
		• Loss of critical habitat due to dredging and dredge material placement (Dredging)	Very Low	Sensitive to habitat loss but dredging and dredge material placement will not remove restricted critical habitat. No significant seagrass habitats that are restricted to the Project areas.
		• Toxic effects from discharges (Discharges)	Very Low	Nearshore wastewater streams discharged via piped ocean outfalls will be treated according to government regulations.

Marine Reptiles				
Flatback Turtle *Natator depressus* Green Turtle *Chelonia mydas* Hawksbill Turtle *Eretmochelys imbricata*	Vulnerable, Migratory	• Recreational access to offshore islands by workforce	**Medium**	Restricted to nesting on islands and susceptible to pressures arising from access by construction and operational workforce.
Loggerhead Turtle *Caretta caretta*	Endangered, Migratory	• Behavioural changes, injury or mortality during construction (Noise and Vibration) • Behavioural changes during operations (Noise and Vibration)	**Low** **Low**	Flatback Turtle tracks have been recorded in low-medium densities on the mainland at Ashburton River Delta and offshore islands including Ashburton Island, Thevenard Island, Bessieres Island, Locker Island and Direction Island. Green Turtle tracks have also been recorded in high densities at Serrurier Island and in low densities at Tortoise and Thevenard Islands. One loggerhead track has been recorded at Locker Island. The closest nesting site to the Project area is Ashburton River Delta (4 km) and Ashburton Island (12 km). Noise will be temporary and localised. It is unlikely that marine turtles would be significantly affected by piling activities during PLF construction or vessel noise given the distance these rookeries are from the Project area.
		• Entrainment in dredge	**Low**	Marine turtles rest and forage on the seabed. Foraging surveys in 2009 revealed that juvenile turtles are common around the islands offshore from the development area. Foraging studies also indicated that the majority of foraging turtles in the region were juvenile Green Turtles. These turtles appeared to favour the reef habitats around the offshore islands.

Common Name	EPBC Act (Cth) Listing Category	Key Potential Impact	Residual Risk Ranking	Basis of Risk Assessment
		• Attraction and interference with sea-finding behaviour (Light emissions)	**Low**	Mainland beaches within and adjacent to the Project area are not recognised as major nesting sites. Medium densities of Flatback Turtle tracks were recorded at the Ashburton River Delta site, while beaches immediately adjacent to the Project area become inundated during spring tide events. Hatchlings emerging from nests at Ashburton River Delta could potentially be disorientated on the beach from the sky glow emanating from the Project area. However, the height of the primary dune is likely to provide sufficient shading that will reduce impact to the population. Nesting by Flatback Turtles has been recorded at Ashburton Island however the island is at a sufficient distance from the Project area that hatchling orientation is unlikely to be affected. Hatchlings emerging from nests on southern beaches at Ashburton Island will crawl towards the Project area and are likely to be influenced by wave direction cues after reaching the ocean.
		• Disturbance to behaviours and migratory patterns (Light Emissions)	**Low**	Light emissions from the Project area are unlikely to affect foraging, mating or nesting behaviour as the nearshore waters adjacent to the Project area are not known to support suitable habitat for these activities.
		• Injury or mortality due to vessel collision (Vessel Movements) • Disturbance from vessel movements (Vessel Movements)	**Low** **Low**	Closest distance between the proposed shipping channel and marine turtle nesting beaches and islands that support nesting turtles is approximately 14 km.
		• Toxic effects from leaks and spills (Leaks and Spills) • Potential smothering and/or oiling of fauna leading to injury or mortality (Leaks and Spills)	**Low** **Low**	High evaporation rates of condensate in tropical environments will tend to reduce extent of effects with concentrations of aromatic compounds substantially reduced by the time the spill reaches nesting beaches on offshore islands in the Project area (e.g. Ashburton Island), the mainland beaches or far afield to nesting sites on North West Cape.
		• Entanglement or ingestion of debris (Construction Activities – marine)	**Low**	Conservation and awareness programs to educate construction and operational workforce in responsible waste disposal, particularly during recreational boating.

		• Disturbance of normal movements/migration (Physical Presence of Marine Infrastructure)	**Low**	The majority of offshore production facilities will be located on the seabed. Structures above the sea surface can be easily avoided.
		• Loss of critical habitat due to dredging and dredge material placement (Dredging)	**Very Low**	Dredge modelling outputs show that no critical habitat for marine turtles will be impacted by dredging and placement.
		• Toxic effects from discharges (Discharges)	**Very Low**	Nearshore wastewater streams discharged via piped ocean outfalls will be treated according to government regulations.
Leatherback Turtle *Dermochelys coriacea*	Endangered	• Injury or mortality due to vessel collision (Vessel Movements)	**Low**	Unlikely to be present in coastal waters or nest in this area. Field studies indicate that the Project area is not an important foraging area for this species.
Fish				
Whale Shark *Rhincodon typus*	Vulnerable	• Injury or mortality due to vessel collision (Vessel Movements) • Toxic effects from leaks and spills (Leaks and Spills) • Potential smothering and/or oiling leading to injury or mortality (Leaks and Spills)	**Low** **Low** **Low**	Migratory in offshore waters, unlikely to be present within the Project area.
Sawfish *Pristis sp.*	Vulnerable	• Behavioural changes, injury or mortality during construction (Noise and Vibration) • Behavioural changes during operations (Noise and Vibration)	**Low** **Low**	Present in coastal waters, including Hooley Creek and the north eastern parts of the Ashburton Lagoon areas. Uncertainties surround the structure of the local population and distribution. Limited data available on the sensitivities of sawfish to noise. Unlikely due to benthic habit of sawfish and mobility to swim away from noise sources. Any impact will be short-term.
		• Injury or mortality due to vessel collision (Vessel Movements)	**Low**	Unlikely due to benthic habit of sawfish.
		• Toxic effects from leaks and spills (Leaks and Spills) • Potential smothering and/or oiling leading to injury or mortality (Leaks and Spills)	**Low** **Low**	Exposure unlikely due to benthic habit of sawfish; however, it is possible that diesel spills at the MOF/PLF could enter Hooley Creek.
		• Toxic effects from discharges (Discharges)	**Very Low**	Nearshore wastewater streams discharged via piped ocean outfalls will be treated according to government regulations.

Common Name	EPBC Act (Cth) Listing Category	Key Potential Impact	Residual Risk Ranking	Basis of Risk Assessment
Seabirds				
Fork-tailed Swift *Apus pacificus*	Endangered, Migratory	• Recreational access to offshore islands by workforce (excludes the oceanic Southern Giant Petrel)	Medium	Restricted to nesting on islands and susceptible to pressures arising from access by construction and operational workforce.
Great Egret, White Egret *Ardea alba*	Migratory	• Toxic effects from leaks and spills (Leaks and Spills)	Low	High evaporation rates of condensate in tropical environments will tend to reduce extent of effects with concentrations of aromatic compounds substantially reduced by the time the spill reaches nesting beaches on offshore islands in the Project area.
Cattle Egret *Ardea ibis*	Migratory	• Recreational access to offshore islands by workforce (excludes the oceanic Southern Giant Petrel)	Medium	Restricted to nesting on islands and susceptible to pressures arising from access by construction and operational workforce.
Bridled Tern *Sterna anaethetus*	Migratory	• Toxic effects from leaks and spills (Leaks and Spills) • Potential smothering and/or oiling leading to injury or mortality (Leaks and Spills)	Low Low	High evaporation rates of condensate in tropical environments will tend to reduce extent of effects with concentrations of aromatic compounds substantially reduced by the time the spill reaches nesting beaches on offshore islands in the Project area.
Caspian Tern *Sterna caspia*	Migratory	• Disturbance from vessel movements (Vessel Movements)	Low	Species are restricted to nesting on islands and so unlikely to be affected by vessel movements.
Southern Giant Petrel *Macronectes giganteus*	Migratory	• Loss of critical habitat due to dredging and dredge material placement (Dredging)	Very Low	Sensitive to habitat loss but dredging and dredge material placement will not remove restricted critical habitat.

8.4.7 Residual Risk Summary

The following table (Table 8.48) provides a summary of the aspects, activities and potential impacts to marine fauna as a result of Project activities. Indicative management and mitigations measures are also listed, along with the residual risk following the implementation of the proposed management and mitigations measures.

Where applicable, reference has been made to the Proposed Marine Fauna Management OBCs (Chapter 12, *Environmental Management Program*). These OBCs have been developed in alignment with the EPA's EAG 4 (EPA 2009f).

Table 8.48: Summary of Management Measures and Residual Risks for Marine Fauna

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Physical presence of marine infrastructure							
Physical presence of the PLF, MOF, trunkline and offshore production facilities.							
	Change to behaviour of protected marine fauna (including seabirds), impacts on migratory patterns, nesting and feeding, and loss and disturbance to habitats.	Design: Nearshore infrastructure location selected to reduce risks to habitat critical (nesting, feeding and calving areas) for marine fauna such as Humpback Whales, Dugongs and turtles. Mitigate: Aerial, boat and land based surveys to identify and map critical habitat for marine mammals and turtles prior to construction.	5	4	**Very Low**	**Reasonable to High** Short-term monitoring results available. Some long-term monitoring results available.	No significant impact.
Change in the abundance and diversity of protected marine fauna from the creation of artificial habitat causing fish aggregation							
	Changes in abundance for some species of fish. Change in the abundance and diversity of protected marine fauna from the creation of artificial habitat.	Design: Nearshore infrastructure location selected to reduce likelihood of fish aggregating in habitat critical (nesting, feeding and calving areas) for marine fauna.	6	3	**Very Low**	**Low** Avaliable information is inadequate.	No significant impact.

Dredging							
Entrainment of marine fauna during construction dredging of the channel, trunkline and berthing area							
	Entrainment of marine fauna (particularly juvenile turtles) resting on the seabed in the dredge.	Refer to DSDMP for complete list of mitigation measures. Refer to Chapter 12, *Environmental Management Program* for Proposed Marine Fauna Management OBCs. Mitigate: Prior to commencement of dredging and dredge material management activities selected crew will receive training, which will include details on procedures in the event turtle sighting, injury and/or death. Mitigate: When operating with less than five metres under keel clearance, the dredge will initially move slowly through the area before commencing dredging so that the noise and vibration disturb marine turtles in the vicinity and encourage them to leave. This will only be applied on dredging in new areas and not once the work area has been established. Mitigate: Dredge pumps will be stopped as soon as practicable after completion of dredging and where reasonably practicable the drag head will remain within four metres of the seabed until the dredge pump is stopped. Mitigate: Management of cetacean interactions will be in accordance with the requirements for cetacean interactions specified under the *Australian National Guidelines for Whale and Dolphin Watching (2005)*. Mitigate: Release of healthy entrained turtles back to the marine environment and contact the DEC if an injured turtle is collected after being entrained. Mitigate: In the event of turtle mortality incident, as a result of entrainment during dredging, revision of existing management measures will be investigated to ascertain whether additional measures may be put in place to reduce the potential for such incidents to occur in the future. Monitor: Humpbacks and Dugong observations throughout the works as part of the marine mammal management procedures Report: Any incident involving the injury or mortality of turtles will be reported to the DEC and DEWHA within 48 hours of the incident occurring.	4	3	**Low**	**Reasonable** Short-term monitoring data available	No significant impact.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Loss of critical habitat due to construction dredging for channel, trunkline and MOF, and placement of dredged material at sea.							
	Loss of or disturbance to critical habitat used by protected marine fauna Disturbance of fauna causing avoidance of area by protected marine fauna Heightened community concern Impacts on local tourism operators	Refer to DSDMP for complete list of mitigation measures. Refer to Chapter 12, *Environmental Management Program* for Proposed Marine Fauna Management OBCs. Refer to Table 8.37 for management and mitigation measures associated with elevated turbidity levels. Design: Selection of navigation channel, MOF and placement sites to reduce risks to habitat critical (nesting, feeding and calving areas) for marine fauna such as Humpbacks, Dugongs and turtles. Mitigate: Dredging and material placement will be conducted during favourable weather, tide and current conditions, as far as reasonably practicable, to reduce the risk of impact to marine fauna while in close proximity to sensitive areas.	5	4	**Very Low**	**Reasonable** Short-term monitoring results available. Modelling conducted but calibration shows occasional aberration from occurrences.	No significant impact.
	Loss of or disturbance to designated nearshore nursery habitat for prawns.	Refer to DSDMP for complete list of mitigation measures. Refer to Chapter 12, *Environmental Management Program* for Proposed Marine Fauna Management OBCs. Refer to Table 8.37 for management and mitigation measures associated with elevated turbidity levels. Design: Selection of navigation channel, MOF and placement sites to reduce risks to habitat critical for prawn nursery habitat. Mitigate: Dredging and material placement will be conducted during favourable weather, tide and current conditions, as far as reasonably practicable, to reduce the risk of impact to prawn nursery habitat while in close proximity to sensitive areas.	4	2	**Medium**	**Reasonable** Short-term monitoring results available. Modelling conducted but calibration shows occasional aberration from occurrences.	No significant impact.

Construction activities (marine)							
Construction of PLF and trunklines, rock placement and anchor placement.							
	Loss of, or disturbance to, habitat critical to marine fauna from seabed disturbance during nearshore construction	Design: Selection of navigation channel, MOF and placement sites to reduce risks to habitat critical (nesting, feeding and calving areas) for marine fauna such as Humpbacks, Dugongs and turtles. Mitigate: Construction will comply with the OPGGS Act (Cth) and the Petroleum (Submerged Lands) (Management of Environment) Regulations 1999 (as amended 2005) as they apply from time to time.	5	2	**Low**	**Reasonable** Short-term monitoring results available.	No significant impact.
Installation of all offshore infrastructure.							
	Loss of, or disturbance to, habitat critical to marine fauna from seabed disturbance during offshore construction	Design: Selection of navigation channel, MOF and placement sites to reduce risks to habitat critical (nesting, feeding and calving areas) for marine fauna such as Humpbacks, Dugongs and turtles. Mitigate: Implementing an approved DEMP in accordance with the OPGGS Act (Cth) and the Petroleum (Submerged Lands) (Management of Environment) Regulations 1999 (as amended 2005) as they apply from time to time.	5	4	**Very Low**	**Reasonable** Short-term monitoring results available	No significant impact.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Vessel movements							
Vessel movements associated with the Project construction and operation.							
	Injury to or fatality of protected marine fauna due to interactions with vessels. Changes to migratory patterns, foraging, breeding behaviour of protected fauna as a result of disturbance. Heightened community/ regulator concern.	Refer to DSDMP and Marine Fauna Management Plan (MFMP) for complete list of mitigation measures. Refer to Chapter 12, *Environmental Management Program* for Proposed Marine Fauna Management OBCs. Mitigate: The following management measures will be applied during construction and operation of nearshore infrastructure: • Prior to the commencement of dredging selected crew will receive training, which will include details on procedures in the event of sighting, injury and/or death of protected marine fauna (e.g. Humpbacks, Dugong, turtles, dolphins). • All sightings of Humpbacks and Dugong that result in management actions being implemented will be recorded. • The vessel master will maintain a log of observed in-water incidents or injured/dead turtles and marine mammals. • Humpback whale and Dugong observations and response procedures, including not commencing dredging or disposal if whales or Dugongs are sighted within a 300 m observation zone and ceasing dredging activities if whales or Dugongs enter a 100 m exclusion zone. A trained crew member will maintain a lookout, during daylight hours, for Humpbacks and Dugongs while dredge are moving to and from the dredge area to dredge material placement sites. If sighted, direction/speed will be adjusted to reduce the likelihood of impact (within the safety constraints of the vessel). Report: Any incident involving the injury or mortality of turtles will be reported to the DEC and DEWHA within 48 hours of the incident occurring.	4	3	**Low**	**Reasonable** Short-term monitoring results available.	No significant impact.

	Introduction of marine pest species. Loss of biodiversity.	Design: Some re-alignment of LEP boundaries. Mitigate: Implement IMP risk assessments, with the objective of assessment all construction vessels entering the nearshore area. Mitigate: Vessels assessed as high or uncertain risk will be inspected prior to mobilisation. Mitigate: If IMP are found vessels will be cleaned prior to mobilisation. Mitigate: If vessel on site is found to have IMP, surveys will be conducted to determine if further action is required. Mitigate: All vessels under the control of the Proponent will comply with AQIS ballast water discharge requirements (Australian Ballast Water Management Requirements V4 2008).	5	3	**Low**	**Reasonable** Available information is adequate.	No significant impact.
	Loss of biodiversity. Breach of marine biosecurity. Introduction of diseases and pathogens to aquaculture operations and commercial and recreational fisheries. Deterioration of industrial infrastructure, navigation aids and vessels.	Design: Some re-alignment of LEP boundaries. Mitigate: Implement IMP risk assessments, with the objective of assessment all construction vessels entering the nearshore area. Mitigate: Vessels assessed as high or uncertain risk will be inspected prior to mobilisation. Mitigate: If IMP are found vessels will be cleaned prior to mobilisation. Mitigate: If vessel on site is found to have IMP, surveys will be conducted to determine if further action is required. Mitigate: All vessels under the control of the Proponent will comply with AQIS ballast water discharge requirements (Australian Ballast Water Management Requirements V4 2008). Monitor: The Proponent will undertake marine pest monitoring and apply risk mitigation in relation to biosecurity that considers DoF protocols and procedures and the specific requirements of the Project.	2	5	**Low**	**Reasonable** Available information is adequate.	No significant impact.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Increased Recreational Pressure Associated with the Project							
Reduction in fish stocks due to increased recreational fishing associated with construction workforce and Onslow's population growth							
	Overfishing of fish stock resulting in stock decline, reduction in abundance, decline in population health, altered trophic levels, potential trophic cascade	Refer to the MFMP Mitigate: To reduce the potential for overfishing occurring in the Project area, the following action may be implemented: • Inform Project staff/contractors of recreational fishing Regulations • The Proponent will work with the DoF to reduce potential risks to the existing recreational fishery • Recreational boats and recreational vehicles will not be permitted within the workforce accommodation village or to travel on the access road from Onslow Road • Behaviour standards to be expected from all construction workers will be clearly articulated in a Recreation Code of Conduct. Construction workers will be asked to sign the Code of Conduct • A community feedback procedure will be established whereby any complaints from the community about unacceptable behaviour from construction workers will be investigated and, where necessary, action taken.	3	3	**Medium**	**Low** Avaliable information is inadequate.	No significant impact.

Injury/mortality and/or disturbance to Dugongs and Turtles due to Increased Recreational Boating							
	Injury/ mortality and/ or disturbance to Dugongs and turtles due to vessel collision.	Refer to MFMP Refer to Chapter 12, *Environmental Management Program* for Proposed Marine Fauna Management OBCs. Mitigate: To reduce the potential for increased vessel strikes of Dugongs and turtles from increased recreational pressure the following action may be implemented: • Inform Project staff/contractors of DEC rules relating to the Wildlife Conservation Act e.g. distance to keep from animals • Recreational boats and recreational vehicles will not be permitted within the boundaries of the Project area or to travel on the access road from Onslow Road. • Behaviour standards to be expected from all construction workers will be clearly articulated in a Recreation Code of Conduct. Construction workers will be asked to sign the Code of Conduct. • A community feedback procedure will be established whereby any complaints from the community about unacceptable behaviour from construction workers will be investigated and, where necessary, action taken.	3	3	**Medium**	**Low to Reasonable** Avaliable information is inadequate. Short-term (incomplete) monitoring results available.	Dugongs All species of marine turtles

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Disturbance to nesting birds and turtles on offshore islands							
	Disturbance leading to reduced breeding success of nesting marine turtles and seabirds. Interference with adult or hatchling turtles Trampling of nests and burrows Erosion of suitable nesting areas	Refer to MFMP Refer to Chapter 12, *Environmental Management Program* for Proposed Marine Fauna Management OBCs. Mitigate: To reduce impacts to protected marine fauna (turtles and nesting birds on islands) from increased recreational pressure the following actions may be implemented: • Make existing mammal and turtle aerial sighting data available to DEC for planning purposes relating to recreational boating activity in the Onslow region. • Inform Project staff/contractors of DEC rules relating to offshore nature reserves e.g. domesticated animals (such as dogs and cats) will be prohibited on offshore islands/reserves • The Proponent will work with the DEC to reduce potential risks from excessive recreational use of the islands within a 25km radius of Onslow • Recreational boats and recreational vehicles will not be permitted within the workforce accommodation village or to travel on the access road from Onslow Road. • Behaviour standards to be expected from all construction workers will be clearly articulated in a Recreation Code of Conduct. Construction workers will be asked to sign the Code of Conduct • A community feedback procedure will be established whereby any complaints from the community about unacceptable behaviour from construction workers will be investigated and, where necessary, action taken.	3	3	**Medium**	**Low** Available information is inadequate.	All species of marine turtles Migratory birds

Entanglement or ingestion of marine debris related to increased recreational boating and fishing							
	Entanglement or ingestion of marine debris from recreational boats by marine fauna e.g. garbage, plastics, fishing line	Refer to MFMP Refer to Chapter 12, *Environmental Management Program* for Proposed Marine Fauna Management OBCs. Mitigate: To reduce impacts to marine fauna from entanglement/ingestion of marine debris the following actions may be implemented: • Conservation induction programs will be run for employees and contractors (e.g. to include education of better disposal of fishing line and use of biodegradable fishing line). • Recreational boats and recreational vehicles will not be permitted within the workforce accommodation village or to travel on the access road from Onslow Road. • Behaviour standards to be expected from all construction workers will be clearly articulated in a Recreation Code of Conduct. Construction workers will be asked to sign the Code of Conduct • A community feedback procedure will be established whereby any complaints from the community about unacceptable behaviour from construction workers will be investigated and, where necessary, action taken.	5	3	**Low**	**Reasonable** Available information is adequate.	No significant impact.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Discharges and wastes from nearshore operations							
Discharge of wastewater, stormwater run-off, reverse osmosis brine and PW during operations							
	Disturbance of protected marine fauna.	Refer to Chapter 12, *Environmental Management Program* for Proposed Marine Fauna Management OBCs. Design: End of pipe diffuser located at the PLF. Design: Mixing zone boundaries to be established and monitoring to achieve applicable water quality targets at mixing zone boundary Design: Selection of outfall location and diffuser design for adequate dilution and dispersion of PW. Design: The Proponent will determine PNEC for PW discharge. Mitigate: Manage discharges by taking into account the threshold limits of the ANZECC/ARMCANZ guidelines Mitigate: Treatment of PW with the objective of meeting the requirements of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 as they apply for time to time. Monitor: Monitor PW concentrations prior to discharge. Monitor: Diffuser design and size of mixing zone shall take into consideration the target for PNEC.	5	4	**Very Low**	**Reasonable** Available information is adequate.	No significant impact.
	Increased nutrients in water leading to eutrophication	Refer to Chapter 12, *Environmental Management Program* for Proposed Marine Fauna Management OBCs. Design: End of pipe diffuser located at the PLF. Design: Mixing zone boundaries to be established and monitoring to achieve applicable water quality targets at mixing zone boundary Mitigate: Manage discharges by taking into account the threshold limits of the ANZECC/ARMCANZ guidelines. Monitor: Monitor nutrient levels in discharge water prior to release.	5	4	**Very Low**	**Reasonable** Available information is adequate.	No significant impact.

Routine discharges from offshore activities (PW, MEG, drill cuttings and mud, sludges and sands, CW, hydrotest fluids, ballast water).							
	Toxic effects to marine fauna from offshore discharges	Design: The Proponent will determine PNEC for PW discharge through ecotoxicity testing. Mitigate: Compliance with OPGGS Regulations (Cth), as they apply from time to time. Mitigate: Control rate, timing and characteristics of discharge of MEG with the objective of maintaining discharge water quality at a level not in excess of 50 mg/L local to the platform (or an agreed distance from the platform).Monitor: Monitor PW concentrations prior to discharge.	5	4	**Very Low**	**Reasonable** Available information is adequate.	No significant impact.
Leaks and spills							
Nearshore leaks and spills							
	Loss of or disturbance to habitat critical to marine fauna (e.g. nursery habitat for prawns, mainland turtle nesting beaches)	Refer to DSDMP and MFMP for complete list of mitigation measures. Design: Implementation, where practicable, of relevant Australia Standards and Codes in the initial design integrity, process and utility equipment, materials handling and operating and maintenance procedures with the objective of reducing spills. Design: A DMP approved MOPP will be implemented and relevant personnel will be trained in accordance with the MOPP. Mitigate: Clean up and remediation methods will be implemented in the event of a spill.	4	4	**Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	No significant impact.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
	Disturbance to protected marine fauna Toxicity effects to protected marine fauna	Refer to DSDMP and MFMP for complete list of mitigation measures. Design: Implementation, where practicable, of relevant Australia Standards and Codes in the initial design integrity, process and utility equipment, materials handling and operating and maintenance procedures with the objective of reducing spills. Design: A DMP approved MOPP will be implemented and relevant personnel will be trained in accordance with the MOPP. Design: The following measures will be used during drilling activities to reduce the risk of a subsea blowout: • Provision of numerous primary and secondary barriers (subsea safety valves, Production Master Valve, Swab Valve, Tree Cup, Production Shutdown Valve, Production Wing Valve etc) • Well bore stability modelling for reservoir and overburden formations • Specific and approved controls for work-over or re-entry operations • Exclusion zone around wellheads with no anchoring in exclusion area gazetted and on navigational charts Mitigate: Clean up and remediation methods will be implemented in the event of a spill.	3	4	**Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	No significant impact.

	Smothering and/ or oiling of marine fauna	Refer to DSDMP and MFMP for complete list of mitigation measures. Design: Implementation, where practicable, of relevant Australia Standards and Codes in the initial design integrity, process and utility equipment, materials handling and operating and maintenance procedures with the objective of reducing spills. Design: A DMP approved MOPP will be implemented and relevant personnel will be trained in accordance with the MOPP. Design: The following measures will be used during drilling activities to reduce the risk of a subsea blowout: • Provision of numerous primary and secondary barriers (subsea safety valves, Production Master Valve, Swab Valve, Tree Cup, Production Shutdown Valve, Production Wing Valve etc) • Well bore stability modelling for reservoir and overburden formations • Specific and approved controls for work-over or re-entry operations • Exclusion zone around wellheads with no anchoring in exclusion area gazetted and on navigational charts Mitigate: Clean up and remediation methods will be implemented in the event of a spill.	3	4	**Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	No significant impact.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Offshore leaks and spills							
	Loss of or disturbance to habitat critical to protected marine fauna (e.g. nesting beaches/sites on islands, North West Cape nesting beaches).	Refer to DSDMP and MFMP for complete list of mitigation measures. Design: Implementation, where practicable, of relevant Australia Standards and Codes in the initial design integrity, process and utility equipment, materials handling and operating and maintenance procedures with the objective of reducing spills. Design: A DMP approved MOPP will be implemented and relevant personnel will be trained in accordance with the MOPP. Design: The following measures will be used during drilling activities to reduce the risk of a subsea blowout: • Provision of numerous primary and secondary barriers (subsea safety valves, Production Master Valve, Swab Valve, Tree Cup, Production Shutdown Valve, Production Wing Valve etc) • Well bore stability modelling for reservoir and overburden formations • Specific and approved controls for work-over or re-entry operations • Exclusion zone around wellheads with no anchoring in exclusion area gazetted and on navigational charts Mitigate: Clean up and remediation methods will be implemented in the event of a spill.	4	4	**Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	No significant impact.

	Toxicity effects to marine fauna from spill	Refer to DSDMP and MFMP for complete list of mitigation measures. Design: Implementation, where practicable, of relevant Australia Standards and Codes in the initial design integrity, process and utility equipment, materials handling and operating and maintenance procedures with the objective of reducing spills. Design: A DMP approved MOPP will be implemented and relevant personnel will be trained in accordance with the MOPP. Design: The following measures will be used during drilling activities to reduce the risk of a subsea blowout: • Provision of numerous primary and secondary barriers (subsea safety valves, Production Master Valve, Swab Valve, Tree Cup, Production Shutdown Valve, Production Wing Valve etc) • Well bore stability modelling for reservoir and overburden formations • Specific and approved controls for work-over or re-entry operations • Exclusion zone around wellheads with no anchoring in exclusion area gazetted and on navigational charts Mitigate: Clean up and remediation methods will be implemented in the event of a spill.	3	4	**Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	No significant impact.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
	Smothering and/ or oiling of marine fauna	Refer to DSDMP and MFMP for complete list of mitigation measures. Design: Implementation, where practicable, of relevant Australia Standards and Codes in the initial design integrity, process and utility equipment, materials handling and operating and maintenance procedures with the objective of reducing spills. Design: A DMP approved MOPP will be implemented and relevant personnel will be trained in accordance with the MOPP. Design: The following measures will be used during drilling activities to reduce the risk of a subsea blowout: • Provision of numerous primary and secondary barriers (subsea safety valves, Production Master Valve, Swab Valve, Tree Cup, Production Shutdown Valve, Production Wing Valve etc) • Well bore stability modelling for reservoir and overburden formations • Specific and approved controls for work-over or re-entry operations • Exclusion zone around wellheads with no anchoring in exclusion area gazetted and on navigational charts Mitigate: Clean up and remediation methods will be implemented in the event of a spill.	3	4	**Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	No significant impact.

Noise and Vibration							
Noise and vibrations from construction activities							
	Altered distribution of fauna due to avoidance of area during noisy construction activities (piling, dredging, drilling) Behavioural effects to protected marine fauna	Refer to MFMP Refer to Chapter 12, *Environmental Management Program* for Proposed Marine Fauna Management OBCs. Design: Nearshore infrastructure location selected to reduce risks to critical habitat. Mitigate: Measures to mitigate against the potential risks from vertical seismic profiling (VSP) will be developed (if required). These measures will consider seismic guidelines (DEWHA, 2008), and will be included in the draft Marine Fauna Management Plan included with the Supplementary EIS. Mitigate: To reduce impacts to marine fauna the following actions will be implemented: • If a marine mammal or turtle enters the observation zone (500 m of an active pile hammer) the piling supervisor (or other individual) will be directed to monitor the movement of it in relation to the activity suspension zone (see below) • Pile driving activities shall cease if a marine mammal or turtle is observed within the activity suspension zone (100 m of an active pile hammer). • Where required site-specific noise modelling will be undertaken to validate or modify the adopted noise management zones for piling activity.	4	3	**Low**	**Reasonable** Short-term monitoring results available.	No significant impact.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk C	Residual Risk L	Residual Risk RR	Confidence Level	Matters of NES
Noise and vibrations from operational activities.							
	Altered distribution of fauna due to avoidance of area during noisy construction activities (dredging, drilling) Behavioural effects to protected marine fauna	Refer to MFMP Refer to Chapter 12, *Environmental Management Program* for Proposed Marine Fauna Management OBCs. Mitigate: Management measures will be implemented during maintenance dredging works as follows: • Prior to the commencement of maintenance dredging and dredge material placement selected crew will receive marine fauna training, which will include details on procedures in the event of sighting, injury and/or death of protected marine fauna (e.g. Humpbacks, Dugong, turtles, dolphins). • All sightings of Humpbacks and Dugong that result in management actions being implemented will be recorded. • Humpbacks 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 material placement works as outlined above in Section 2.1. • In the event that a Humpback or Dugong is sighted within the 300 m observation zone, the dredge will relocate to a minimum distance of 300 m away from the individual. • In the event that a Humpback or Dugong is sighted within the 100 m exclusion zone, dredging will cease until the individual has moved out of the 100 m exclusion zone OR until no Humpbacks or Dugong have been observed within this zone for 10 minutes. • A lookout will be maintained, during daylight hours, for Humpbacks and Dugongs while dredge are moving to and from the dredge area to dredge material placement sites. If sighted, direction/speed will be adjusted to reduce the likelihood of impact (within the safety constraints of the vessel). • Report: Any incident involving the injury or mortality of turtles will be reported to the DEC and DEWHA within 48 hours of the incident occurring. (Cont'd)	6	2	**Low**	**Reasonable** Short-term monitoring results available.	No significant impact.

		Measures to mitigate against the risks of vertical seismic profiling (VSP) will be developed if required and will consider the seismic guidelines (DEWHA 2008) and be included in this Plan (which will be included with the Supplementary EIS).					
Underwater blasting associated with construction activity							
	Behavioural changes, injury or mortality to marine fauna associated with blasting.	Refer to the BEMP (to be developed only if blasting is required). Mitigation: Examples of mitigation measures for all blasting activities may include: • Use of marine fauna observers to confirm that no mammals and turtles are within the vicinity of designated fauna exclusion zones.	5	4	**Very Low**	**Low** Available information is inadequate.	No significant impact.
Light emissions							
Light emissions from onshore infrastructure							
	Attraction of marine turtle hatchlings	Refer to DSDMP and MFMP for complete list of mitigation measures. Refer to Chapter 12, *Environmental Management Program* for Proposed Marine Fauna Management OBCs. Mitigate: To reduce impacts to turtle hatchlings, light spill from construction and operation vessels operating nearby offshore islands and mainland beaches that support marine turtle nesting will be reduced, where reasonably practicable. Monitor: The Proponent will monitor onshore infrastructure-attributable changes to the sea-finding success of marine turtle hatchlings at rookeries on Ashburton Island and at the Ashburton delta beach for a period to be determined based on the initial monitoring results. Monitor: Monitoring will be conducted during construction, to coincide with planned flaring events to assess the effects of this activity on hatchling behaviour, particularly in relation to their orientation to the beach and sea-finding success.	4	3	**Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	No significant impact.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
	Interference with marine turtle nesting behaviour	Refer to "Attraction of marine turtle hatchlings" above.	4	3	**Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	No significant impact.
	Attraction of seabirds creating potential for increased predation of turtle hatchlings.	Design: Onshore infrastructure location selected to reduce risks to critical habitat.	4	3	**Low**	**Reasonable** Modelling conducted but calibration shows occasional aberration from occurrences.	No significant impact.
Additive effects							
All construction and operational activities							
	The sum of all potential Project-attributable impacts from all Project phases and aspects.	See above for proposed management/mitigation measures. *NB: The risk ranking for Additive Effects is determined by the highest risk ranking for the marine fauna section.*	4	2	**Medium**	**Low** No modelling conducted on additive effects.	Humpback Whales Dugongs All species of marine turtles Migratory birds Sawfish Indo-Pacific Humpback Dolphins Bottlenose Dolphins

8.4.8 Predicted Environmental Outcome

Humpback Whales, Dugongs, dolphins, sawfish, marine turtles and other protected marine fauna have been documented as occurring in the Project area. It is unlikely that Project activities will have a measurable effect on local populations of species. No habitat, critical to threatened or migratory species, occurs in the Project area and therefore cannot be impacted by Project activities. Some indirect impact to seagrass beds, on which Dugongs feed, is predicted however this disturbance will be temporary and seagrasses should recover after the cessation of dredging. Although some activities, such as dredging and piling, are likely to result in the disturbance of individuals of some species, these activities should not result in impacts at a population level.

The aspects described above have the potential to impact marine fauna in an additive manner. The conservative additive residual environmental risk to marine fauna as a result of Project-attributable impacts was assessed as being "Medium" – of "Moderate" consequence, arising from the combined effects of the predicted increase in recreational boating and fishing, the physical presence of nearshore and offshore infrastructure, discharge into the marine environment, construction and maintenance dredging, acoustic emissions and blasting, light emissions, vessel movements and potential leaks or spills of hydrocarbons, and of "Likely" occurrence.

A MFMP (Appendix O6) and a DSDMP (Appendix S1) will be developed and finalised prior to the commencement of Project construction. These Plans will, in part, provide a high level indication of how impacts to marine fauna will be managed. Additionally, it will specify the management and mitigation measures which will be implemented to limit Project-attributable impacts to marine fauna. If blasting is required as part of Project construction, a BEMP may also be developed and finalised before any blasting activities are undertaken.

Proposed Marine Fauna Management OBCs have been developed for marine fauna, and are presented in Chapter 12, *Environmental Management Program*.

The MFMP (Appendix O6), DSDMP (Appendix S1), BEMP and the OBCs should be read in conjunction with the summary management measures and residual risk table above (Table 8.48) for a complete understanding of potential management and mitigation measures under consideration for the Project.

8.5 Coastal Processes

The following sections present the assessment of Project-attributable impacts on coastal processes, taking into account design modifications and management and mitigation measures applied to manage impacts.

Potential changes to coastal processes arising from the presence of Project infrastructure are described. Nearshore infrastructure includes the MOF, the PLF and the associated breakwaters and dredged navigation channels. Onshore infrastructure includes the LNG plant and access road.

8.5.1 Management Objective

The management objectives for coastal processes are to:

- Ensure that coastal facilities and development takes into account coastal processes including erosion, accretion, storm surge, tides, wave conditions, sea level change and biophysical criteria
- Maintain the integrity and stability of the coast, the seafloor, the intertidal environment and tidal creek systems.

The following sections present the assessment of potential impacts on coastal processes associated with the Project, taking into account design and management and mitigation measures applied to reduce impacts.

8.5.2 Description of Factor

8.5.2.1 Coastal Processes

The term "coastal processes" refers to the interaction of coastal landforms, coastal hydrodynamics and the distribution of sediments. Change to any of these components is likely to cause corresponding changes to the remaining two, often with resultant change to coastal habitats. Baseline characteristics of coastal geomorphology and coastal processes were assessed through a number of studies, as described in Chapter 6, *Overview of Existing Environment*. Sources of data included:

- Coastal Geomorphology of the Ashburton River Delta and Associated Areas (Damara WA 2010, Appendix P1)
- Coastal Impacts Modelling (DHI 2010, Appendix P2)
- Hooley Creek Dynamics Assessment (Damara WA 2010 in prep.)
- Geological Heritage of the Wheatstone Project and Adjacent Areas (Damara WA 2010 in prep.).

Figure 8.67: Apparent Evolution of Coastal Landforms

The Ashburton River delta exhibits dynamic characteristics, with a series of chenier ridges and alternative channels that suggest a general encroachment to the east, subject to significant occasional channel avulsion (Figure 8.67). Field investigations and radiocarbon dating indicate that the modern delta has developed over an older rock structure and that parts of the delta have been significantly reworked within the last thousand years. Historic observations have confirmed that the delta is active, with the easternmost chenier being subject to considerable evolution from 1963 to the present. Even more drastically, the main flow path of the Ashburton River across the delta has switched channels, as the river previously exited near Entrance Point (British Admiralty 1923). High level wrack deposits caused by a once-in-700 year tsunami or cyclone provide evidence of rare high magnitude events that have the potential to affect the Project area.

Sediments from the Ashburton River delta contribute to a net eastwards transport of sediment through the combined effects of waves and tidal currents. The transport is subject to a mild reversal during winter (Damara WA 2010, Appendix P1; DHI 2010, Appendix P2). This supply has allowed the development of active sedimentary structures, including beaches and sand spits, which have been generally accreting over the last 50 years. Occasional disruption or erosion is brought about by tropical cyclones passing close to the Project area, which have capacity to transport large volumes of sand in either direction along the coast, and to cause significant run-off flooding through intense rainfall. Estimated rates of net sediment transport, derived from shoreline movement plans are:

- Supply to the Project area 60 000 to 105 000 m^3/yr from the west
- Loss from the east of the Project area 35 000 to 70 000 m^3/yr.

Modelling results also support a net easterly transport figure of between 50 000 and 100 000 m^3/yr. Average annual rates of accumulation are indicated in the following figure (Figure 8.68).

The coastline adjacent to the Project area has been relatively stable, with gradual accretion, since the earliest aerial imagery in 1963. However, eastward migration of a chenier spit from the Ashburton River delta may contribute an increased supply of sand in the future. Movement of this spit is part of the eastwards encroachment of the delta over longer timeframes. The anticipated changes to coastal processes resulting from the Project have been examined in the context of existing and historic dynamics.

Coastal processes in the Ashburton-Onslow region are developed through interplay of fluvial run-off, prevailing weather conditions, occasional intense tropical cyclones

Figure 8.68: Erosion, Accretion and Net Transport Rates Derived from Shoreline Movements

and rare extreme tsunami impacts, interacting with a complex geological framework developed over multiple eras. The Ashburton River is the major regional source of considerable, although highly variable, sediment supply transported to the coast by floodplain run-off. A coarse fraction of this sediment supply is deposited near the river entrance, where it has accumulated to form an extensive delta. Analysis of the coastal landforms, historical shoreline positions and the prevailing metocean conditions indicate that the Ashburton River provides a major supply of sediment to the coast.

Historical aerial photographs have shown beach movement in the order of 20 m as a result of cyclonic erosion. More active dynamics have been observed for sediment structures related to fluvial run-off and tidal exchange, including delta, cheniers and sand spits at tidal creeks (Figure 8.69).

The Ashburton River delta is comprised of two distinct formations, being the western delta and the eastern delta. The main river channel switched from the eastern to western delta over an unknown period between 1923 and 1963. This change relocated sediment delivery to the coast, causing significant local changes to coastal structure, with accretion at the western delta and erosion at the eastern delta near Entrance Point. The eastern delta entrance migrated eastwards by about 2 km between 1973 and 2009 through extension of the entrance spit.

The eastern margin of the delta has an extensive, low-lying chenier spit in front of a narrow barrier lagoon, which has changed dramatically over the available record of aerial imagery (1963-2009). The spit is developed through the release of a sediment mass from the Ashburton River, which gradually evolves and migrates eastward. The historic pattern of change includes breaching of the chenier and episodes of erosion. Unlike older cheniers behind it, the eastern chenier is not underlain by rock, and consequently, has much lower stability. Although the chenier sequence is indicative of a progressive eastward encroachment of the Ashburton River delta, the process is not continuous. Within this context, the form and hydrodynamics of the chenier and barrier lagoon are not fixed, although they may remain steady for periods of 5-10 years.

The Project area is adjacent to, and overlies, a tidal complex which irregularly acts as a breakout floodplain for the Ashburton River. The lagoon is connected to the ocean by a set of small channels, including Hooley Creek, East Creek and Four Mile Creek (Figure 8.70), which switch roles between flood and non-flood conditions. During flood events these channels act as run-off channels and typically open up. During low flow conditions, the channels and lagoon act as a tidal creek network and the channels typically narrow. The entrance channel is maintained through tidal exchange, which prevents alongshore sediment transport blocking the entrance (Figure 8.73).

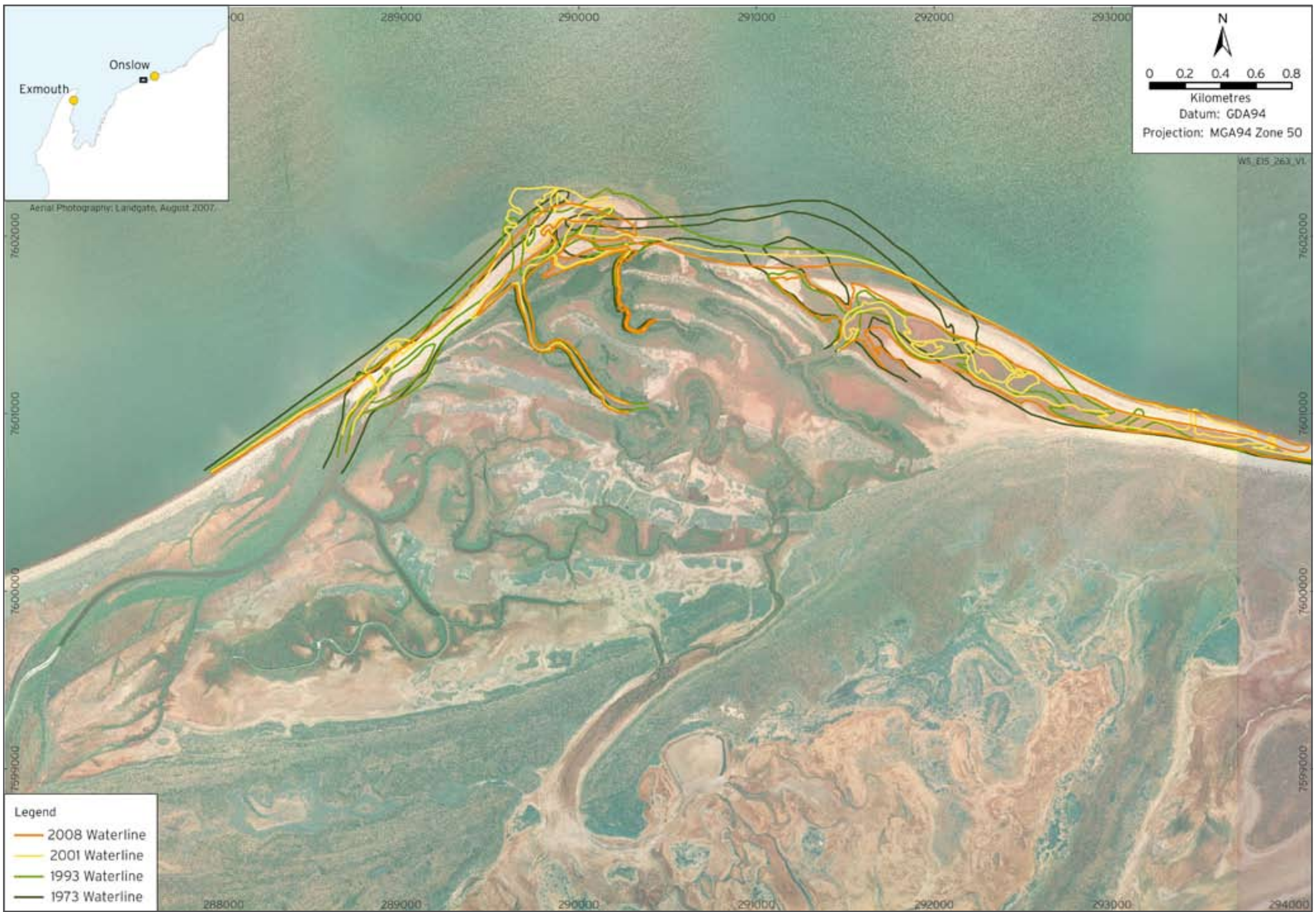


Figure 8.69: Shoreline Movements in the Vicinity of the East Ashburton River Delta

Internally, the tidal creek network redistributes sediment, balancing short-term fluctuations of hydrodynamic conditions.

The beaches between Hooley Creek and Beadon Point have been largely depositional over the available record of aerial imagery (1963-2009), with recovery occurring within approximately 5 years after tropical cyclone Vance caused approximately 20 m of shoreline erosion. The beach east of Four Mile Creek has high recreational value to the residents of Onslow.

Onslow Town Beach, between Beadon Point and Beadon Creek, has experienced significant change, including response to construction of a rock training wall with accumulation to the south and erosion to the north. A seawall has been constructed adjacent to the town site to limit the potential for storm erosion. This section of coast has been accreting as a whole, and Beadon Creek harbour requires maintenance dredging.

8.5.2.2 Geological Heritage

The significance of coastal features and the geological heritage of the deltaic complex of the Ashburton River relates to the degree to which the landforms:

- Collectively and individually provide essential life services

  and/or

- Are recognised by experts within geological disciplines for inclusion within the Register of the National Estate (Australian Heritage Commission 1990).

These landforms may include a suite of geologic features comprising the shoreface, coastal dunes, chenier plains, mudflats, upper deltaic floodplains and palaeochannels. Assessment of the value of geologic and geomorphologic features from a geological heritage perspective is a function of scale and geographic distribution, as well

Figure 8.70: Features near the Hooley Creek Tidal Complex

as perceived cultural significance. These features may also give insight into the evolution of the delta and coastal stability.

Biogeography of the system with its old shell taxa is also of considerable scientific interest as well as of potential engineering interest in terms of landscape stability. This contrasts with the younger components of recent chenier development on the eastern delta. The range of species preserved is of considerable biogeographic interest as the features provide an understanding as to the development of modern reef forms. Additionally, the complexity in the range of materials and landforms of the ancient shoreline, away from the reef system, provides a record of extreme events in the region.

Features specific to the Project area include:

- High level wrack (shell) on the western section of the coastal dune ridge deposited by a 700 year old storm or tsunami event. Similar deposits have been observed elsewhere along the dunes between Turbridgi Point and Onslow
- A Last Interglacial event shoreline, as identified through radiometric analyses of in-situ coral outcrops (Damara WA 2010 in prep.)
- Rock platforms adjoining islands on mudflats between Urala Station and landward of Weld Island, and rock platforms abutting lithified cheniers on the eastern delta of the Ashburton River
- Pleistocene shorelines on Urala Station and the mainland, east of Direction Island.

8.5.3 Assessment Framework

While no relevant assessment framework for coastal processes exists at a State or Commonwealth level, several State Policies exist. The Department of Planning (DoP: formerly the Department of Planning and Infrastructure [DPI]) *State Coastal Planning Policy* – State Planning Policy (SPP) No. 2.6 (WAPC 2003a) and the Department of Transport (DoT) (formerly the DPI) *Coastal Protection Policy for Western Australia* (DPI 2006) both address coastal development. The form, location and quality of coastal structures that influence erosion, such as harbour breakwaters, are controlled under the *Jetties Act 1926*. It is also likely that potential changes to coastal processes may be considered in relation to coastal habitats, under the EP Act (WA) (EAG No. 3, EPA 2009d; GS 1, EPA 2001).

The strictly coastal nature of the Project infrastructure determines that the Project is outside the categories of development for which development setback requirements apply through SPP No. 2.6. However, the objectives of the Policy will continue to apply. These are to:

- Protect, conserve and enhance coastal values, particularly in areas of landscape, nature conservation, indigenous and cultural significance
- Provide for public foreshore areas and access to these on the coast
- Ensure the identification of appropriate areas for the sustainable use of the coast for housing, tourism, recreation, ocean access, maritime industry, commercial and other activities
- Ensure that the location of coastal facilities and development takes into account coastal processes including erosion, accretion, storm surge, tides, wave conditions, sea level change and biophysical criteria. (WAPC 2003a: 2064).

The Coastal Protection Policy (DPI 2006) does not have a firm legislative basis. However, it provides detailed interpretation of the SPP 2.6 (WAPC 2003a) and gives a clear policy context for DoT advice to the EPA, which is often sought for similar coastal development projects. The Coastal Protection Policy (DPI 2006) reads:

9.5 Sand Bypassing of Maritime Developments

The natural supply of littoral sand is a resource shared by all West Australians. Accordingly, those benefiting from future works or developments that change the natural supply of that sand along the coast shall compensate for the change to that supply by:

> *9.5.1 the operators of ports or boat harbours or the waterway managers of canal estates being responsible for funding and carrying out artificial sand bypassing of the interrupted supply;*
>
> *9.5.2 the party that best represents the majority of beneficiaries of other navigable ocean entrances being responsible for the funding of sand bypassing; and*
>
> *9.5.3 the sand bypassing works at least replicating the natural net annual cycle, unless an alternative regime can be shown to provide greater benefit to downdrift interests.*

For existing developments where the natural littoral drift of sand has been interrupted and where there has been no formal requirement for bypassing, negotiations will be held with the parties who best represent the majority of beneficiaries of those developments to seek a contribution to any sand bypassing which is now needed to preserve the downdrift coastlines.

8.5.4 Consequence Definitions

To enable assessment of risks associated with the Project, specific consequence definitions were developed. Table 8.49 provides the consequence definitions that have been used in the risk assessment of coastal processes.

8.5.5 Impact Assessment and Management

Impacts to the coastal environment, through changes in coastal processes, will occur to some extent as a result of Project activities. The following sections summarise the aspects and activities that may directly and indirectly affect coastal processes in, and surrounding, the Project area. Chapter 7, *Impact Assessment and Methodology* contains the risk matrix used to assess the likelihood and consequence of the impacts occurring. The potential impacts and the management measures to be implemented to be implemented are discussed in detail. Table 8.50 in Section 8.6.7 provides a summary of the potential impacts, management and mitigation measures and residual risk to the coastal environment as a result of changes in coastal processes, resulting from Project activities. The aspects which are considered in this section include:

- The formation of fixed nearshore infrastructure (MOF, Figure 8.71)
- Interruption of alongshore littoral transport and change to the hydrodynamics of the Hooley Creek tidal complex system through placement of onshore infrastructure.

Table 8.49: Consequence Definitions for the Physical Marine Environment

Marine						
	1	2	3	4	5	6
	Catastrophic	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Coastal Processes	• Regional loss of a unique landform and/or habitat and generation of substantial regional coastal instability • Massive intervention required to mitigate adverse effects leading to secondary environmental impacts	• Regional loss of well represented landform and/or habitat • Substantial damage to locally unique landform • Recurrent intervention required to mitigate adverse effects leading to secondary environmental impacts	• Major localised loss of a well represented landform and/or habitat • Intervention required to mitigate adverse effects leading to secondary environmental impacts	Localised loss of well represented landform and/or habitat	• Minor disturbance of well represented landform and/or habitats • Localised coastal re-adjustment	No measurable changes to coastal processes, landforms or habitats

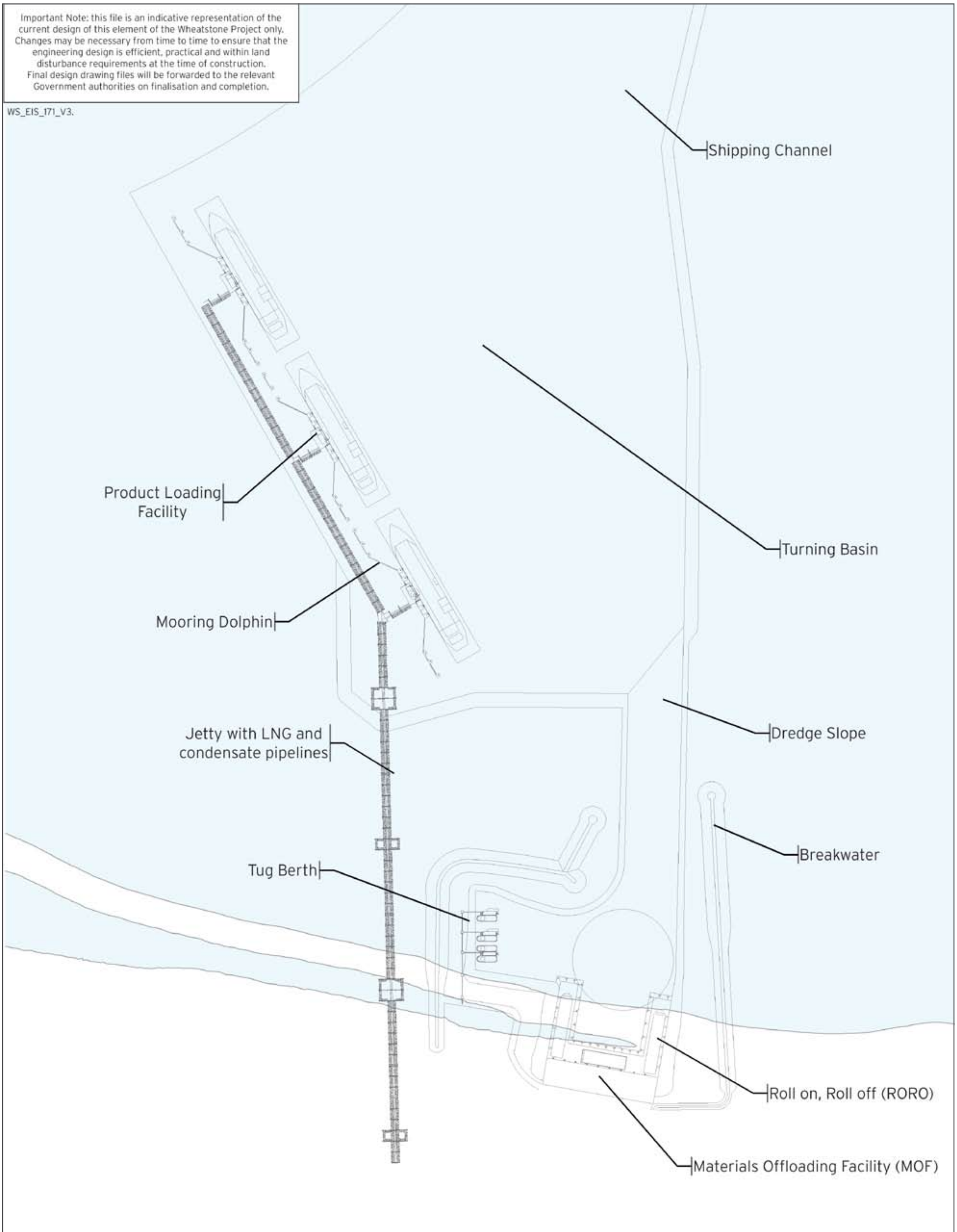


Figure 8.71: Conceptual Design of the Projects Onshore and Nearshore Infrastructure

The proposed MOF breakwaters and dredged navigation channel provide an interruption to shoreface sediment transport patterns, particularly close to the coast. Modelling results suggest that the MOF will block all littoral sediment transport, with the limited amount that may pass over the top of the breakwaters becoming trapped in the dredge navigation channel (DHI 2010, Appendix P2). Damara WA (2010, Appendix P1) identified the following potential impacts to coastal erosion and siltation processes:

- Construction of the proposed MOF and breakwaters will cause a "near-field" impact, developed through sedimentation within the capture zones of the proposed facility. Some accretion is likely to occur on either side of the MOF, with a greater volume accreting on the western side. This accretion will be more rapid than long-term rates of littoral drift, and is counterbalanced in the short term by erosion from the adjacent coast, which may cause destabilisation of the outer chenier adjacent to the Ashburton eastern delta.
- Interruption of ongoing littoral drift is likely to cause updrift accretion on the western side and downdrift erosion on the eastern side of the MOF, modulated by seasonal, inter-annual and episodic fluctuations in the direction of sediment transport (Damara WA 2010, Appendix P1). This may be partially mitigated through sand management, although the discrete nature of such works, either spatially or temporally, is likely to affect the coastal dynamics and increase local shoreline variability.
- The effect of wave sheltering adjacent to the Hooley Creek tidal spit will produce a local imbalance in sediment transport and is likely to cause erosion of the spit. Marginal increase in the water level exchange through to Hooley Creek West is anticipated due to the more open entrance, including exposure to greater wave action.

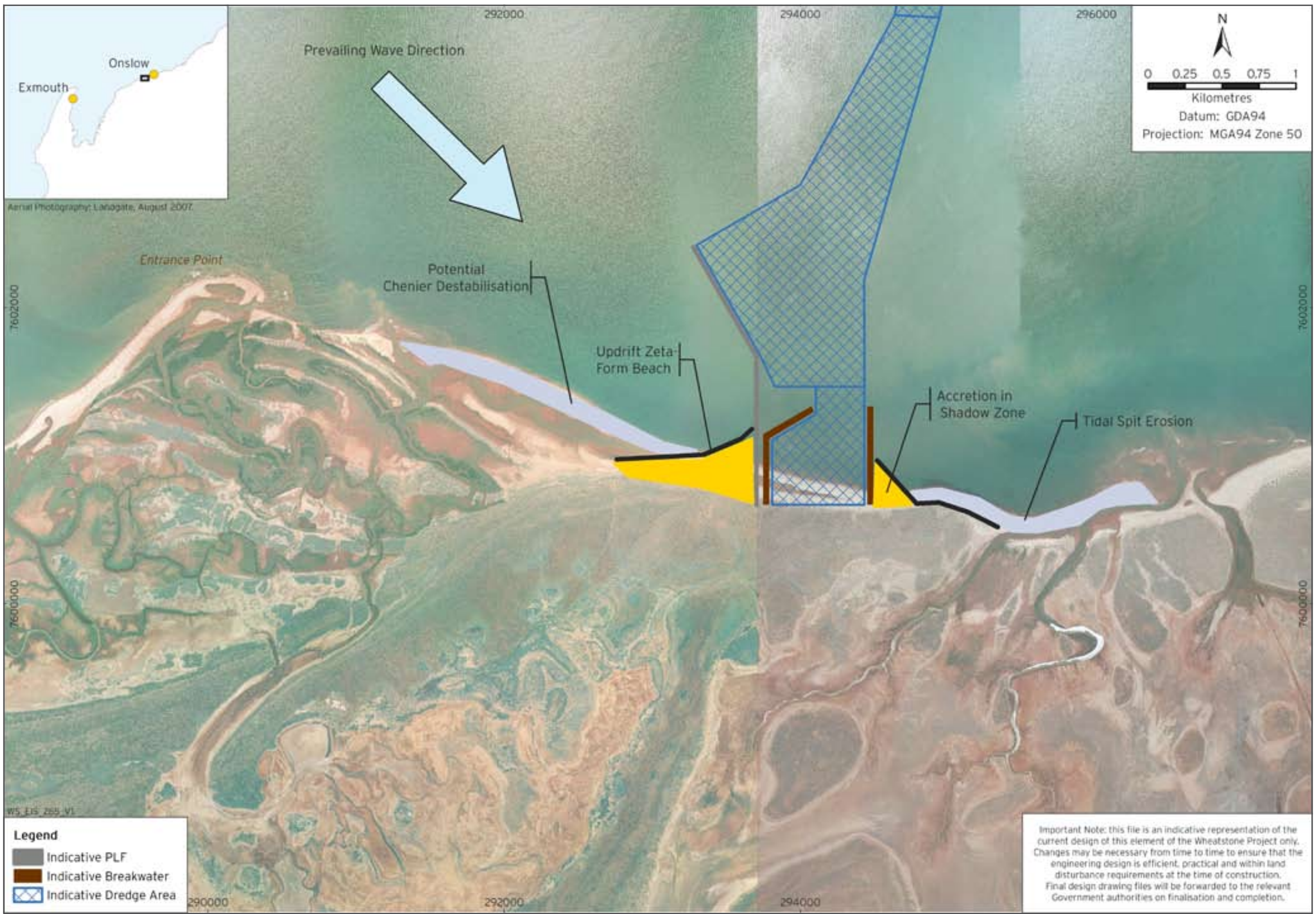


Figure 8.72: Shoreline Effects Caused by the Presence of MOF Breakwaters

- Deeper waters provided by the dredged navigation channel will provide a trap for any sediment bedload transport passing in either direction. This accumulation may be managed by incorporating siltation allowances in the design and undertaking maintenance dredging.

These findings are further supported by modelling outcomes confirming the accretion of sediment on the west of the MOF and a slight erosive trend on the east of the MOF, with limited erosion occurring on the west side in winter (DHI 2010a, Appendix P2). A further outcome of modelling indicates that, post-construction, development of a sediment "sink" on the west side of the MOF may cause erosion up to 1 km further west of the area, potentially impacting on the spit.

The potential adverse impacts associated with disruption of the non-cyclonic littoral drift have been considered for the main coastal units between Ashburton Delta and Onslow.

8.5.5.1 Construction of Nearshore Infrastructure

Interruption of the Non-cyclonic Littoral Sediment Path

Alteration of the entrance regime of Hooley Creek

Residual risk to environmental values from changes to the entrance regime of Hooley Creek through interruption of non-cyclonic littoral transport is	**Medium**

The morphology of the entrance of Hooley Creek is determined through the interaction of rainfall run-off, tidal exchange and alongshore sediment supply (Figure 8.73, Damara WA 2010, Appendix P1). As the entrance is located immediately east of the MOF breakwaters, it will experience downdrift erosion caused by interruption of the net non-cyclonic littoral drift. Due to the complex and dynamic nature of the entrance, change is likely to occur regardless of the strategy adopted for sand management. Without sand supply from the east, the existing spit would erode over approximately 5–10 years, with a more narrow spit likely to form from the eastern side of the entrance that varies in length on a seasonal basis.

Erosion of the existing spit will reduce the amount of wave protection to the mouth of Hooley Creek and the seaward fringing mangroves. Under cyclone conditions, this may result in localised erosion of shoreline mangroves. It should be noted that the spit is a very dynamic feature which has grown and deflated on many occasions over the past 30 years (Damara WA 2010, Appendix P1).

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.50, it is possible that the construction of the MOF breakwaters will result in impacts to the entrance regime of Hooley Creek. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Moderate" consequence, due to the disruption of alongshore sediment supply potentially leading to localised loss of a well represented spit landform, and "Likely" occurrence, due to the placement of the MOF breakwaters.

Erosion of Sunset Beach

Residual risk to amenity values from erosion of Sunset Beach through interruption of non-cyclonic littoral transport is	**Low**

Sunset Beach provides high recreational value to the Onslow community for fishing and four wheel driving. A number of Indigenous heritage sites are located behind the primary dunes, and hence will be automatically protected if the recreational value is preserved.

Sunset Beach is east of the MOF breakwaters and therefore likely to experience reduced sediment supply. Structural control at Beadon Point limits the potential for erosion as a direct result of reduced sand supply. However, the lack of supply limits recovery following storm erosion and will lead to gradual, episodic shoreline retreat unless mitigated.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.50, it is possible that the construction of the MOF breakwaters will result in erosion of Sunset Beach. The residual environmental risk for this potential impact was assessed as being "Low" – of "Minor" consequence, arising from localised coastal re-adjustment, and of "Possible" likelihood, due to the presence of the MOF breakwaters preventing the natural nourishment of the beach structure.

Figure 8.73: Hooley Creek Entrance Bar and Creek System

Erosion of Onslow Town Beach

Residual risk to recreational values from erosion of Onslow Town Beach through interruption of non-cyclonic littoral transport is	**Low**

Onslow Town Beach is located immediately in front of the town site and provides high recreational value for the community. As the beach is east of the MOF breakwaters, it is likely to experience reduced sediment supply. The structurally controlled nature of this beach determines that a loss of supply would not cause erosion, but could limit the rate of the beach to recover after a storm event.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.50, it is possible that the construction of the MOF breakwaters will reduce the rate at which the beach can recover, following a storm event. The residual environmental risk for this potential impact was assessed as being "Low" – of "Moderate" consequence, due to possible localised loss of a well represented landform, and of "Possible" likelihood, due to the presence of the MOF breakwaters slowing the rate at which the beach would recover following a storm event.

Destabilisation of Ashburton East Chenier

Residual risk to environmental values caused by destabilisation of Ashburton East Chenier through non-cyclonic littoral transport is	Low

The easternmost chenier of the Ashburton River delta is west of the MOF breakwaters and therefore the MOF breakwaters are likely to have negligible effect on ongoing sediment transport. However, during the construction phase and shortly afterwards, sediment accumulation immediately adjacent the western breakwater will cause erosion that may potentially destabilise the eastern chenier. This is further supported by modelling work, indicating that erosion of the chenier could occur up to 1 km to the west (DHI 2010a, Appendix P2). During the construction phase, it is proposed to maintain the integrity of the chenier by sand nourishment if required.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.50, it is possible that, following construction of the MOF breakwaters, near-field erosion may occur to the west of the MOF breakwaters. The residual environmental risk for this potential impact was assessed as being "Low" – of "Major" consequence, due to the localised change of the chenier landform, and of "Unlikely" occurrence.

Interruption of the Cyclonic Littoral Sediment Path

Alteration of the entrance regime of Hooley Creek

Residual risk to environmental values from changes to the entrance regime of Hooley Creek through interruption of cyclonic littoral transport is	Medium

As the entrance to Hooley Creek is located eastward of the MOF breakwaters, eastward downdrift erosion will cause massive change to the entrance morphology in the event of a significant cyclone. Similar impacts have occurred over an historic period, with limited damage resulting to the mangrove community due to protection provided by the entrance spit.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.50, it is possible that construction of nearshore infrastructure will interrupt the littoral sediment transport path during cyclonic events. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Moderate" consequence, due to the expected alteration of Hooley Creek entrance morphology from downdrift erosion, and of "Likely" occurrence.

Erosion of Sunset Beach

Residual risk to amenity values from erosion of Sunset Beach through interruption of cyclonic littoral transport is	Low

As Sunset Beach is located to the east of the Project area, some downdrift erosion during a cyclone event may produce strong eastwards transport. As the majority of downdrift erosion will occur in close proximity to the MOF breakwaters, the impact on Sunset Beach will only be slightly greater than the present situation.

Approximately 20 m of beach was eroded during tropical cyclone Vance, suggesting that the existing beach is sufficiently wide to withstand severe cyclone impact, and to recover. However, as identified above, the breakwaters are expected to slow the rate of recovery after an erosion event.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.50, it is possible that construction of nearshore infrastructure will interrupt the littoral sediment transport path during cyclonic events. The residual environmental risk for this potential impact was assessed as being "Low" – of "Minor" consequence, arising from localised coastal re-adjustment, and of "Likely" occurrence.

Erosion of Onslow Town Beach

Residual risk to recreational values from erosion of Onslow Town Beach through interruption of cyclonic littoral transport is	Medium

The effects of downdrift erosion due to the presence of the MOF breakwaters are unlikely to reach Onslow Town Beach. However, as identified above, interruption of the non-cyclonic littoral transport path will slow beach recovery following an erosion event. Approximately 20 m of beach was eroded during tropical cyclone Vance, suggesting that the existing beach is sufficiently wide to withstand severe cyclone impact, and to recover. However, the Onslow seawall provides back-up protection against storm erosion.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.50, it is possible that construction of nearshore infrastructure will interrupt the littoral sediment transport path during cyclonic events. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Moderate" consequence, due to the localised loss of well represented landform, and of "Likely" occurrence, as tropical cyclones and other storm surge events occur infrequently in the region.

Destabilisation of Ashburton East Chenier

Residual risk to environmental values caused by destabilisation of the Ashburton East Chenier through cyclonic littoral transport is	**Medium**

As the Ashburton River east chenier is located to the west of the MOF breakwaters, downdrift erosion may focus on the chenier under cyclonic pressure, causing strong westerly sediment transport. The chenier presently protects the eastern margin of the Ashburton River delta mangrove community. Although limited erosion was observed during tropical cyclone Vance, it is estimated that erosion in the order of 20 to 30 m could be expected during a severe tropical cyclone event, and an equivalent buffer would need to be maintained to manage cyclonic impact on the mangroves.

Given the recent and unstable nature of the chenier system over the historic record (1963-2009), the need for artificial management of cyclone induced modifications to the chenier is questionable.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.50, it is possible that construction of nearshore infrastructure will interrupt the littoral sediment transport path during cyclonic events. The residual environmental risk for this potential impact was assessed as being "Medium" – of "Major" consequence, arising from major localised loss of a well represented habitat, and "Possible" likelihood, due to the potential for erosion to the chenier during infrequent cyclonic events.

8.5.5.2 Construction of Onshore Infrastructure

Disruption of fluvial pathway

Ashburton River channel avulsion

Residual risk to environmental values due to avulsion of the Ashburton River channels is	**Very Low**

The geomorphology of the wider Ashburton River floodplain indicates that the river has experienced significant changes in flow path. Damara WA (2010, Appendix P1) identified a large number of palaeochannels across the floodplain, including a channel that presently acts as a breakout for the Ashburton River channel, flowing into the south-west end of the Hooley Creek tidal complex. Changes that reduce the hydraulic resistance offered by this pathway will increase the proportion of flow through the breakout, and consequently may expand the channel. A channel forming flood requires extreme rainfall run-off.

Possible changes that may occur due to the construction of the MOF and onshore infrastructure, reducing hydraulic resistance of the breakout pathway, include:

- The opening up of the Hooley Creek entrance due to reduced littoral transport
- The focusing of flow (into channels) on the Hooley Creek lagoon mudflats
- The increase in flood flows if alternative channels are reduced or cut off due to the access road and plant earthworks.

Although it is possible that each of these changes could occur, river channel avulsion requires all of them to occur, along with a more significant channel to be established across the breakout basin. This sequence of events is considered to be unlikely to occur. The effect of the access road on surface water drainage during flood events has been modelled and shown to be minor for floods up to 1:25 ARI (URS 2010f, Appendix G1).

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.50, it is possible that construction of onshore infrastructure will disrupt the fluvial pathway, resulting in channel avulsion. The residual environmental risk for this potential impact was assessed as being "Very Low" – of "Minor" consequence, due to the potential for current channel widening during high flow events, and of "Unlikely" occurrence, as all three forms of hydraulic resistance would need to coincide for avulsion to occur.

Increased Flows through Channel (includes drainage)

Reactivation of Palaeochannels

Residual risk to environmental values from reactivation of palaeochannels by tidal creek incursion is	**Very Low**

The Hooley Creek tidal complex presently acts as a breakout pathway for floodwaters of the Ashburton River, under extreme events. The low gradient of the tidal flats and small channels presently provides strong hydraulic resistance, which limits the proportion of floodwaters that pass through the breakout. Reduction of hydraulic resistance, caused by the expanding of tidal channels, may increase the proportion of floodwaters passing through the Hooley Creek complex. During a strong flood, rapid channel expansion may result, as occurred at Exmouth following the construction of the Exmouth Boat Harbour and heavy rainfall events (Martens *et al*. 2000).

The Hooley Creek tidal complex already demonstrates some capacity to adjust to changing hydrodynamics through erosion and deposition at its headwaters. Focusing of run-off flooding, including site drainage, may result in creek expansion if directed down a single channel. The residual palaeochannel in close proximity to the proposed site (Hooley Creek East) provides a likely pathway for expansion, as it is likely to contain less cemented sediments. Therefore Hooley Creek East is likely to expand landward, thereby providing additional habitat suitable for colonisation by mangroves.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.50, it is possible that construction of onshore infrastructure will result in increased flow through Hooley Creek East, resulting in the landward extension of existing tidal creek channels. The residual environmental risk for this potential impact was assessed as being "Very Low" – of "Minor" consequence, arising from redistribution of tidal flat habitats due to the potential for additional flood waters widening the creek complex, and of "Unlikely" occurrence.

8.5.5.3 Excavation of Borrow Pits

Loss of Geological Heritage Features

Residual risk to geological heritage values due to borrow pit excavation is	**Low**

Features of geological heritage significance, specific to the Project area, include high level wrack, a Last Interglacial event shoreline, and Pleistocene shorelines on Urala Station and the mainland, east of Direction Island. These features are determined to be valuable due to information they provide on ancient shoreline development and stability. While it is unlikely that geological heritage features (e.g. high level wrack) will be affected by changes to coastal processes, remnant fossilised coral platforms are potentially at risk due their location on three of the proposed borrow pits.

Summary

Following the implementation of appropriate management (and contingency plans) presented in Table 8.50, it is possible that excavation of onshore islands for use as borrow pits will result in the loss of sites of geological heritage significance. The residual environmental risk for this potential impact was assessed as being "Low" – of "Major" consequence, as the geological features in the Project area are significant indicators of ancient shoreline movement and stability, and of "Unlikely" occurrence, as the application of appropriate mitigation measures during borrow pit excavation should protect these features.

8.5.6 Implications for Matters of National Environmental Significance

There are no matters of NES directly attributable to coastal processes.

8.5.7 Residual Risk Summary

The following table (Table 8.50) provides a summary of the aspects, activities and potential impacts to the coastal environment as a result of alteration of coastal processes through the construction and operation of onshore and nearshore infrastructure. Indicative management and mitigations measures are also listed, along with the residual risk following the implementation of the proposed management and mitigations measures.

Where applicable, reference has been made to the Proposed Coastal Processes Management OBCs (Chapter 12, *Environmental Management Program*). These OBCs have been developed in alignment with the EPA's EAG 4 (EPA 2009f).

Figure 8.74: Location of Geological Heritage Sites on Borrow Pit Islands

Table 8.50: Summary of Management Measures and Residual Risk for Coastal Processes

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Construction of nearshore infrastructure							
Interruption of the Non-cyclonic Littoral Sediment Path							
	Alteration of entrance regime of Hooley Creek	Refer to CPMP for complete list of mitigation measures. Refer to Chapter 12, *Environmental Management Program* for Proposed Coastal Processes Management OBCs. Design: Manage construction and operation activities to reduce, as far as practicable, nearshore infrastructure-attributable impacts on the physical integrity and functionality of coastal processes at Hooley Creek. Mitigate: Mitigation will be instigated to maintain the integrity of the entrance regime of Hooley Creek if it is determined that the nearshore infrastructure, not a natural agent of disturbance, was the cause of the destabilisation. Mitigate: Mitigation measures may include sand management consisting of nourishment of the features. (Nourishment is the process of placing or pumping sand from elsewhere onto an eroding feature to reshape the existing beach). Monitor: Adaptive monitoring program to monitor changes to the spit width at Hooley Creek and all entrance bars from Ashburton River entrance to Beadon Creek. Report: The Proponent to prepare an annual coastal processes monitoring report. This report shall be made available to relevant agencies.	4	2	**Medium**	**Reasonable** Available information is adequate	Not applicable.

	Erosion of Sunset Beach	Refer to CPMP for complete list of mitigation measures. Design: Manage construction and operation activities to reduce, as far as practicable, nearshore infrastructure-attributable impacts on the physical integrity of coastal processes and functionality at Sunset Beach. Mitigate: Mitigation will be instigated to maintain the integrity of Sunset Beach if it is determined that the nearshore infrastructure, not a natural agent of disturbance, was the cause of the erosion. Mitigation measures may include beach nourishment. Monitor: Adaptive monitoring program to monitor changes to beach profile and width. Report: The Proponent to prepare an annual coastal processes monitoring report. This report shall be made available to relevant agencies.	5	3	**Low**	**Reasonable** Available information is adequate	Not applicable.
	Erosion of Onslow Town Beach	Refer to CPMP for complete list of mitigation measures. Design: Manage construction and operation activities to reduce, as far as practicable, nearshore infrastructure-attributable impacts on the physical integrity of coastal processes and functionality at Sunset Beach. Mitigate: Mitigation will be instigated to maintain the integrity of Sunset Beach if it is determined that the nearshore infrastructure, not a natural agent of disturbance, was the cause of the erosion. Mitigation measures may include beach nourishment. Monitor: Adaptive monitoring program to monitor changes to beach profile and width. Report: The Proponent to prepare an annual coastal processes monitoring report. This report shall be made available to relevant agencies.	4	3	**Low**	**Reasonable** Available information is adequate	Not applicable.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
	Destabilisation of Ashburton East chenier	Refer to CPMP for complete list of mitigation measures. Refer to Chapter 12, *Environmental Management Program* for Proposed Coastal Processes Management OBCs. Design: Manage construction and operation activities to reduce, as far as practicable, nearshore infrastructure-attributable impacts on the physical integrity and functionality of coastal processes at the East Ashburton Delta. Design: Manage the volume of potential updrift capture of sediments on the west side of the MOF breakwaters. Mitigate: Mitigation will be instigated to maintain the integrity of the Ashburton East chenier if it is determined that the nearshore infrastructure, not a natural agent of disturbance, was the cause of the destabilisation. Mitigate: sand management consisting of nourishment of the chenier (nourishment is the process of placing or pumping sand from elsewhere onto an eroding feature to reshape the existing beach). Monitor: Adaptive monitoring program to monitor changes to Ashburton East chenier width. Report: The Proponent to prepare an annual coastal processes monitoring report. This report shall be made available to relevant agencies.	3	4	**Low**	**Reasonable** Available information is adequate	Not applicable.

Interruption of the Cyclonic Littoral Sediment Path							
	Alteration of entrance regime of Hooley Creek	Refer to CPMP for complete list of mitigation measures. Refer to Chapter 12, *Environmental Management Program* for Proposed Coastal Processes Management OBCs. Design: Manage construction and operation activities to reduce, as far as practicable, nearshore infrastructure-attributable impacts on the physical integrity and functionality of coastal processes at Hooley Creek. Mitigate: Mitigation will be instigated to maintain the integrity of the entrance regime of Hooley Creek if it is determined that the nearshore infrastructure, not a natural agent of disturbance, was the cause of the destabilisation. Mitigate: Mitigation measures may include sand management consisting of nourishment of the features. Monitor: Adaptive monitoring program to monitor changes to the spit width at Hooley Creek and all entrance bars from Ashburton River entrance to Beadon Creek. Report: The Proponent to prepare an annual coastal processes monitoring report. This report shall be made available to relevant agencies.	4	2	**Medium**	**Reasonable** Available information is adequate	Not applicable.
	Erosion of Sunset Beach	Refer to CPMP for complete list of mitigation measures. Design: Manage construction and operation activities to reduce, as far as practicable, nearshore infrastructure-attributable impacts on the physical integrity of coastal processes and functionality at Sunset Beach. Mitigate: Mitigation will be instigated to maintain the integrity of Sunset Beach if it is determined that the nearshore infrastructure, not a natural agent of disturbance, was the cause of the erosion. Mitigation measures may include beach nourishment. Monitor: Adaptive monitoring program to monitor changes to beach profile and width. Report: The Proponent to prepare an annual coastal processes monitoring report. This report shall be made available to relevant agencies.	5	2	**Low**	**Reasonable** Available information is adequate	Not applicable.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
	Erosion of Onslow Town Beach	Refer to CPMP for complete list of mitigation measures. Design: Manage construction and operation activities to reduce, as far as practicable, nearshore infrastructure-attributable impacts on the physical integrity of coastal processes and functionality at Sunset Beach. Mitigate: Mitigation will be instigated to maintain the integrity of Sunset Beach if it is determined that the nearshore infrastructure, not a natural agent of disturbance, was the cause of the erosion. Mitigation measures may include beach nourishment. Monitor: Adaptive monitoring program to monitor changes to beach profile and width. Report: The Proponent to prepare an annual coastal processes monitoring report. This report shall be made available to relevant agencies.	4	2	**Medium**	**Reasonable** Available information is adequate	Not applicable.
	Destabilisation of Ashburton East chenier	Refer to CPMP for complete list of mitigation measures. Refer to Chapter 12, *Environmental Management Program* for Proposed Coastal Processes Management OBCs. Design: Manage construction and operation activities to reduce, as far as practicable, nearshore infrastructure-attributable impacts on the physical integrity and functionality of coastal processes at the East Ashburton Delta. Design: Manage the volume of potential updrift capture of sediments on the west side of the MOF breakwaters. Mitigate: Mitigation will be instigated to maintain the integrity of the Ashburton East chenier if it is determined that the nearshore infrastructure, not a natural agent of disturbance, was the cause of the destabilisation. Mitigate: sand management consisting of nourishment of the chenier. Monitor: Adaptive monitoring program to monitor changes to Ashburton East chenier width. Report: The Proponent to prepare an annual coastal processes monitoring report. This report shall be made available to relevant agencies.	3	3		**Reasonable** Available information is adequate	Not applicable.

Construction of onshore infrastructure							
Disruption of fluvial pathway							
	Ashburton River Channel Avulsion	Refer to CPMP for complete list of mitigation measures. Refer to Chapter 12, *Environmental Management Program* for Proposed Coastal Processes Management OBCs. Design: Manage construction and operation activities to reduce, as far as practicable, nearshore infrastructure-attributable impacts on the physical integrity and functionality of the fluvial pathway of the Ashburton River. Mitigate: Mitigation will be instigated to maintain the integrity of the fluvial pathway of the Ashburton River if it is determined that the nearshore infrastructure, not a natural agent of disturbance, was the cause of the disruption. Mitigate: Manage Project-attributable sedimentation during construction. Monitor: Channel cross-section monitoring. Report: The Proponent to prepare an annual coastal processes monitoring report. This report shall be made available to relevant agencies.	5	4	**Very Low**	**Reasonable** Available information is adequate	Not applicable.
Increased flows through channel (includes drainage)							
	Reactivation of palaeochannels	Refer to CPMP for complete list of mitigation measures. Design: Manage construction and operation activities to reduce, as far as practicable, nearshore infrastructure-attributable impacts on the physical integrity and functionality of the fluvial pathway of the Ashburton River. Monitor: Channel cross-section monitoring. Report: The Proponent to prepare an annual coastal processes monitoring report. This report shall be made available to relevant agencies.	5	4	**Very Low**	**Reasonable** Available information is adequate	Not applicable.

Aspect and Activity	Potential Impacts	Management and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Excavation of borrow pits.							
	Loss of geological heritage features.	Refer to CPMP for complete list of mitigation measures. Survey: Field surveys to be undertaken to confirm, where practicable, the geological heritage value of the Project area and identify features requiring protection. Mitigate: During borrow pit excavation, mitigation will be implemented to reduce potential impacts to, and to protect, these features as reasonably practicable.	4	4	**Low**	**Low** Survey data available from one expert.	Not applicable.
Additive Effects							
All construction and operation activities							
	The sum of all potential Project-attributable impacts from all Project phases and aspects.	See above for proposed management/mitigation measures. *NB: The risk ranking for Additive Effects is determined by the highest risk ranking for the coastal processes section.*	5	1	**Medium**	**Low** No modelling conducted on additive effects.	Not applicable.

8.5.8 Predicted Environmental Outcome

Although coastal processes hold no specific conservation value on their own, impacts causing change in coastal processes have the potential to impact conservation values of the nearby mangrove and algal mat communities. Coastal processes, including fluvial processes and longshore sediment transport, will still occur, albeit at a much slower rate.

The aspects described above have the potential to alter coastal processes, resulting in impacts to nearby ecological communities, in an additive manner. The conservative additive residual environmental risk to these communities as a result of Project-attributable impacts was assessed as being "Medium" – of "Minor" consequence, due to the interruption of coastal processes (cyclonic and non-cyclonic littoral sediment path, fluvial processes, longshore sediment transport, channel avulsion) and the potential for impact to geological heritage sites, and "Almost Certain" likelihood.

A CPMP (Appendix T1) will be developed and finalised prior to the commencement of Project construction. This Plan will, in part, provide a high level indication of how impacts to coastal processes will be managed. Additionally, it will specify the management and mitigation measures which will be implemented to limit Project-attributable impacts to coastal processes.

Proposed Coastal Processes Management OBCs have been developed for coastal processes, and are presented in Chapter 12, *Environmental Management Program*.

The CPMP (Appendix T1) and the OBCs should be read in conjunction with the summary management measures and residual risk table above (Table 8.50) for a complete understanding of potential management and mitigation measures under consideration for the Project.

9.0

Terrestrial Risk Assessment and Management

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9.1 Introduction

The semi-arid terrestrial environment of the proposed Wheatstone Project (Project) site contains soils and landforms that are relatively undisturbed by human activities, and are representative of soils and landforms in the region. The superficial groundwater aquifer is generally located near the ground surface, and is recharged with surface water during regular seasonal flooding events. The site also supports relatively intact, often sparse, communities of flora and fauna. Although the Project area is largely uncleared, its natural integrity has been degraded to some degree by the effects of vehicle access (public roads), pastoral grazing, weed invasion and predation by introduced species.

This chapter describes the potential impacts of the Project on the local and regional terrestrial environment. Factors of this environment include soil and landforms, groundwater, surface water, native vegetation, flora and fauna communities and air quality. This chapter discusses the design and management measures proposed to assist in reducing these impacts. An assessment of the effectiveness of these measures and the residual risk associated with construction, operation and decommissioning of the Project is also included.

Following guidance from the Environmental Protection Authority (EPA), a risk assessment was conducted on each aspect for each of the terrestrial factors (where applicable) listed in Table 9.1. Chapter 7, *Risk Assessment Methodology* provides details of the processes used in assessing the risks associated with development of the Project.

The predicted impacts, controls and residual risks from the Project for each of these environmental factors are discussed in the following sections. Aspects that have been identified as posing a higher risk to a factor are generally discussed in greater detail than those aspects that are expected to pose a lesser risk.

The key legislations for the factors listed in Table 9.1 are presented in Table 9.2. Additional legislation and guidelines relevant to specific factors or aspects are discussed in the following sections.

Development of the Project requires construction of the following terrestrial infrastructure:

- A gas processing and export facility, including 25 MTPA LNG processing facility and domestic gas processing plant, LNG and condensate product storage, power generation, water supply, waste disposal, and associated support facilities

Table 9.1: Terrestrial Environmental Factors and Aspects

Factors	Aspects
Soils and landforms (Section 9.2)	Clearing vegetation
Groundwater (Section 9.3)	Dust
Surface water (Section 9.4)	Fire
Flora and vegetation (Section 9.5)	Air emissions
Terrestrial fauna (Section 9.6)	Vehicular activity
Subterranean fauna (Section 9.7)	Construction earthworks
Air quality (Section 9.8)	Spills and leaks

Table 9.2: Legislation Relevant to Terrestrial Environment

Legislation or Guideline	Intent
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act [Cth])	This Commonwealth Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places – defined in the Act as matters of National Environmental Significance (NES).
Environmental Protection Act 1986 (EP Act [WA])	This Act provides for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment in Western Australia.
Wildlife Conservation Act 1950 (WC Act [WA])	This Act provides a legal framework to protect and manage flora and fauna in Western Australia.

- A multi-purpose infrastructure corridor (SIC), which will incorporate an access road to the site as well as the domestic gas pipeline connecting to the existing Dampier-to-Bunbury Natural Gas Pipeline (DBNGP)
- An accommodation village, access roads and supporting infrastructure.

Further descriptions of the above infrastructure and facilities are found in Chapter 2, *Project Description*.

9.2 Soils and Landforms

The following sections present the assessment of impacts on terrestrial soils and landforms associated with the Project, taking into account design modifications, mitigation methods and controls applied to reduce impacts.

9.2.1 Management Objective

The EPA objective for this assessment is to maintain the integrity, ecological functions and environmental values of soils and landforms.

9.2.2 Description of Factor

The baseline characteristics of the receiving terrestrial environment were assessed through studies described in Chapter 6, *Overview of Existing Environment*, and in the technical report, included as Appendix H1. Sources of data included:

- Site investigations into the natural soils and landform environment within the terrestrial assessment area
- A desktop literature review
- Interpretation of aerial photography.

For the purpose of describing soil and landforms for the terrestrial assessment area, the study areas are referred to as Ashburton North and surrounds, the SIC, accommodation village, domgas pipeline route, and construction study areas.

9.2.2.1 Land Systems

A series of seven land systems were identified within the boundaries of the terrestrial assessment area and include the Onslow, Littoral, Dune, Minderoo, Girala, Stuart and Uaroo land systems.

9.2.2.2 Landforms

Eleven major landform units have been described within the terrestrial assessment area. An assessment of landform significance for the terrestrial assessment area was based on the identification of landforms comprising conservation values significant for the Pilbara region. No current landforms of significance were identified within the terrestrial assessment area.

9.2.2.3 Soils

There are three major identifiable soil types encountered in the shallow soil profile for Ashburton North and surrounds and of the SIC study area (note that intrusive works had not been completed for the accommodation village, domgas and construction study areas). These three soil types are red earths, marine/organic deposits and calcareous sands/rock.

A soil erosion assessment for the various landform units and associated soil types found within the terrestrial assessment area identified three landform units (the fringing and coastal dunes, the longitudinal dunes and interdunal swales, and mainland remnant dunes) that have a high potential for wind and water erosion when disturbed.

Field dispersion tests were conducted on surface and subsurface clayey soil samples with the objective of determining soil characteristics across appropriate soil types. In summary, red brown clay and/or clayey soils generally slake (slightly) but are non dispersive (Class 4, 5 or 6). Brown to grey clay identified within Ashburton North and surrounds was generally identified as potentially dispersive (Class 3).

9.2.2.4 Heavy Metal Assessment

As part of the soils and landforms studies, an assessment of metal concentrations was conducted on shallow soils (approximately 3 m below ground level [mbgl]) considered representative of the soil types and landforms encountered. The objective of the assessment was to determine baseline metal concentrations. A range of heavy metals were identified, with the concentrations being considered representative of background conditions given the absence of human induced disturbance within the terrestrial assessment area, the distance from the Onslow Salt operations and based on a comparison with other North West coast deltaic systems within the Pilbara region (Oceanica 2005).

Based on a review of the levels against published human health threshold levels, the background concentration of metals are not considered to pose an adverse risk to human health. Although some metal concentrations exceeded the relevant ecological threshold values, these metals are naturally occurring in the area and therefore will not pose an unacceptable risk to ecological receptors.

9.2.2.5 Potential Acid Sulfate Soils

The results of the intrusive works completed as part of the soils and landforms assessment demonstrate that potential acid sulfate soils (PASS) are present at shallow depths ranging between 0.5 mbgl and 4.5 mbgl with a thickness ranging between 0.2 m and 3.5 m (see Section 6.4.4.2). PASS exists predominantly along the north-eastern extent of the terrestrial assessment area.

Soil profiles indicative of PASS material are considered to be of marine/organic origin and are generally located within landform units associated with the intertidal flats, tidal creek and mangrove swamp, the samphire flats and supratidal salt flats. PASS was also reported in the underlying marine/organic deposits of the alluvial/colluvial plains, and fringing and coastal dunes of Ashburton North and surrounds. It is believed that these shallow marine/organic deposits may be associated with the bordering Ashburton River delta and the Hooley Creek catchment that underlies this landform unit as what has been identified as a chenier formation.

The acid neutralising capacity (ANC) for soils of Ashburton North and surrounds and the SIC study area is generally high; however, ANC is typically absent in soil profiles identified as PASS. Soils with the highest ANC throughout Ashburton North and surrounds generally comprised of sands and sand clays with shell, limestone and/or sandstone interbedded throughout. ANC of the SIC study area was significantly lower with highest buffering capacity detected in the red clayey sands. Where net acidity concentrations in exceedence of the adopted action criteria were reported, corresponding ANC concentrations were nonexistent or negligible.

Based on the findings of the soils and landforms assessment a PASS map was produced identifying areas of low, moderate and high risk for PASS for the terrestrial assessment area. The PASS map was produced based on the understanding that high to moderate risk for PASS is classified as material within 3 m of natural soil surface that could be disturbed by most land development activities (DEC 2009).

High risk areas have been delineated in the north-eastern extent of Ashburton North and surrounds. There is a moderate risk of intercepting PASS (assuming incidental excavation for these areas) for landform units associated with the samphire flats and the supratidal salt flats where PASS was typically located at shallow depths. These areas are generally within Ashburton North and surrounds and incidentally within the SIC and accommodation village study areas.

There is considered to be low to no PASS associated with the longitudinal dune network of Ashburton North and surrounds, where soils are typically of terrestrial origin and contain significant authigenic carbonates (formed in-situ) and of the coastal dunes located to the east of the Ashburton River delta. The domgas corridor study area and the majority of the SIC study area are also considered low to no risk areas for PASS.

9.2.3 Assessment Framework

Relevant assessment frameworks for soils and landforms exist at Commonwealth and State levels. Specific policy and framework documents relating to soils and landforms are identified in Table 9.3.

9.2.4 Consequence Definitions

To enable assessment of risks associated with the Project, specific consequence definitions were developed. Table 9.4 provides the consequence definitions that have been used in the risk assessment of soils and landforms.

9.2.5 Impact Assessment and Management

Impacts to soils and landforms will occur as a result of Project activities. The following sections summarise the aspects and activities that may directly or indirectly affect soils and landforms in, and surrounding, the Project area. Chapter 7, *Impact Assessment Methodology* contains the risk matrix used to assess the likelihood and consequence of impacts occurring. Potential management and mitigation measures are generally provided in greater detail for those aspects that have been identified as posing a higher risk to a factor than those aspects that are expected to pose a lesser risk. Table 9.5 in Section 9.2.7 provides a summary of the potential impacts, management measures and residual risk as a result of Project activities.

The methodology for the assessment of the risk to the soils and landforms environment from the Project is based on:

- Development of PASS risk map based on information collected as part of the soils and landform survey (Section 6.4.4.2)
- Delineation of the approximate vertical and horizontal extent of PASS to enable appropriate management of this material. The approximate vertical and horizontal extent for PASS along Ashburton North and surrounds is illustrated in Appendix H1
- Characterising landforms with regard to potential for erosion, using criteria adopted from van Gool et al. (2005)

Table 9.3: Legislation and Guidelines Relevant to Soils and Landforms

Legislation or Guideline	Intent
EPA Position Statement No. 5	EPA Position Statement No. 5, "Environmental Protection and Ecological Sustainability of the Rangelands in Western Australia" (EPA 2004), outlines the environmental attributes and values of rangelands, their pressures and environmental condition, management issues, principles and objectives for the environmental protection and ecological sustainability of the rangelands and management responses required. This Position Statement identifies grazing, horticulture (in the floodplains), fire, feral animals and weeds, mining and climate change as pressures on the rangeland environment.
EPA Guidance Statement No. 6	EPA Guidance Statement No. 6, "Rehabilitation of Terrestrial Ecosystems" (EPA 2006), recognises that a key aim of rehabilitation is to ensure the long-term stability of soils, landforms, and hydrology required for the sustainability of sites. When discussing abiotic factors, the Guidance Statement describes the maintenance of soil properties as being a key aspect of rehabilitation to ensure vegetation establishment and resistance to erosion. It also states that effective topsoil and subsoil management is essential to ensure adequate plant growth and normal root distribution patterns.
EPA Position Statement No. 8	EPA Position Statement No. 8, "Environmental Protection in Natural Resource Management" (EPA 2005), outlines the EPA's role in natural resource management (NRM) with respect to evaluating environmental performance. The EPA has been given the task of environmental performance evaluation of NRM agencies by Government. This task will link closely with Western Australia's State of the Environment Reporting Program.
Planning Bulletin No. 64	The Western Australian Planning Commission Planning Bulletin No. 64, "Acid Sulfate Soils" (WAPC 2003b), provides advice on matters that should be taken into account in the development of lands that contain acid sulfate soils (ASS). The Bulletin provides planning guidelines for ASS and refers proponents to the Acid Sulfate Soils Guidelines Series, prepared by the Department of Environment (now DEC), which assist developers and individuals to manage development in areas where ASS may, or will be affected.
Acid Sulfate Soils Guideline Series	The Department of Environment and Conservation Guidelines is a comprehensive statutory and policy framework for the identification, assessment, treatment and management of Acid Sulfate Soils. The significant guidelines for this Project include: • Department of Environment and Conservation (2009b) Acid Sulfate Soils Guideline Series – Treatment and Management of Soils and Water in Acid Sulfate Soil Landscapes • Department of Environment and Conservation (2009) Acid Sulfate Soils Guideline Series – Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes.
Contaminated Sites Guideline Management Series	The Department of Environment and Conservation Guideline used for this Project outlines the criteria used by the department in assessing site contamination and determining the requirements for further investigation, or assessment of risk to determine if any further action is required. Further, the guidelines have been prepared to assist consultants, local government authorities, industry and other parties interested in the assessment of contaminated sites in WA. Department of Environment and Conservation (2003) Contaminated Sites Guideline Management Series
Erosion Control Guideline	The following reference will be used as a guideline for the management of erosion for the Project. The guideline assesses land qualities and determined land capabilities of soils. The report describes standard methods for attributing and evaluating conventional land resource survey maps so that strategic decisions about the management, development and conservation of land resources can be made. van Gool, D., Tille, P. And Moore, G. 2005. *Land Evaluation Standards for Land Resource Mapping*. Third Edition. Department of Agriculture, Perth, WA

Table 9.4: Consequence Definitions for Soil and Landforms

Terrestrial						
Factor	**1**	**2**	**3**	**4**	**5**	**6**
	Catastrophic	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Soil and Landforms	• Regional soil contamination that will severely threaten ecological integrity across this area and cannot be readily remediated • Extensive erosion or loss of landforms at a regional scale resulting in substantial loss of environmental values over the region	• Regional soil contamination or change in specific soil characteristics that will severely threaten ecological integrity across this area but can be remediated over the long term • Long-term loss of environmental values at a regional scale requiring extensive, ongoing remediation	• Local soil contamination that will severely threaten ecological integrity across the local area requiring long-term remediation or regional short-term change in specific soil characteristics • Extensive erosion of local landforms, or local loss of a unique landform habitat-	• Local soil contamination requiring long-term remediation, or local short-term change in specific soil characteristics • Moderate erosion of local landforms • Extensive local loss of well represented landform habitats	• Local soil contamination that can be readily remediated; or minor impacts to specific soil characteristics • Minor erosion or loss of local landforms	• Localised and short-term disturbances to well represented landform that can be readily remediated

Impact: *direct interaction of a stressor with the environment |* ***Local area:*** *directly affected by the development and the surrounding environs (radius of 2 km from the Ashburton North site) |* ***Regional area:*** *extending to well beyond the development and surrounding environs (Carnarvon and Pilbara Bioregions) |* ***Short term:*** *<5 yrs from commencement of the construction phase |* ***Long term:*** *>5 yrs from commencement of the construction phase*

- Development of management concepts that limit potential impacts to the soils and landforms environment and receiving environments.

9.2.5.1 Construction – Clearing and Earthworks

Residual risk to soils and landforms from clearing and earthworks during construction is	Low

Clearing of approximately 3100 ha and subsequent ground disturbance, excavation of fill material and filling of designated areas as necessary will be required in order to facilitate the construction of the Terrestrial infrastructure (refer to Chapter 2, *Project Description* for further infrastructure details). These activities will require clearing of vegetation and changing the shape of the natural landform, particularly landforms associated with the dune networks (fringing and coastal dunes and the longitudinal dune network). Clearing and earthworks may also impact upon marine geoheritage sites within terrestrial landforms. Any impact to these sites are assessed in Chapter 8, *Marine Risk Assessment and Management*.

Impacts that may be associated with the clearing and associated earthworks during construction include:

- Degradation of soil quality (acidity and heavy metals) through the disturbance of PASS
- Soil erosion (wind and water) due to ground disturbance.

Disturbance of PASS

The footprint of the LNG plant and the potential dredge material placement area (and potentially the pipeline shore crossing and borrow pits) are located in areas identified as high to moderate risk for intercepting PASS. The unmanaged disturbance of PASS may result in the oxidation of these soils and the subsequent production of sulfuric acid and the mobilisation of heavy metals into the receiving environment. This may result in impacts to groundwater and surface water quality, and subsequent impacts to the health of terrestrial and marine flora and fauna. However, the majority of the infrastructure is expected to be built upon a raised pad, therefore decreasing the requirement for excavation into the natural landforms. This decreases the likelihood of excavating PASS material.

Management controls are required in any areas of the terrestrial assessment area that have been identified as high to moderate risk for PASS as part of the PASS risk assessment (illustrated in Section 6.4.4.2) and where ground disturbance is proposed. In addition, if the action criteria identified in the Acid Sulfate Soils Guideline Series (Department of Environment and Conservation 2009a) are reached or exceeded, management of disturbed PASS will occur. A summary of PASS management controls and mitigation measures and definition of criteria to determine the successful treatment of PASS material is presented in Table 9.5.

The management controls will be developed as part of Construction Environmental Management Plan (CEMP). These controls, and the criteria to determine successful treatment of PASS material, will be prepared taking into account the Department of Environment and Conservation (2009b) Acid Sulfate Soils Guideline Series – Treatment and Management of Soils and Water in Acid Sulfate Soil Landscapes.

The management controls will include the following:

- Inform workforce of the nature and potential impacts of PASS
- Review PASS Risk Map to ascertain whether PASS will be disturbed
- Avoid the disturbance of PASS where practicable
- Refer to the CEMP for management strategies when disturbance is unavoidable
- Management of PASS material utilising best practice management methods, as outlined in the CEMP.

Soil Erosion Due to Ground Disturbance

Landforms and soils have the potential to erode during and after clearing and earthworks associated with the excavation of the borrow pits and construction of the LNG plant. The risk assessment for erosion based on landform type is discussed in Chapter 6, *Overview of Existing Environment* and is based on van Gool et al. (2005). Susceptible landforms include the longitudinal dune and interdunal swales, fringing and coastal dunes and mainland remnant dunes. Any soil stockpiles created during construction activities are also susceptible to erosion. Secondary erosion impacts caused by rill, sheet or gully erosion may lead to an increase in sedimentation along adjacent environmental receptors including the Ashburton River and Hooley Creek.

Erosion controls and measures will be implemented as part of the CEMP, which will be produced prior to commencement of construction activities. Where disturbance of the natural ground and stockpiling is proposed erosion controls and measures will be implemented so that earthwork activities are managed to reduce the potential dust generation and sedimentation from erosion of disturbed landforms and stockpiling. Surface water run-off from cleared areas will be controlled by utilising approved silt fence/barriers and/or other appropriate erosion/sediment controls managed and maintained in accordance with the CEMP. All perimeters will be reviewed for application of the necessary run-off control.

The management controls for erosion will include the following, where practicable:

- Reduce dust generation through application of suppressant or soil stabiliser
- Install erosion control and flow diversion devices if required
- Routinely inspect and maintain erosion and sediment control structures, particularly following heavy or prolonged rainfall
- Keep vehicle and equipment movement within designated areas (e.g. access tracks and turning circles).

An identified secondary impact associated with erosion due to ground disturbance and stockpiling is sedimentation of adjacent environmental receptors including creek systems and the marine environment. This is discussed as part of the surface water assessment in Section 9.3.

Proposed Cane River Conservation Park Extension

The Cane River Conservation Park is located approximately 100 km south of Onslow and 4.5 km to the east of the eastern end of the domgas study area, and therefore outside the terrestrial assessment area. However, the National Reserves System Co-operative Program is proposing to include extensions to the Cane River Conservation Park to incorporate the Mt Minnie Pastoral Lease (110 921 ha), and part of the Nanutarra Pastoral Lease (70 030 ha). This may occur in 2015 and, once implemented, the eastern 44 km section of the domgas corridor assessment area will be located within the Park.

Conservation values of the Cane River Conservation Park include:

- Landforms and vegetation types of particular interest not found in other conservation reserves in the Pilbara
- Contrasting granite outcrops and sandstone ranges including the Parry Range and Mt Minnie (DEC 2009).

Disturbance to soils and landforms within the proposed Cane River Conservation Park extension is expected to occur primarily through the temporary excavation of a shallow trench in which the domgas pipeline will be laid. Strategies for limiting impact to soils during the domgas pipeline trenching operations and rehabilitation activities will be prepared in accordance with The Australian Pipeline Industry Association Ltd *Code of Environmental Practice Onshore Pipelines* (2009).

Based on the survey results, the landform units listed above are not present in the terrestrial assessment area. Therefore, no disturbance of PASS of erosion is expected to occur, and no landforms of significance will be disturbed in this area. The landforms present within the area identified for the expansion of the Cane River Conservation Park are well represented in the region.

Summary

With PASS management and erosion controls in place, the potential for impacts to occur to soils and landforms through clearing and earthworks is expected to be substantially reduced. Therefore, the residual environmental risk to the soils and landforms from Project related clearing and earthworks is assessed as being "Low" - it is "Likely" that impacts to soils and landforms will occur, however, following the implementation of appropriate management and contingency plans presented in Table 9.5, the impacts will be of "Minor" consequence.

9.2.5.2 Operations – Earthworks and Maintenance

Residual risk to soils and landforms associated with earthworks and maintenance during operations is	**Very Low**

Operational activities will include incidental earthworks associated with ongoing operations of the LNG plant facility and maintenance works that may be required throughout the life of the Project. Earthworks may include maintenance of bunds, installation of drains, installation of underground services and maintenance of drainage lines.

Impacts that may be associated with the earthworks and maintenance during operational works include:

- Degradation of soil quality through the disturbance of PASS (acidity and heavy metals)
- Soil erosion due to ground disturbance (wind and water).

Disturbance of PASS

As discussed in the previous section, management controls are required in any areas of the terrestrial assessment area that have been identified as high to moderate risk for PASS (See Section 6.4.4.2) and where ground disturbance is proposed.

Although the earthworks and maintenance conducted during operations are likely to be minor, there is potential for disturbance of PASS. It is anticipated that the same management controls implemented as part of the CEMP will also be included in the Operational Environmental Management Plan (OEMP), which will be developed prior to commencement of operational activities and will be required for the duration of the Project. These management controls and mitigation measures for the potential disturbance of PASS are described in Table 9.5.

Soil Erosion Due to Ground Disturbance

The likelihood of erosion as a result of operations earthworks and maintenance can be reduced through the implementation of management controls as outlined in Section 9.2.5.1. Where disturbance of the natural ground and stockpiling is proposed, erosion controls and measures will be implemented so that earthwork activities are managed to reduce the potential dust generation and sedimentation from erosion of disturbed landforms and soil stockpiles.

Erosion controls and management measures implemented as part of the CEMP are likely to be included in the OEMP (where deemed to have been successful in the construction phase), which will be developed prior to commencement of operational activities and will be required for the duration of the Project. Erosion management controls and mitigation measures are described in Table 9.5.

Summary

Earthworks and maintenance conducted during operations are likely to be minor. Following the implementation of appropriate management and contingency plans presented in Table 9.5, it is unlikely that the activities associated with the operation phase of the Project will result in impacts to the soil and landforms of the Project area. Therefore, the residual environmental risk for this potential impact was assessed as being "Very Low" – of "Negligible" consequence and "Unlikely".

9.2.5.3 Leaks and Spills

Residual risk to soils and landforms from spills and leaks is	**Low**

Leaks and spills may occur during the construction, commissioning, operations and decommissioning phases of the Project. Leaks and spills are most likely to occur in association with pipeline or equipment failure, storage and handling of product, fuels and chemicals, waste storage and disposal. There is also potential for spills and leaks of hydrocarbons, wastes and other hazardous materials during transport and transfer of products.

Release of contaminants into the natural environment is likely to have a negative impact on soil quality if they are not removed or remediated. Leaks and spills may also incur impacts where contaminants enter surface water or groundwater systems, with subsequent transport to terrestrial ecosystems, local watercourses and marine receiving environments.

The likelihood of spills and leaks occurring in the terrestrial environment will be reduced through implementation of design controls and a program of inspection, monitoring and maintenance. This management program will be in place for all phases of the Project. Management controls have been developed with the aim of reducing risks associated with various potential sources of leaks or spills.

The management controls for spills and leaks will include the following:

- Appropriate design, construction and maintenance of storage, handling and transfer infrastructure (to AS 1940:2004)
- A risk-based integrity assurance program for storage vessels and pipelines
- Adequate and appropriate emergency response capability
- Spill response procedures and training
- Implementation of appropriate treatment and/or rehabilitation techniques where significant impacts to soils or landforms occurs.

These management controls will be implemented as part of the CEMP and the OEMP, which will include relevant management plans, procedures and training requirements with the objective of facilitating the prevention and management of spills and leaks.

Summary

The residual environmental risk to the soils and landforms from Project related spills and leaks are assessed as being "Low". The most conservative risk ranking assesses the impacts of a major onshore spill or leak. It is anticipated that, with the adoption of management controls and mitigation measures presented in Table 9.5, this event would be "Unlikely", but could perceivably be of "Major" consequence.

Table 9.5: Summary of Management Controls and Residual Risk for Soils and Landforms

Aspect and Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Construction							
Clearing and earthworks	• Degradation of soil quality through the disturbance of PASS (i.e. acidity and heavy metals) • Soil erosion due to ground disturbance (i.e. wind and water)	• Review PASS Risk Map to ascertain whether PASS will be disturbed • Avoid the disturbance of PASS where practicable • Refer to the CEMP for treatment and disposal strategies when disturbance is unavoidable • Management of PASS material utilising best management practice methods, as outlined in the CEMP • Reduce dust generation through application of suppressant or soil stabiliser • Installation of erosion control and flow diversion devices if required • Routine inspection and maintenance of erosion and sediment control structures, particularly following heavy or prolonged rainfall • Keep vehicle and equipment movement within designated areas (e.g. access tracks and turning circles)	5	2	**Low**	**Reasonable** Survey data available from one expert – complies with EPA Guidance Available information is adequate	No

Operations							
Earthworks and maintenance	• Degradation of soil quality through the disturbance of PASS (i.e. acidity and heavy metals) • Soil erosion due to ground disturbance (i.e. wind and water)	• Review PASS Risk Map to ascertain whether PASS will be disturbed • Avoid the disturbance of PASS where practicable • Refer to the CEMP for treatment and disposal strategies when disturbance is unavoidable • Management of PASS material utilising best management practice methods, as outlined in the CEMP • Reduce dust generation through application of suppressant or soil stabiliser • Installation of erosion control and flow diversion devices if required • Routine inspection and maintenance of erosion and sediment control structures, particularly following heavy or prolonged rainfall • Keep vehicle and equipment movement within designated areas (e.g. access tracks and turning circles)	6	4	**Very Low**	**Reasonable** Survey data available from one expert – complies with EPA Guidance Available information is adequate	No
Leaks and Spills							
Storage, handling and transport	• Degradation of soil quality due to hydrocarbons spills	• Appropriate design, construction and maintenance of storage, handling and transfer infrastructure • A risk-based integrity assurance program for storage vessels and pipelines • Adequate and appropriate emergency response capability • Spill response procedures and training implementation of appropriate treatment and/or rehabilitation techniques where significant impacts to soils or landforms occur	3	4	**Low**	**High** Several expert investigations/studies Excellent survey data	No

Aspect and Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Additive effects							
All of the above	All of the above	All of the above	5	2	**Low**	**Reasonable** Survey data available from one expert - complies with EPA guidance Available information is adequate	No

9.2.6 Implications for Matters of National Environmental Significance

There are no recognised matters of NES relating to soils and landforms within the Project area.

9.2.7 Residual Risk Summary

Table 9.5 provides a summary of the aspects, activities and potential impacts to soils and landforms as a result of Project activities. Indicative management controls and mitigating factors are also listed, along with the residual risk following implementation of the management controls.

9.2.8 Predicted Environmental Outcome

With the implementation of appropriate avoidance and management measures during construction and operational earthworks the risks associated with exposure of PASS and the occurrence of soil erosion can be reduced to a low level of risk.

With the implementation of appropriate management controls, it is anticipated that spills or leaks will be minor, detected rapidly and result in minor localised consequences. Spills and leaks are therefore considered to pose a low risk to soils and landforms environment.

The aspects described above have the potential to impact soils and landforms in an additive manner. The combined consequence of construction, operation, and leaks and spills on soils and landforms has been determined to be "Minor". The likelihood of this consequence occurring is "Likely". The additive risk from the Project on soils and landforms is "Low".

Project activities associated with the disturbance of soils and landforms therefore pose a low level of risk to the conservation values of the terrestrial assessment area and surrounds. The EPA management objective for soils and landforms is expected to be achieved.

A framework Construction EMP (Appendix U1) has been developed which, in part, provides a high level indication of how impacts to soils and landforms will be managed. Prior to Project construction, a Subsidiary (internal) EMP will be developed that specifies the management and mitigation measures and actions which will be implemented to limit Project related impacts to soils and landforms. This approach is consistent with the EPA's guidance on using a Risk-based approach in that factors containing low risks are managed via Subsidiary EMP's that will not be submitted for regulatory review but will be developed consistent with the strategies listed in the framework Construction EMP.

9.3 Groundwater

The following sections present the assessment of Project related impacts on the groundwater environment, taking into account design modifications, mitigation methods and controls applied to reduce impacts.

9.3.1 Management Objective

The EPA management objectives for groundwater are:

- To maintain the quantity of groundwater so that existing and potential environmental values, including ecosystem maintenance, are protected
- To ensure that emissions do not adversely affect environmental values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

9.3.2 Description of Factor

A summary of the site investigations into the natural groundwater environment of the terrestrial assessment area is provided below, with further details included in Chapter 6, *Overview of Existing Environment,* and in the technical report, included as Appendix F1.

Sources of data included:

- A desktop literature review
- Site investigations into the natural groundwater environment within the terrestrial assessment area
- Hydrogeological modelling of natural and extreme environmental conditions.

9.3.2.1 Hydrostratigraphy

The interpreted hydrostratigraphy is based on the local lithological profiles intersected during the site investigations and consists of alluvial superficial formations successions including Dune Sands, underlain by Ashburton River Delta Alluvium, which in turn is underlain by Ashburton River Delta Clay and Unconformity. Beneath the superficial formations is a confined aquifer hosted by Tertiary successions of the Trealla Limestone.

9.3.2.2 Conceptual Hydrogeology Model

The groundwater study developed a conceptual hydrogeological model of the local groundwater environments by incorporating data from both site investigations and numerical simulations. The conceptual hydrogeological model of Ashburton North shows the groundwater environment is characterised by shallow water table settings and predominantly saline to hypersaline groundwater environments. The Project area is predominantly a groundwater discharge zone associated with the superficial formations and regional Carnarvon Basin successions. Exceptions occur seasonally, when the dunal landforms intercept and transmit rainfall recharge.

The direction of local shallow groundwater flow is strongly influenced by topography. Within the Dune Sands, the influence of topography on groundwater flow is more apparent than for the underlying successions. This aspect reflects occurrence of lateral groundwater flow from dune crests to lowlands, driven in part by topography and seasonal recharge.

Local groundwater flow is also influenced by density effects typical of groundwater flow dynamics in highly saline environments. Salinity distributions in the shallow groundwater settings control density coupled flow dynamics and environmental heads. The interpreted environmental heads indicate groundwater flow in the Dune Sands, Ashburton River Delta Alluvium and Trealla Limestone is strongly influenced by vertical upward hydraulic gradients. The water table is mounded beneath the dunes and discharges towards lowlands formed by supratidal, samphire and tidal flats. The vertical upward flow of groundwater indicates discharges from the underlying regional Carnarvon Basin successions and potential mixing of both regional sources and local groundwater, particularly within the Ashburton River Delta Alluvium and Dune Sands successions. Occurrence of mixing would contribute to the accumulation of salt in the shallower successions.

The local groundwater environments are predominantly independent of, and isolated from, tidal influences. The vertically upward hydraulic gradients and density effects appear to locally limit seawater intrusion into the shallow water table zones. Presumably, the seawater interface in the groundwater environment occurs offshore.

The interpreted hydraulic characteristics of the discrete hydrostratigraphic units include:

- Effective transmissivity for the Dune Sands, Ashburton River Delta Alluvium, Ashburton River Delta Clay and Trealla Limestone of 12 to 24, 10, 2 and 50 m^2/day
- Vertical hydraulic conductivity for the Dune Sands, Ashburton River Delta Alluvium, Ashburton River Delta Clay and Trealla Limestone of 4, 0.05, 0.03 and 5 m/day.

All local superficial formations and Trealla Limestone successions are interpreted to be accumulating salt. The local successions show vertical salinity stratification, with Trealla Limestone hosting hypersaline groundwater and salinity being progressively diluted in the shallowing successions. The local dune sands typically host saline and hypersaline groundwater resources.

The measured baseline salinity (as total dissolved solids, TDS) include:

- 20 000 to 120 000 mg/L TDS in the water table zone and Dune Sands
- 50 000 to 150 000 mg/L TDS in the Ashburton River Delta Alluvium
- 156 000 to 200 000 mg/L TDS in the Trealla Limestone.

Dissolved metals are evident in groundwater sampled from most monitoring bores. The data from the sampled groundwater indicate that the dissolved concentrations of cadmium, chromium, copper, lead, nickel and zinc naturally occur above marine Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines in many of the monitoring bores. The marine ANZECC guidelines are used as a reference due to the comparatively high concentrations of salt in the local groundwater. The comparatively high dissolved metals concentrations are considered to be representative of background conditions and are commensurate with the accumulation of salt in the local groundwater environment.

9.3.3 Assessment Framework

Table 9.6 provides a list of guidance statements specifically related to the assessment and management of groundwater.

9.3.4 Consequence Definitions

To enable assessment of risks associated with the Project, specific consequence definitions were developed. Table 9.7 provides the consequence definitions that have been used in the risk assessment of groundwater.

9.3.5 Impact Assessment and Management

Impacts to groundwater will occur as a result of Project activities. The following sections summarise the aspects and activities that may directly or indirectly affect groundwater in, and surrounding, the Project area. Chapter 7, *Impact Assessment Methodology* contains the risk matrix used to assess the likelihood and consequence of impacts occurring. Potential management and mitigation measures are generally provided in greater detail for those aspects that have been identified as posing a higher risk to a factor than those aspects that are expected to pose a lesser risk. Table 9.9 in Section 9.3.7 provides a summary of the potential impacts, management measures and residual risk as a result of Project activities.

The methodology for the assessment of the risk to the groundwater environment from the Project is based on:

- Field assessments of the local groundwater environment, derived from the development of 69 groundwater bores and 28 drive point piezometers
- Characterise baseline groundwater environments and develop conceptual hydrogeological models
- Inclusion of Project description information into the conceptual models to determine likely changes to the baseline groundwater environments
- Development of management concepts that limit potential impacts to the groundwater environment and receiving environments.

9.3.5.1 Construction Earthworks – Dredge Material Placement Area

Residual risk to groundwater from the dredge material placement area is	**Medium**

The Project considers two placement options for material dredged from the MOF, Product Loading Facility (PLF) and shipping channel. The preferred option includes all dredged material being placed offshore – this option would significantly decrease the impacts to the terrestrial environment. Offshore placement of all dredged material is assessed in Chapter 8, *Marine Risk Assessment and Management*.

The second option involves the onshore placement of dredged material. The onshore placement is assessed in this chapter, and would involve dredged material being transported hydraulically and discharged through a pipeline into a purpose built placement area located within the Plant footprint. The location of the onshore dredged material placement area is depicted in Figure 9.1. Further details of the characteristics and operation of

Table 9.6: Position and Guidance Statements Relevant to Groundwater

Legislation or Guideline	Intent
ANZECC Guidelines for Fresh and Marine Water Quality 2000	Water quality limits for protection of ecosystem health. The local groundwater environment typically hosts saline and hypersaline groundwater. As such, the Marine Water Quality Guidelines have been considered applicable.
EPA Position Statement No. 8, 2005	Environmental Protection in Natural Resource Management. An outline of the EPA role in natural resource management with respect to evaluating environmental performance.
Water and Rivers Commission Statewide Policy No 5 – Environmental water provisions policy for Western Australia, 2000	This policy informs the Department of Water how water will be provided and managed to protect ecological values and sustainable development consistent with the requirements of the *Rights in Water and Irrigation Act 1914* and the *Environmental Protection Act 1986*. The policy incorporates the concepts of Ecological Water Requirements and Ecological Water Provisions for water dependent environments.
Rights in Water and Irrigation Act 1914: Section 5C licence to take water and manage its use	This Act governs the regulation of water resources in WA. Regulatory licences and permits issued under this Act define water management and monitoring for individual projects. The Act includes: • Section 26D Licence to construct or alter a well • Section 5C Licence to take and manage water • Section11/17/21A Permit to alter bed and banks
Statewide Policy No. 19 – Hydrogeological reporting associated with a Groundwater Well Licence, Department of Water, September 2007	Provides policy on the content and context of hydrogeology assessments with respect to taking of groundwater and/or ecological impacts management. The guidelines are intended to inform the Department of Water of the potential impacts that proposed projects may impose on the environment, other users and available water resources.

Table 9.7: Consequence Definitions for Groundwater

Terrestrial						
Factor	**1**	**2**	**3**	**4**	**5**	**6**
	Catastrophic	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Groundwater	Long-term loss of groundwater quality at a regional scale, which cannot be remediated	• Major changes in regional groundwater recharge patterns due to landform alteration significantly affecting critical groundwater dependent ecosystems over a region • Regional short-term exceedence of background and applicable ANZECC Water Quality Guidelines	• Changes to water quality of local water resources resulting in localised long-term exceedence of background and applicable ANZECC Water Quality Guidelines • Long-term significant effects to groundwater quality in a localised area with extensive, long-term remediation required to restore environmental values • Major changes in sub-catchment groundwater recharge patterns over a local area over the long term	• Short-term significant effects to local groundwater quality with short-term remediation required • Changes to local groundwater resources resulting in localised short-term exceedence of background and applicable ANZECC Water Quality Guidelines • Local and significant change in sub-catchment groundwater recharge patterns over the long term	• Minor changes to local groundwater resources, resulting in local short-term and small reduction in groundwater quality with no exceedence of background and applicable ANZECC Water Quality Guidelines • Local and minor change in sub-catchment groundwater recharge patterns	• Localised and short-term reduction in groundwater quality that can be readily remediated. • Localised and short term disturbance to groundwater recharge patterns that can be readily remediated

Impact*: direct interaction of a stressor with the environment |* ***Local area****: directly affected by the development and the surrounding environs (radius of 2 km from the Ashburton North site) |* ***Regional area****: extending to well beyond the development and surrounding environs (Carnarvon and Pilbara Bioregions) |* ***Short term****: <5 yrs from commencement of the construction phase |* ***Long term****: >5 yrs from commencement of the construction phase*

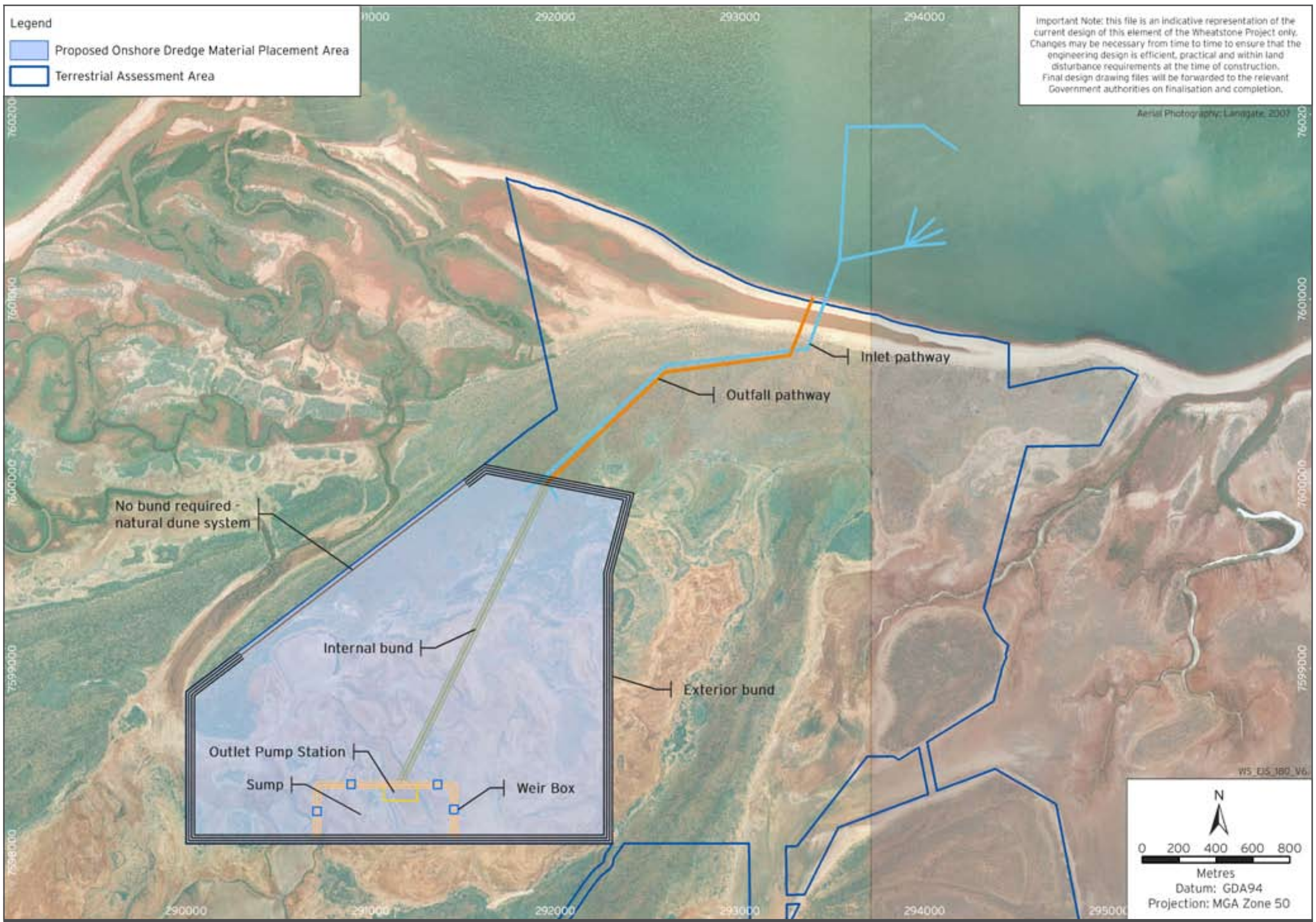

Figure 9.1: Conceptual Location of Potential Dredge Material Placement Area

the placement area are in included in Chapter 2, *Project Description* and Chapter 8, *Marine Risk Assessment and Management*.

Typically, the dredging operations will produce seawater slurry with solids to seawater ratio of about 1:5. The onshore placement of dredge material is characterised as follows:

- Up to 10 Mm^3 dredged material to be disposed to land in seawater slurry
- Approximately 50 Mm^3 seawater to be disposed to land.

The onshore placement area will be bunded around the perimeter, using the dunes as part of the western bund (width of approximately 100 m). The perimeter bunds will be constructed using suitable material. It is likely that the placement area will be divided into approximately equal parts by a single internal bund running from north to south. At the southern end of the internal bund, a sump area will be created with weirs controlling the flow from either of the two placement areas.

It is proposed that dredged material is placed initially into the eastern part of the placement site filling from the northeast. The coarse material will settle out first, the finer fractions being transported over greater distances and seawater flowing to the south with reducing suspended sediment concentrations. Over time the coarse material will trap fines within the placement site. The decant seawater will be pumped to the marine outfall from the sump at the south of the placement area. As the amount of material placed into the area increases the spread of settled dredge materials will approach the southern limit of the site. During the onshore placement operations (approximately 12 to 18 months) the concentration of fines near the outflow into the sump may increase, at which point the discharge of dredge material to the placement area would transfer to the western part of the placement area and the filling process repeated.

Decant seawater and rainfall on to the placement area will be pumped offshore from the southern sump and discharged by pipeline to the marine outfall for approximately 18 to 24 months.

Consolidation and dewatering of the disposed dredge material will occur after deposition within the placement area. The processes of consolidation and dewatering will occur through the decanting of supernatant seawater, seepage of seawater into the groundwater environment and evaporation.

Potential groundwater impacts related to the onshore disposal of dredge material include:

- Mounding of the local water table due to the infiltration of seawater within the placement area. The placement area naturally contains saline and hypersaline groundwater in shallow water table settings
- Seepage of groundwater and seawater beneath perimeter bunds, expressing as groundwater discharge on the ground surface on the outside perimeter of the placement area and associated surface water flows within the Southwest and Ashburton River Mouth Catchments
- Changes to groundwater salinity.

Approach to Mitigation of Effects of Onshore Placement

In order to reduce the potential for environmental impacts, including those on the Ashburton River Delta, the following mitigation measures will be implemented in the design and operation of the dredge material placement area:

- The placement area has been selected to reduce the footprint used
- Dredged material will be contained in a bunded area with the objective of preventing the unconfined release of seawater and sediments
- The bunded area incorporates a sump and associated weir boxes to intercept and manage decant seawater and sediment. Drainage of decant seawater over the placement area will be to the south away from the Ashburton River Delta therefore limiting the potential impact from rising groundwater levels
- The placement of material into the sites will be undertaken with the aims of promoting the trapping of fines in the settled material and reducing the amounts of fines in suspension
- Seepage will concentrate on the southern perimeter bund
- The placement approach will potentially reduce groundwater levels in the placement areas and consequently seepage potentials
- Where practicable, placement in the eastern half of the placement area will be preferred to limit water table mounding and seepage from the western placement area
- Bunds will be designed with the objective of withstanding erosion during inundation events
- Discharge of decant water during the first 18 to 24 months will be pumped via pipeline to a marine outfall
- A drain (with sump and pump system) will be installed on the outside perimeter of the southern embankment with the objective of collecting and diverting seepage away from the Ashburton River Delta
- Groundwater monitoring bores will be installed to detect any alteration of groundwater environments that may indicate a potential risk to the Ashburton River Delta.

A groundwater flow model (using MODFLOW-Surfact [Waterloo Hydrogeologic Inc, 2000]) has been developed to investigate the potential water table mounding and potential seepage from the placement area. The model domain covers an area of 52 km^2, and contains both recharge and discharge (evaporation) zones that contribute to the water balance and enable configuration of the baseline water table. The groundwater flow model has been calibrated under steady-state simulations. The term steady-state describes a flow condition that does not change with time. Further details of the modelling method are included in Appendix F1.

The steady-state calibrated model has been applied to predictive simulations of the disposal of dredge material in the placement area over a deposition period of about 18 months. These simulations incorporate dredge material deposition strategies with the intent of focussing deposition away from the perimeter bunds, promoting consolidation, dewatering and solar drying, limiting the potential for water table mounding and reducing seepage. It is assumed that:

- Perimeter bunds to the storage areas placement area are formed of inert dry fill
- Dredge material will be disposed up to a peak elevation of approximately 6.0 m AHD within the storage areas
- The dredge material has an estimated 1 m/day isotropic hydraulic conductivity
- The dredge material is inert, but contains sea salt
- The embankments have 0.2 m/day hydraulic conductivity.

Mounding of the Water Table

Mounding of the water table is predicted to occur due to the infiltration of seawater from the placement area. The simulated mounding propagates from, and expresses as, groundwater seepage on the perimeter of the containment bunds of the placement area. The simulated maximum mounded water table elevation of up to about 6.0 m AHD is temporary within the placement area as the dredge cuttings are disposed. After the cessation of the dredge material disposal, the mounding of the water table progressively decays. The decay occurs in response to dewatering and consolidation of the disposed dredge material and water losses to seepage and evaporation.

The rate at which the mounded water table decays within the broader placement area depends on factors including:

- Depth of dredge material deposition
- Effective hydraulic conductivity of the disposed dredge cuttings
- Effective transmissivity of the Dune Sands and Ashburton River Delta Alluvium strata beneath the placement area
- Depth to the water table beneath the placement area
- Rates of evaporation from the beached dredge material
- Lengths of flow paths from recharge sources to discharge zones.

Dissipation of the water table mound occurs through radial flow of groundwater. Predictive simulations show that:

- Mounding of the water table leads to changes in groundwater flow directions and zones of discharge
- Mounding of the water table predominantly occurs in the vicinity of the dredge material placement , embankments and adjacent dune terrain
- Temporary water table mounding from 1 to 3 m in height preferentially occurs in the Dune Sands adjacent to the embankments: a reflection of the available storage above the baseline water table and effective transmissivity of the saturated profiles
- Discharge from the mounded water table occurs on fronts that radiate from the placement area, including along perimeter embankments, with residual heads typically up to 0.5 m above the baseline water table elevation
- The residual heads express the water table at the ground surface, promoting visible seepage and groundwater flow.

Ultimately, a modified steady-state water table mound is likely to occur beneath the dredge material placement area and Plant Pad. After 50 years, the water table is predicted to have decayed to a steady-state with subtle (about 0.5 to 1 m height) mounding above the baseline water table elevations. This residual mound is likely due to an altered local water balance (with increased potential recharge across the raised placement area and Plant Pad).

Seepage of Seawater

The mounded water table is likely to express on the ground surface outside of the dredge material placement area. The seepage fronts are linked with the areas of mounded water table and vary over time as the mound decays. The predictive simulations show total seepage from the dredge material placement area peaks at a rate of about 2 200 kL/day (Figure 9.2) Contributions to the total seepage include a peak of about 200kL/day through the facility embankments and up to about 1 900 kL/day that propagates through the base of the facility and manifests as seepage on the embankment perimeters.

The predicted seepage rates rise progressively throughout the campaign of dredge material disposal onshore, peaking as the campaign ceases. Thereafter the seepage rates decay over a period of five to 10 years to about 200 to 400 kL/day. Predicted seepage rates above 1 000 kL/day occur for about one year.

Seepage discharge from the dredge material placement area is predicted to predominantly occur on the perimeter of the southern embankment (Figure 9.3). Substantially smaller scale seepage discharges occur on the perimeter of the western and natural dune sands embankments. These seepage zones are all characterised by shallow water table settings that hold limited water storage potential and form groundwater discharge zones. Deposition and accumulation of salt is expected at locations where the seepage expresses at the ground surface.

Within the Ashburton River Mouth Catchment (western and natural sand dune embankments) the predicted seepage footprint and seepage rates are comparatively small. Low rates of seepage may, however, occur for up to ten years. The simulated seepage rates are sufficiently low that they may be intercepted by evaporation and not express as significant surface water flows on the ground surface. Changes to water and salt budgets of the Ashburton River Delta are expected to be insignificant.

Changes to Groundwater Quality

The mounded water table is likely to contain, to a large extent, seawater that infiltrates from the disposed dredge material within the placement area. The infiltration of seawater may alter the local salinity profiles within the local Dune Sands and Ashburton River Delta Alluvium. Thereafter, it is expected that the consolidated and dewatered dredge material will contain residual salt, and that the salt in storage above the water table will eventually be dissolved and mobilised by rainfall infiltration, and eventually enter the water table.

The baseline salinity of the shallow groundwater beneath the placement area is saline to hypersaline, being typically 50 000 to 150 000 mg/L in the Ashburton River Delta Alluvium and 20 000 to 120 000 mg/L in the Dune Sands. Successions of Ashburton River Delta Alluvium predominantly underlie the placement area.

Dissolved salts in the seepage water would mix with the local groundwater. The mixing with the groundwater and ultimate flow paths would be controlled by the salinity (density) of the seepage water compared with those of the shallow groundwater.

Potential impacts on groundwater quality have been assessed based on baseline quality data and water and salt balances. The ANZECC Guidelines for Fresh and Marine Water Quality (2000) have also been referenced for groundwater quality assessments. The ANZECC Guidelines (2000) default trigger values for salinity in slightly disturbed ecosystems in tropical Australia, including North West Western Australia (WA), are shown in Table 9.8.

This approach is considered appropriate given that:

- The local environment typically contains saline and hypersaline groundwater
- The receiving environments occur predominantly at marine interfaces where groundwater is discharging.

The ANZECC Guidelines, together with baseline data, will be used to develop site-specific trigger values for water quality salinity and turbidity which should not be exceeded, in order to protect the local ecosystems. The trigger values will be provided in the CEMP and OEMP and linked to contingency plans that would be implemented should prescribed non-conformance circumstances become apparent from monitoring programs.

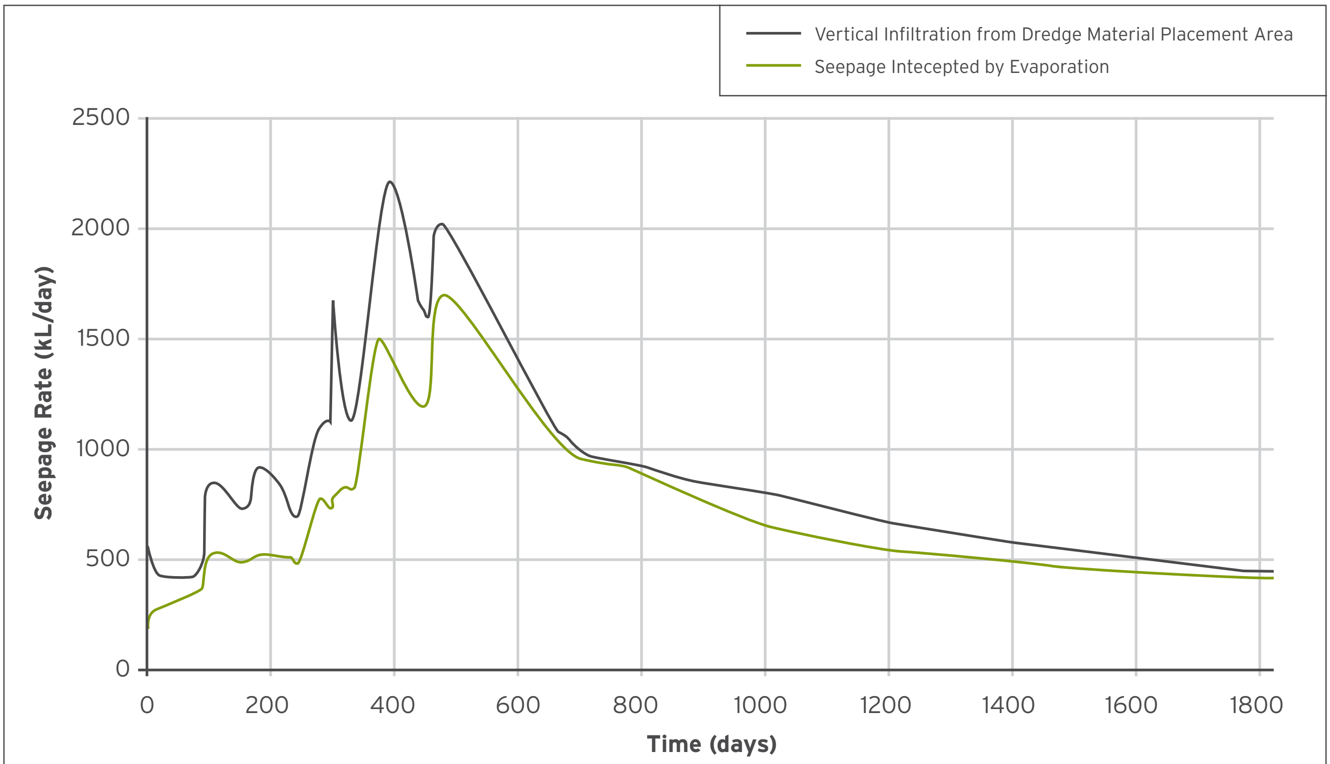

Figure 9.2: Predicted Seepage to the Water Table Intercepted by Evaporation

Table 9.8: ANZECC Guidelines for Salinity in Tropical Australia

Ecosystem Type	Salinity	
	Electrical Conductivity (µS/cm)	Equivalent Estimated TDS (mg/L)
Upland and lowland rivers	20-250	10-150
Lakes, reservoirs and wetlands	90-900	50-550
Estuarine and marine	52 000	33 000

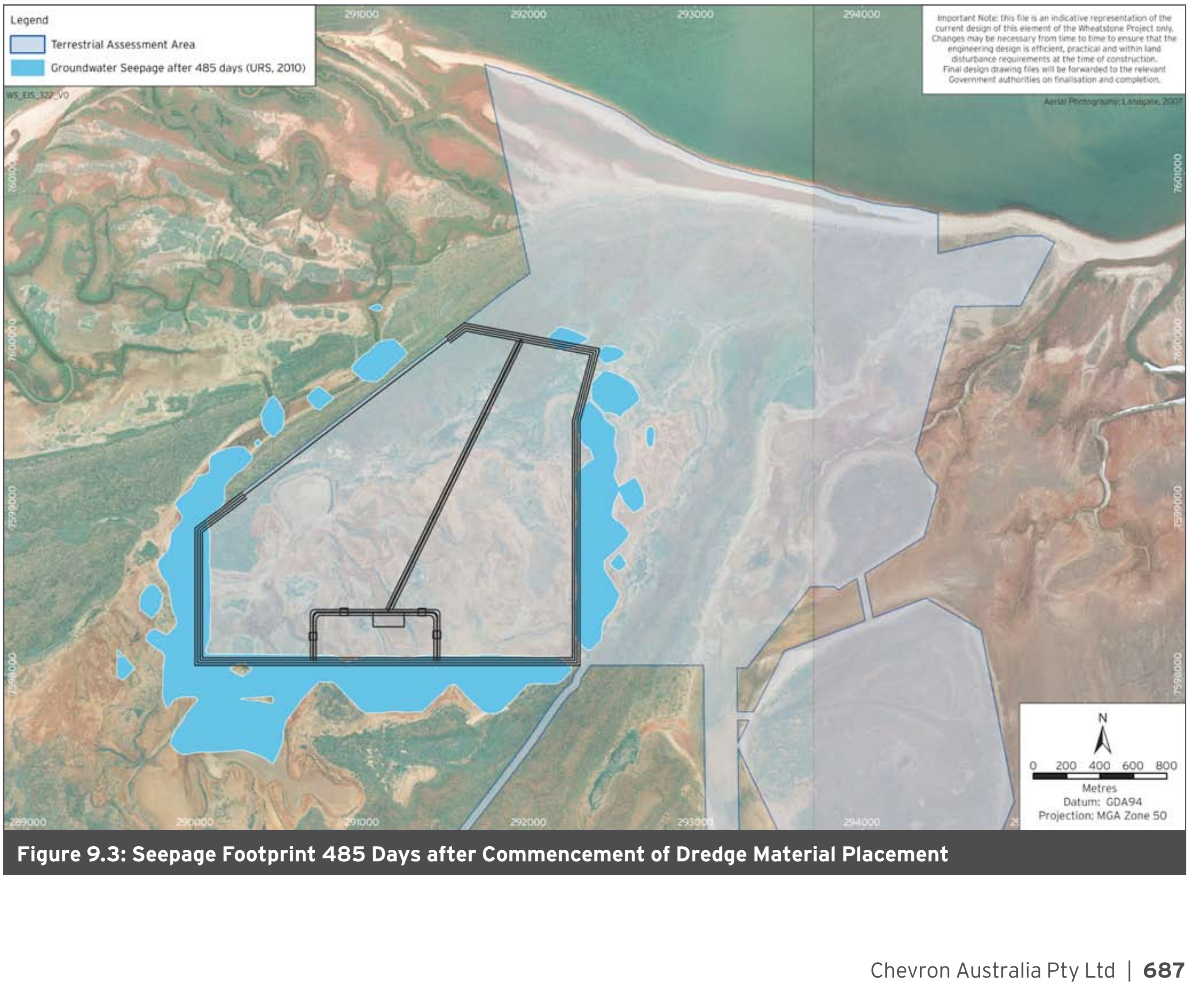

Figure 9.3: Seepage Footprint 485 Days after Commencement of Dredge Material Placement

Summary

The predictive groundwater flow modelling and associated assessments of the dredge material placement area have explored the potential issues linked to mounding of the water table, seepage to the environment and changes to salt loadings. The assessments show that:

- Mounding of the water table occurs beneath the placement area, but the magnitude of the mound decays after cessation of dredge material placement
- The residual mounded heads are likely to express the water table at the ground surface, promoting visible seepage of groundwater
- The mounded water table may initially contain seawater (about 33 000 mg/L TDS) that is predominantly less saline than the baseline 50 000 to 150 000 mg/L and 20 000 to 120 000 mg/L TDS groundwater in the Ashburton River Delta Alluvium and Dune Sands
- Infiltration of residual salt from the disposed dredge material may be of lesser salinity than the baseline groundwater
- The simulated seepage rates are sufficiently low that they may be intercepted by evaporation and not express on the ground surface as flows.

In order to monitor and assist with the management of the potential impact of the dredge material placement area on the local environment, a groundwater monitoring system will be developed. This system, installed before the start of the construction of the placement area, would capture additional data to characterise the local baseline groundwater environment, particularly in the setting of shallow water tables adjacent to watercourses of the Southwest and Ashburton River Mouth Catchments. During construction and operation of the placement area the same system would be used to capture the data to establish change and characterise the impact (if any) of the presence and operation of the placement area on the groundwater environments. The groundwater monitoring system will be developed as part of the CEMP.

A secondary risk of groundwater mounding or changes to groundwater quality is the potential changes to the environment within the Ashburton River Delta. Potential impacts to these habitats are assessed in Chapter 8, *Marine Risk Assessment and Management*.

In conclusion, it is expected that potential impacts of onshore dredge material placement area option on the groundwater system can be mitigated and managed with the use of appropriate engineering controls. Consequently, the residual risk to the groundwater environment from the placement area is assessed as "Medium" – Should dredge material placement occur onshore then impacts are "Likely", and of "Moderate" consequence with the adoption of management controls and mitigation measures presented in Table 9.9.

9.3.5.2 Presence of Infrastructure

Residual risk to groundwater from the presence of the facility is	Low

The Project comprises the construction of a Plant Pad, shared infrastructure corridor and accommodation village. The processing facility will be constructed on a pad that may include some bunding, to provide protection of the plant to a 1:100 year flooding event (approximately 7.5 m AHD). The accommodation village pad and SIC will be designed predominantly above a 1:100 year flood event (approximately 6 m AHD). Earthworks will be required throughout the onshore Project area to prepare the site for construction and installation of infrastructure. The earthworks component of site development is expected to include significant addition of fill material to the plant site, as well as compaction and excavation activities. Construction of the pad will be engineered using suitable material. Chapter 2, *Project Description* provides further detail of the design and construction method.

The large volumes of fill material being brought into Ashburton North and the methods of transport and placement will alter the landforms and may impact on the groundwater environment. Groundwater issues related to the construction and presence of the Plant Pad and other infrastructure and associated altered landforms include:

- Raised landforms promoting increased recharge and consequent localised mounding of the water table
- Changes in local groundwater flow directions.

The impacts to groundwater associated with the Plant Pad, shared infrastructure corridor and accommodation village are expected to be insignificant and have not been simulated. In the absence of the onshore dredge material placement area, a comparatively small water table mound (less than 0.5 m height) may develop beneath the Plant Pad. This mound would tend to conform to the topography of the elevated platform of the Plant Pad and closely mimic the baseline groundwater flow directions. The groundwater monitoring system identified in Section 9.3.5.1 will identify any changes to the groundwater environment. Should the onshore placement option be chosen, mounding of the water table will initially occur due to the onshore placement of dredge material. This activity initially masks any mounding linked to the presence of the facility.

Changes in groundwater levels and groundwater flow will be minimal along the SIC. There may be small-scale local changes in water table elevations in immediate proximity to and beneath the access road embankment. There are no expected changes to groundwater quality.

Summary

It is likely that impacts on the groundwater environment due to the presence of the Plant Pad and associated infrastructure will be minimal. Therefore, the residual environmental risk to the groundwater environment from Project infrastructure is assessed as being "Low" - it is "Likely" that impacts to the groundwater environment will occur, however, following the implementation of appropriate management and contingency plans presented in Table 9.9, the impacts will be of "Minor" consequence.

9.3.5.3 Operational Spills and Leaks

Residual risk to groundwater from spills and leaks is	**Low**

Leaks and spills may occur during the construction, commissioning, operations and decommissioning phases of the Project. Leaks and spills are most likely to occur in association with pipeline or equipment failure, storage and handling of product, fuels and chemicals, waste storage and disposal. There is also potential for spills and leaks of hydrocarbons, wastes and other hazardous materials during transport and transfer of products.

Release of contaminants into the natural environment is likely to have a negative impact on groundwater quality. Where contaminants enter the groundwater environment, subsequent transport to terrestrial ecosystems, local watercourses and marine receiving environments may occur. Leaks and spills may enter the groundwater environment via:

- Infiltration of run-off containing contaminants from the processing facility
- Spills or leaks of contaminants such as hydrocarbons that may infiltrate to the water table during rainfall events. The fate of contaminants that enter the water table will be dependent on the altered water balance and mounded configuration of the water table.

The likelihood of spills and leaks occurring in the terrestrial environment will be reduced through implementation of design controls and a program of inspection, monitoring and maintenance, conducted in accordance with the Contaminated Sites Guideline Management Series. This management program will be in place throughout the construction, commissioning, operations and decommissioning phases of the Project. Management controls have been developed to reduce risks associated with various potential sources of leaks or spills and will be undertaken in accordance with the CEMP and the OEMP.

The management controls for spills and leaks will include the following:

- Appropriate design, construction and maintenance of storage, handling and transfer infrastructure
- A risk-based integrity assurance program for storage vessels and pipelines
- Adequate and appropriate emergency response capability
- Spill response procedures and training
- Implementation of appropriate treatment and/or rehabilitation techniques where significant impacts to groundwater occurs.

These management controls will be implemented as part of the CEMP and the OEMP, which will include appropriate management plans, procedures and training requirements to facilitate management of spills and leaks.

In addition, should spills or leaks occur, transit times for contaminants in the groundwater environment would be comparatively slow, typically limited to tens of metres per year. Consequently, there would be time to intercept contaminants before the local groundwater enters discharge zones.

Summary

Given the planned management measures, it is unlikely that spills and leaks will enter the groundwater environment near the Plant Pad. Operational leaks from storage are generally small in volume and therefore the potential impacts on the groundwater environment are expected to be minimal.

The residual environmental risk to the groundwater environment from Project related spills and leaks is assessed as being "Low". The most conservative risk ranking assesses the impacts of a major onshore spill or leak. It is anticipated that, with the adoption of management controls and mitigation measures presented in Table 9.9, this event would be "Unlikely", but could perceivably be of "Moderate" consequence.

Table 9.9: Summary of Management Options and Residual Risk for Groundwater

Aspect and Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Construction Earthworks							
Dredge Material Placement Areas	• Mounding of the water table • Altered salt loadings to the water table • Seepage from the placement area	• The placement area has been selected to reduce the footprint used • Dredged material will be contained in a bunded area to prevent unconfined release of seawater and sediments • The bunded area incorporates a sump and associated weir boxes to intercept and manage decant seawater and sediment. Drainage of decant seawater over the placement area will be to the south away from the Ashburton River Delta therefore limiting the potential impact from rising groundwater levels • The placement of material will promote trapping of fines in the settled material and reduce the amounts of fines in suspension • The placement approach will potentially reduce groundwater levels in the placement areas and consequently seepage potentials • Where practicable, placement in the eastern half of the placement area will be preferred to limit water table mounding and seepage from the western placement areas • Bunds will be designed to withstand erosion during inundation events • Discharge of decant water during the first 18-24 months will be pumped via pipeline to a marine outfall • A drain (with sump and pump system) will be installed on the outside perimeter of the southern embankment to collect and divert seepage away from the Ashburton River Delta. • Groundwater monitoring bores will be installed to detect any alteration of groundwater environments that may indicate a potential risk to the Ashburton River Delta	4	2	Medium	**Reasonable** Survey data available from one expert - complies with EPA guidance Short-term monitoring results available Available information is adequate	No

Presence of Infrastructure							
Presence of Plant Pad, Access Road, Shared Infrastructure Corridor and Accommodation Village area	• Mounding of the watertable • Change in groundwater flow directions • Change in groundwater quality	• Groundwater monitoring bores will be installed to detect any alteration of groundwater conditions	5	2	**Low**	**Reasonable** Survey data available from one expert – complies with EPA guidance Short term monitoring results available Available information is adequate	No
Operations							
Operational Spills and Leaks and Stormwater run-off	Changes to quality of groundwater	• Appropriate design, construction and maintenance of storage, handling and transfer infrastructure • A regular testing program for storage vessels and pipelines • Adequate and appropriate emergency response capability • Spill response procedures and training • Implementation of appropriate treatment and/or rehabilitation techniques where significant impacts to groundwater occurs • Management controls will be implemented as part of the CEMP and the OEMP.	4	4	**Low**	**Reasonable** Survey data available from one expert – complies with EPA guidance Short-term monitoring results available Available information is adequate	
Additive Effects							
All of the above	All of the above	All of the above	4	2	**Medium**	**Reasonable** Survey data available from one expert – complies with EPA guidance Short-term monitoring results available Available information is adequate	No

9.3.6 Implications for Matters of National Environmental Significance

There are no matters of NES that will be affected by potential impacts associated with groundwater.

9.3.7 Residual Risk Summary

Table 9.9 provides a summary of the aspects, activities and potential impacts to groundwater as a result of Project activities. Indicative management controls and mitigating factors are also listed, along with the residual risk following implementation of the management controls.

9.3.8 Predicted Environmental Outcome

The results of this study show that predicted impacts to the water table environment linked to the Project are local effects that are not likely to substantially propagate beyond the processing facility footprint.

The risks to groundwater are predominantly linked to the potential for seepage from the onshore dredge placement area option. The predominant potential groundwater impacts relate to changes to the local baseline water table elevations and to the frequency and quality of groundwater discharge to receiving environments. The aspects described above have the potential to impact groundwater in an additive manner. The combined consequence of construction earthworks (including the potential onshore dredge material placement option), presence of infrastructure and operations has been determined to be "Moderate". The likelihood of this consequence occurring is "Likely". The additive risk from the Project on groundwater is "Medium".

The greatest Project risk to the groundwater environment relates to the onshore placement of dredge material. The preferred option is to dispose of the dredge material offshore. Regardless, with the inclusion of the onshore dredge placement option, the Project activities likely to impact upon the groundwater environment pose a medium level of risk to the conservation values of the terrestrial assessment area and surrounds. The EPA management objective for groundwater is expected to be achieved.

A framework Construction EMP (Appendix U1) has been developed which, in part, provides a high level indication of how impacts to groundwater will be managed. This approach is consistent with the EPA's guidance on using a Risk-based approach in that EMPs for 'relevant environmental factors' are included with the EIS for assessment.

Prior to Project construction, a set of Subsidiary EMPs will be developed for relevant work scopes and activities, which detail the specific mitigation measures and management actions which will be implemented to limit Project related impacts to groundwater. Subsidiary plans will not be submitted for regulatory review but will be developed consistent with the strategies listed in the framework Construction EMP.

9.4 Surface Water

The following sections present the assessment of Project-related impacts on the surface water environment, taking into account design modifications, mitigation methods and controls applied to reduce impacts.

9.4.1 Management Objective

The EPA management objectives for surface water are:

- To maintain the quantity of surface water so that existing and potential environmental values, including ecosystem maintenance, are protected
- To ensure that emissions do not adversely affect environmental values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

9.4.2 Description of Factor

A summary of the assessments of the natural surface water environment within the terrestrial assessment area are provided below, with further details included in Chapter 6, *Overview of Existing Environment,* and in the technical report, included as Appendix G1.

9.4.2.1 Baseline Hydrology

Ashburton North is located in the Ashburton River Catchment and several small coastal sub-catchments. The Ashburton River is one of the major rivers of the Pilbara and is characterised by a catchment area of approximately 78 777 km^2. Major flows occur in the Ashburton River every one to three years. When in flood, flow from the Ashburton River spills onto the coastal floodplain and significantly adds to the stream flow in the sub-catchments of the Project area. Recorded Ashburton River flows vary widely between nil and 11 000 m^3 per second, with annual flow volumes from 3 to 4500 GL (2007 and 1997).

At a local scale, Ashburton North is located within the Ashburton River Delta. The Ashburton River Delta hosts the Ashburton River Mouth, Southwest, Hooley Creek and Northeast Sub-catchments. Ashburton North is located on the catchment divide between the Southwest and Hooley Creek Sub-catchments.

The Hooley Creek West, Hooley Creek East, Eastern Creek and Four Mile Creek watercourses of the Ashburton River Delta are predominantly dry, except for tidal reaches. Stream flow occurs in response to significant rainfall events, usually linked to cyclones, and typically is short-lived.

Stream flow is generated during and after regional and/or local rainfall events. The baseline evidence indicates that the local stream flow is supplemented by flows from the Ashburton River at about two-year average recurrence intervals (ARIs). Surface water quality in the local sub-catchments is a mixture of tidal seawater, run-off and salt concentration effects due to evaporation. When in flow, the local watercourses and the Ashburton River may mobilise and transport large volumes of sediment. The sediment load is widely variable from year to year, dependent on rates and volumes of stream flow discharge. Mobilisation and transport of sediment is a natural regional and local occurrence.

Turbidity in the Ashburton River and Ashburton River Delta, including tidal reaches of the Ashburton River Mouth, Southwest and Hooley Creek sub-catchments, is widely varied due to run-off, tidal and marine influences. Turbidity measured in the Ashburton River and local surface waters in clay pans near the Project area ranged from 0 to about 9000 mg/L TSS (Ruprecht & Ivanescu 2000, Biota & Timms 2009). The turbidity for the Ashburton River ranges from less than 15 mg/L TSS at low flows to 5000 mg/L TSS at flow rates that would induce flooding of the local sub-catchments. The flow weighted turbidity for Ashburton River is approximately 2700 mg/L TSS. Typically it is expected that turbidity would be less than 30 mg/L TSS except during and after stream flow and flood events.

9.4.2.2 Conceptual Hydrological Model

A conceptual hydrological model was developed for the Project area using data from both site investigations and numerical simulations. The hydrology of the Ashburton River Catchment and Ashburton River Delta has been characterised in *xprafts* models to obtain hydrographs representing run-off contributing to stream flow for different potential rainfall ARIs. Subsequently, a MIKE 21 two-dimensional hydrodynamic model of the Ashburton River Delta was developed in order to characterise the baseline surface water environment, assess the effects of flooding from the Ashburton River, investigate tidal inundation and assess the potential impacts of the Project. Hydrographs simulated by *xprafts* for both the Ashburton River Catchment and the Ashburton River Delta are used as input into the MIKE 21 model. Details of the modelling methods are included in Appendix G1.

The conceptual hydrological model indicates that the Ashburton River Delta and its sub-catchments are dynamic, with natural changes to landforms and watercourses actively occurring through erosion and deposition driven by both fluvial and marine processes. The Ashburton River typically breaks its banks every second year, leading to the occurrence of a broad flood plain within the Ashburton River Delta. When the river breaks its banks, water flows from the river onto low-lying areas of the Southwest and Hooley Creek Sub-catchments. When flow occurs, sediment is mobilised and may be transported to floodplain and marine environments at comparatively high concentrations and loadings (as measured by Ruprecht & Ivanescue 2000 and Biota & Timms 2009).

Depths and extents of flood inundation and concentrations and loadings of sediment are influenced by several factors including:

- Regional cyclonic rainfall occurrence and intensity within the Ashburton River Catchment
- Local rainfall within the Ashburton River Delta and discrete sub-catchments therein
- The Ashburton River breaking its banks
- Tidal and storm surge circumstances (Figure 9.4).

Each flood event is different, with different regional and local catchment responses. Under this setting it is interpreted that changes to landforms and watercourses that would be imposed by the Project may cause only subtle changes to baseline hydrology compared to the likely changes that would occur due to the natural dynamic processes.

The sub-catchments of the Ashburton River Delta are discreet only during short-term low intensity rainfall events. Cyclonic and other high intensity rainfall events are known to cause shallow catchment boundaries to be submerged. Typically, every second year, Ashburton North becomes part of broader scale Ashburton River coastal flood plain. During cyclonic rainfall and high run-off events, flood flows in the Hooley Creek spill over to both the eastern and western adjoining sub-catchment divides. To the east, flood waters spill across the Onslow Road into the adjoining catchment. To the west, a palaeo-tributary of the Ashburton River provides a hydraulic connection for flood flows to spill into the Southwest and Hooley Creek Sub-catchments. These are the natural characteristics of the coastal flood plain. Diversion of flood flows to adjoining sub-catchments is a natural consequence of the hydrology and topography of Ashburton North.

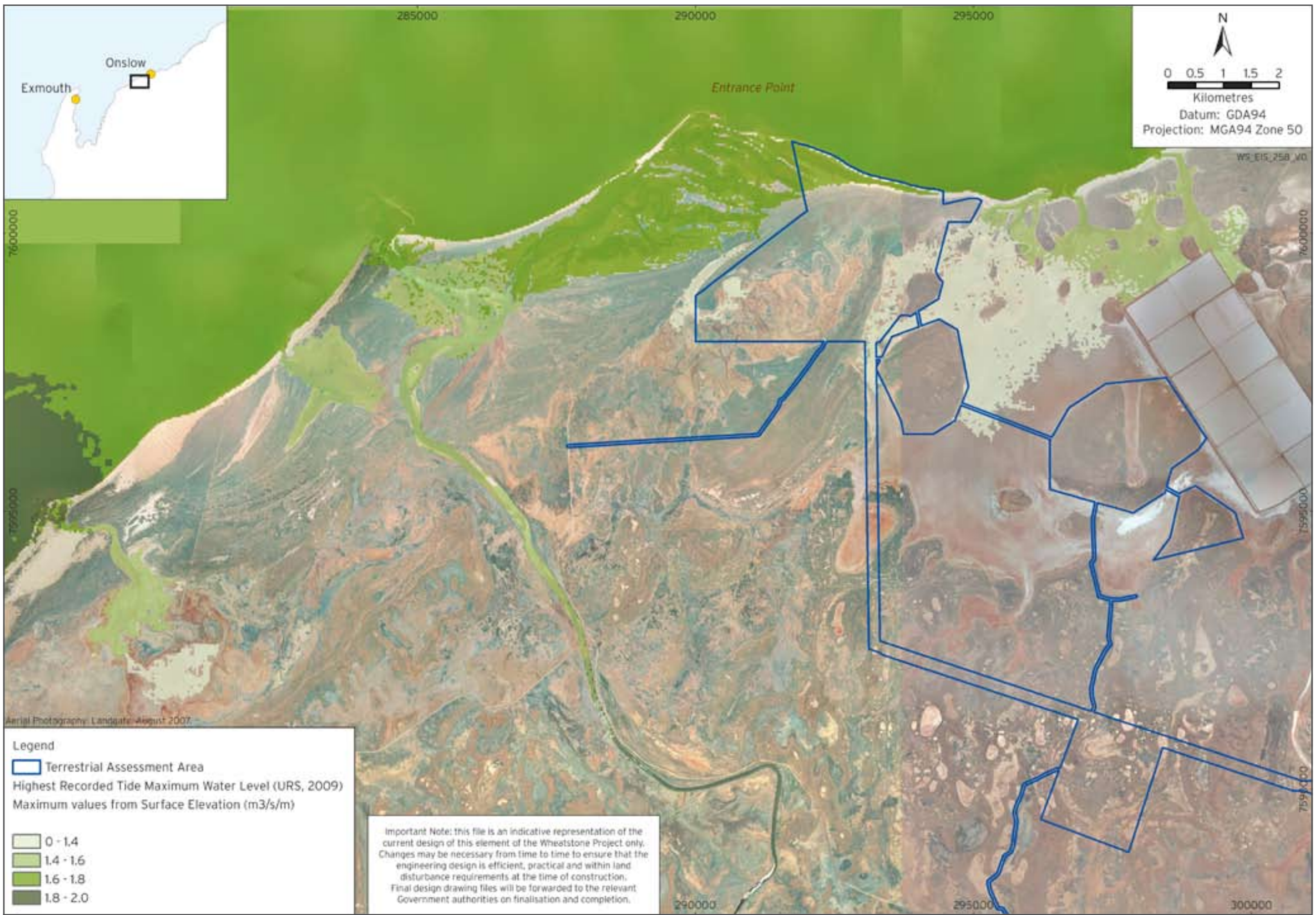

Figure 9.4: Baseline Setting – Inundation Linked to Highest Recorded Tide

The key potential surface water receptors at Ashburton North are the marine habitats of the Ashburton River Delta and tidal reaches of Hooley Creek. The Ashburton River Delta is recognised as an important, high conservation value and regionally significant ecosystem.

9.4.3 Assessment Framework

Table 9.10 provides a list of guidance statements specifically related to the assessment and management of groundwater.

9.4.4 Consequence Definitions

To enable assessment of risks associated with the Project, specific consequence definitions were developed. Table 9.11 provides the consequence definitions that have been used in the risk assessment of surface water.

9.4.5 Impact Assessment and Management

Impacts to surface water will occur as a result of Project activities. The following sections summarise the aspects and activities that may directly or indirectly affect surface water in, and surrounding, the Project area. Chapter 7, *Impact Assessment Methodology* contains the risk matrix used to assess the likelihood and consequence of impacts occurring. Potential management and mitigation measures are generally provided in greater detail for those aspects that have been identified as posing a higher risk to a factor than those aspects that are expected to pose a lesser risk. Table 9.13 provides a summary of the potential impacts, management measures and residual risk as a result of Project activities.

The methodology for the assessment of the risk to the surface water environment from the Project is based on:

- Field assessment of the local surface water environment, including the collection of surface water quality samples
- Interpretation of the available data to characterise the baseline surface water environments and develop conceptual models

Table 9.10: Position and Guidance Statements Relevant to Surface Water

Legislation or Guideline	Intent
ANZECC Guidelines for Fresh and Marine Water Quality 2000	Water quality limits for protection of ecosystem health. The local surface water environment is typically ephemeral following cyclonic rain events with salinity ranging from brackish to hypersaline. As such, the Marine Water Quality Guidelines have been considered applicable.
EPA Position Statement No. 8, 2005	Environmental Protection in Natural Resource Management. An outline of the EPA role in natural resource management with respect to evaluating environmental performance.
Pilbara water in mining guideline, Department of Water, September 2009	This Guideline builds on the Pilbara regional water plan, providing a specific focus on managing water associated with mining and resource projects.
Water and Rivers Commission Statewide Policy No 5 – Environmental water provisions policy for Western Australia, 2000	This policy informs the Department of Water how water will be provided and managed to protect ecological values and sustainable development consistent with the requirements of the *Rights in Water and Irrigation Act 1914* and the *Environmental Protection Act 1986*. The policy incorporates the concepts of Ecological Water Requirements and Ecological Water Provisions for water dependent environments.
Rights in Water and Irrigation Act 1914: Section 5C licence to take water and manage its use	This Act governs the regulation of water resources in WA. Regulatory licences and permits issued under this Act define water management and monitoring for individual projects.

- Inclusion of Project description information into the conceptual models to determine likely changes to the baseline surface water conditions
- Development of management concepts that limit potential impacts to the surface water environment and receiving environments.

9.4.5.1 Construction Earthworks – Clearing and Disturbance of Surface Soils

Residual risk to surface water due to clearing and disturbance of surface soils is	**Low**

Construction earthworks and associated clearing and disturbance of surface soils may impact on the surface water environment. The potential impacts to the baseline surface water environment include:

- Clearing promoting increased run-off and erosion
- Clearing and ground disturbances promoting increased mobility of salt and sediment
- The use of fill material increasing sediment loads and sediment concentrations.

The predominant potential impact is linked to changes in salt concentrations and increases in sediment concentrations and sediment loads in run-off that enters the surface water environments and marine habitats of the Hooley Creek, Southwest and Ashburton River Mouth Sub-catchments.

Potential impacts on surface water quality have been assessed based on baseline quality, salinity and sediment concentrations. The ANZECC National Guidelines for Fresh and Marine Water Quality (2000) have been referenced for the surface water assessments. The ANZECC Guidelines (2000) default trigger values for salinity and turbidity in slightly disturbed ecosystems in tropical Australia, including North West WA, are shown in Table 9.12.

The ANZECC Guidelines, together with available baseline data, will be used to develop site specific trigger values for salinity and turbidity. This approach is considered appropriate given:

- The receiving environments occur predominantly in marine habitats where surface water enters the sea
- The local environment typically is in part exposed to tidal influences and seawater.

Table 9.11: Consequence Definitions for Surface Water

Terrestrial						
Factor	**1**	**2**	**3**	**4**	**5**	**6**
	Catastrophic	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Surface water	Long-term loss of surface water quality at a regional scale, which cannot be remediated	• Major changes in regional surface water hydrology and flow regimes due to landform alteration significantly affecting critical surface and groundwater dependent ecosystems over a region • Regional short-term exceedence of background and applicable ANZECC Water Quality Guidelines	• Changes to water quality of local surface water resources resulting in localised long-term exceedence of background and applicable ANZECC Water Quality Guidelines • Long-term significant effects to surface water quality in a localised area with extensive, long-term remediation required to restore environmental values • Major changes in sub-catchment surface water hydrology and flow regimes over a local area over the long term	• Short-term significant effects to local surface water quality with short-term remediation required • Changes to local surface water resources resulting in localised short-term exceedence of background and applicable ANZECC Water Quality Guidelines • Local and significant change in sub-catchment surface water hydrology and flow regimes over a local area over the long term	• Minor changes to local surface water resources, resulting in local short-term and small reduction in surface water quality with no exceedence of background and applicable ANZECC Water Quality Guidelines • Local and minor change in sub-catchment surface water hydrology and flow regimes	• Localised and short-term reduction in surface water quality that can be readily remediated • Localised and short term disturbance to surface water hydrology and flow regimes that can be readily remediated

Impact: *direct interaction of a stressor with the environment |* ***Local area:*** *directly affected by the development and the surrounding environs (radius of 2 km from the Ashburton North site) |* ***Regional area:*** *extending to well beyond the development and surrounding environs (Carnarvon and Pilbara Bioregions) |* ***Short term:*** *<5 yrs from commencement of the construction phase |* ***Long term:*** *>5 yrs from commencement of the construction phase*

Table 9.12: ANZECC Guidelines for Salinity and Turbidity in Tropical Australia

Ecosystem Type	Salinity		Turbidity (NTU)
	Electrical Conductivity (µS/cm)	Equivalent Estimated TDS (mg/L)	
Upland and lowland rivers, such as Ashburton River and local watercourses	20–250	10 - 150	2–15
Estuarine and marine settings, such as tidal reaches of Ashburton River Delta, including Hooley Creek	52 000	33 000	1–20

The trigger values will be developed once additional baseline information has been collected, provided in the CEMP and OEMP prior to construction, and linked to contingency plans that would be implemented should prescribed non-conformance circumstances become apparent from monitoring programs.

The available baseline evidence suggests that the local terrestrial and tidal marine habitats are turbid, at least temporarily and/or seasonally during and after stream flow and flood events. Accordingly it may be assumed that these habitats have robustness in exposures to and potential impacts from sediment in stream flow and tidal reaches of the local watercourses. Notwithstanding, sustained exposure to increased sediment concentrations and sediment loads to receiving marine environments of the West Hooley Creek and Ashburton River Delta may impact on local marine habitats. As such, the potential run-off to Hooley Creek and within the Southwest Sub-catchment may require that management of total suspended sediment (TSS) concentrations and sediment loads is designed for compatibility with, and will limit potential stresses on, the baseline environments. To mitigate the risks associated with run-off that contains increased sediment concentrations and sediment loads, the areas cleared and with disturbed surface soils are likely to need management to limit turbidity concentrations of the surface water run-off. Sedimentation traps and silt fences may be constructed on local watercourses and on the perimeters of the earthworks areas to intercept sediment that has been mobilised by the earthmoving.

Accordingly, to mitigate potential impacts, the Project will be designed to incorporate practicable run-off and erosion control measures. A system of drains will be constructed to divert run-off from the Plant Pad to storm water sedimentation ponds. The storm water sedimentation ponds may be used in conjunction with other engineering solutions including silt fencing, stone dikes and riprap aprons to control local run-off, erosion and sedimentation.

Summary

The potential impacts to surface water due to clearing and disturbing of surface soils during earthworks can be mitigated through the implementation of appropriate design aspects, management measures and engineering controls to limit erosion and sediment concentrations. The residual environmental risk to the surface water environment is assessed as being "Low" - it is "Likely" that impacts to surface water will occur, however, following the implementation of appropriate management and contingency plans presented in Table 9.13, the impacts will be of "Minor" consequence.

9.4.5.2 Construction Earthworks - Dredge Material Placement Area

Residual risk to surface water from dredge material placement area is	Medium

The Project considers two placement options for the dredge material. One option includes offshore placement area and is assessed in Chapter 8, *Marine Risk Assessment and Management*. The second option considers onshore placement of the dredge material and is assessed in this chapter. The onshore placement option involves the dredged material being transported hydraulically and disposed into a purpose-built placement area within the Plant Pad footprint. The placement area would be bunded around the perimeter and constructed to the west of the Plant Pad (Figure 9.1). Chapter 2, *Project Description* provides additional details of the onshore dredge material placement area.

Dewatering of the dredge material will occur during and after the emplacement. Dewatering will occur through the decanting of supernatant seawater, with consolidation processes aided by evaporation and seepage into the groundwater and surface water environments. Decant seawater and rainfall on to the placement area will be pumped offshore from the southern sump and discharged by pipeline to the marine outfall for approximately 18 to 24 months. The remaining minimal run-off from the area arising from natural dewatering of the placed material and rainfall will be allowed to follow the natural drainage path for surface water into the south-west catchment. The disposal of decanted seawater may require the management of TSS concentrations and sediment loads compatible with those of the baseline environments.

In order to reduce the potential for environmental impacts, including those on the Ashburton River Delta, the following mitigation measures will be implemented in the design and operation of the dredge material placement area:

- The placement area has been selected to reduce the footprint used
- Dredged material will be contained in a bunded area to prevent unconfined release of seawater and sediments
- The bunded area incorporates a sump and associated weir boxes to intercept and manage decant seawater and sediment. Drainage of decant seawater over the placement area will be to the south away from the Ashburton River Delta therefore limiting the potential impact from rising groundwater levels
- The placement of material will promote trapping of fines in the settled material and reduce the amounts of fines in suspension. The placement approach will potentially reduce groundwater levels in the placement areas and consequently seepage potentials
- Where practical, placement in the eastern half of the placement area will be preferred to limit water table mounding and seepage from the western placement areas
- Bunds will be designed to withstand erosion during inundation events
- Discharge of decant water during the first 18-24 months will be pumped via pipeline to a marine outfall. The disposal of decanted seawater to the near-shore marine environment would involve pumping from the placement area to a marine outfall immediately north of the Plant Pad. These potential impacts are discussed further in Chapter 8, *Marine Risk Assessment and Management*
- Surface water levels within the bunded area will be managed to avoid overtopping of the bunds, even during extreme high rainfall
- A drain (with sump and pump system) will be installed on the outside perimeter of the southern embankment to collect and divert seepage away from the Ashburton River Delta
- Groundwater monitoring bores will be installed to detect any alteration of groundwater environments that may indicate a potential risk to the Ashburton River Delta.

Potential impacts to the surface water environment related to the onshore disposal of dredge material may occur due to seepage and water shed from the dredge material placement area.

Seepage from the Dredge Material Placement Area

Seepage of seawater from the dredge material placement area may express as discharge on the ground surface and associated surface water flows within the Southwest and Ashburton River Mouth Sub-catchments.

Seepage that expresses as surface water flows has the potential to:

- Change the frequency of surface water flows on local watercourses
- Lead to water-logging of watercourses and surrounds.

Predictive modelling assessments of the potential seepage indicate seepage occurs:

- On the southern perimeter of the placement area, within the Southwest Sub-catchment
- On the western perimeter of the placement area, within the Ashburton River Mouth Sub-catchment.

The predictive simulations show total seepage from the dredge material placement area peaks at a rate of about 2 200 kL/day (see Figure 9.2). The predicted seepage rates rise progressively throughout the campaign of dredge material disposal onshore, peaking as the campaign ceases. Thereafter the seepage rates decay over a period of five to ten years to about 200 to 400 kL/day. Predicted seepage rates above 1 000 kL/day occur for about one year.

Seepage discharge from the dredge material placement area is predicted to predominantly occur on the perimeter of the southern embankment (see Figure 9.3). Substantially smaller scale seepage discharges occur on the perimeter of the western and natural dune sands embankments. Deposition and accumulation of salt is expected at locations where the seepage expresses at the ground surface.

Within the Ashburton River Mouth Catchment the predicted seepage footprint and seepage rates are comparatively small. Low rates of seepage may, however, occur for up to ten years. The simulated seepage rates are sufficiently low that they may be intercepted by evaporation and not express as significant surface water flows on the ground surface. Changes to water and salt budgets of the Ashburton River Delta are expected to be insignificant.

The seawater seepage expressed as surface water flows may discharge to marine habitats of the Ashburton River Delta. This surface water discharge may potentially impose impacts to the marine habitat. These impacts to the marine environment are assessed in Chapter 8, *Marine Risk Assessment and Management*.

The inherent environmental risks from seepage of seawater from the dredge material placement area are expected to be "Medium", predominantly due to the simulations that show effective methods for management of seepage, predicted rates of seepage and the wide seepage front.

Water Shed from the Dredge Material Placement Area

Once dredging has ceased, runoff captured within the dredge material placement area would initially be diverted to the sump within the facility and subsequently discharged into the Southwest Catchment. The sump and associated weir boxes would enable management and storage of runoff, providing residence time for settlement of sediment. After completion of the dredge material placement, the runoff capture zone for the Southwest Catchment would approximate that of the baseline environment. Consequently, the volumes of runoff from the catchment would be similar to the baseline.

Summary

It is likely that impacts on surface water from construction earthworks associated with the dredge material placement can be appropriately managed with engineered controls on design of the placement area, seepage and water shedding from the facility. Consequently, the residual environmental risk to the surface water environment from the placement area is assessed as being "Medium". Should dredge material be placed onshore, there is "Likely" to be impacts to the surface water environment, however, these impacts have been assessed to be of "Moderate" consequence with the adoption of management controls and mitigation measures presented in Table 9.13.

9.4.5.3 Construction Earthworks – Potential Acid Sulfate Soils

Residual risk to surface water from potential acid sulfate soils is	**Low**

The construction of the Plant Pad and the excavation of the MOF and borrow areas may expose PASS. The oxidation of PASS may result in the generation of acids and or mobilisation of metals. The distribution of PASS in the Project area is detailed in Section 6.4.4.2.

Management controls are required in any areas of the terrestrial assessment area that have been identified as high to moderate risk for PASS as part of the PASS risk assessment (illustrated in Section 6.4.4.2) and where ground disturbance is proposed. In addition, if the action criteria identified in the Acid Sulfate Soils Guideline Series (Department of Environment and Conservation 2009a) are reached or exceeded, management of disturbed PASS will occur. A summary of PASS management controls and mitigation measures and definition of criteria to determine the successful treatment of PASS material is presented in Table 9.13.

The management controls will be developed as part of Construction Environmental Management Plan (CEMP). These controls, and the criteria to determine successful treatment of PASS material, will be prepared taking into account the Department of Environment and Conservation (2009b) Acid Sulfate Soils Guideline Series – Treatment and Management of Soils and Water in Acid Sulfate Soil Landscapes.

The management controls will include the following:

- Inform workforce of the nature and potential impacts of PASS
- Review PASS Risk Map to ascertain whether PASS will be disturbed
- Avoid the disturbance of PASS where possible
- Refer to the CEMP for management strategies when disturbance is unavoidable
- Management of PASS material utilising best practice management methods, as outlined in the CEMP.

Summary

The residual environmental risk to the surface water environment from the exposure of PASS soils is assessed as being "Low". Given the conservative approach to PASS mapping, excavation of borrow areas is likely to expose PASS material. Therefore, there is "Likely" to be impacts to the surface water environment, however, these impacts have been assessed to be of "Minor" consequence with the adoption of management controls and mitigation measures presented in Table 9.13.

9.4.5.4 Operations – Presence of the Facilities

Residual risk to surface water from the presence of a raised Plant Pad and other infrastructure is	Low

The Project comprises the construction of a Plant Pad, shared infrastructure corridor and accommodation village. The processing facility will be constructed on a pad that may include some bunding, to provide protection of the plant to a 1:100 year flooding event (approximately 7.5 m AHD). The accommodation village pad and SIC will be designed predominantly above a 1:100 year flood event (approximately 6 m AHD). The fill (structural) material will be sourced in accordance with the Acid Sulfate Soils Guideline Series – Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes.

The Plant Pad and associated infrastructure (including the SIC and accommodation village) is partly located in the Hooley Creek Sub-catchment and partly in the upper portion of the Southwest Sub-catchment. As such, stream flow on tidal reaches of West Hooley Creek, East Hooley Creek, Eastern Creek and Four Mile Creek may be altered.

In the Southwest Sub-catchment the Plant Pad and dredge material placement area will cover a considerable portion of the catchment area, thereby changing the storage capacity and run-off characteristics in the catchment.

The proposed alignment of the SIC intersects 16 drainage lines of the Hooley Creek Sub-catchment. These drain local rainfall run-off from the Hooley Creek Catchment and periodic Ashburton River flood water after intense rainfall events. In order to limit the potential impacts on the baseline surface water characteristics, the conceptual design provides for drainage infrastructure. That is, culverts are incorporated into the MIKE 21 model for all 16 drainage crossings traversed by the shared infrastructure corridor.

The assumed modelling design elements for the SIC include:

- Minimum elevation of road at drainage line crossings is 4.5 m AHD, but typically about 6.0 mAHD
- Minimum road cover above culvert infrastructure is 0.5 m
- Drainage structures designed for a 1:25-year ARI rainfall event.

Final elevations for the SIC will be determined during detailed engineering design.

The accommodation village is located approximately 10 km south-east of the Plant Pad. The accommodation village site does not intersect any major watercourses but may alter local watercourses.

The presence of the Plant Pad and associated infrastructure is expected to change the local landforms. Changes to the landforms tend to alter the local catchments and natural drainage lines, promoting changes in run-off and channel flow. This impact is likely to be long-term due to the proposed raised elevations of the constructed landforms.

Potential surface water impacts related to the presence of the Plant Pad and associated infrastructure include changes to:

- Flood water depths and elevations
- Stream flow periods and peak discharges
- Stream flow velocities.

The Project area is characterised by sporadic rainfall, with rainfall events usually limited to about 16 days each year. As such, the terrestrial environment is predominantly dry. Further, the Project area is situated on a dynamic floodplain of the Ashburton River and coastal environments that are characterised by active deposition and erosion processes. Variations in rainfall locations, amounts and intensity across the local and regional catchments and sub-catchments manifests in widely varied surface water flows. Stream flow is irregular and widely varied dependent on local and regional sources of rainfall and rainfall intensity. Local stream flow is commonly (about every second year) supplemented by flood flows in the Ashburton River and from adjoining sub-catchments on the coastal plain. As such, individual stream flow events are unique, with likely unique rainfall sources and flow paths.

The MIKE 21 model was applied to predict the potential impacts of the altered hydrology linked to the Project and associated presence of infrastructure. The MIKE 21 model is adapted to incorporate the proposed footprints of the Plant Pad, SIC and accommodation village, with appropriate design elevations and drainage structures applied. Predictive simulations that incorporate the Project infrastructure were assessed for a range of storms, including 5-, 10-, 25- and 100-year ARI events. These events were simulated in combination with a range of tidal events including Mean Sea Level, Highest Recorded Tide and 1:100-year storm surge.

Since no historical flood heights have been obtained for the Ashburton River Delta and the Project area, the MIKE 21 predictive model is not calibrated. As a consequence, the vertical accuracy of the MIKE 21 model, simulated flood elevations and predicted flood water distributions is primarily determined by the accuracy of LIDAR topographic survey data which has a vertical resolution of 0.3 m. The predictive model and grid size does not allow fine-scale resolution of flow paths at flood heights less than 0.3 m. The predicted impacts of events more frequent than 1:25-year ARI are typically within the vertical resolution of the model.

Flood Depths and Elevations

The predictive simulations show the potential impact of the Plant Pad and SIC on the baseline hydrology is minimal for events more frequent than a 25-year ARI. Under such circumstances, the predicted changes in flood depths are typically in the range from 0.1 to 0.25 m. There are local exceptions along the proposed SIC where the differences in flood depth may range up to 0.5 m.

Predicted impacts of the 25 and 100-year ARI events are similar. Minor differences occur in the areas impacted by changes in flood depths less than 0.5 m, with the 100-year ARI event likely to cause impacts over a marginally broader area. In both predictive simulations, the SIC may be linked to local changes in flood depths in the range from 0.5 to 1.0 m. These predicted impacts occur adjacent to the northern portions of the road and southern part of the Plant Pad, typically marginally east of the divide between the Southwest and Hooley Creek Sub-catchments. These impacts may include:

- Temporary retardation and damming of flood flows upstream (west and south) of the SIC and Plant Pad
- Increasing maximum water elevations for flood events less frequent than a 10-year ARI
- Retardation of flows for a 1:100-year ARI event causing potential increasing of spill into the Southwest Sub-catchment.

The predicted changes to the flood depths and elevations would be maintained as long as the Project infrastructure remains in place. Notwithstanding, the Project area is situated within a naturally dynamic flood plain environment wherein stream flow events are sporadic, widely varied and occur over short terms. In many instances, the periods of flow would be less than a few days to one week each year. As such, the predicted changes are interpreted to potentially impose short-term and temporary changes to the local surface water environments. It is expected that actual changes may not be measurable.

Stream Flow Period and Peak Discharges

The presence of the Plant Pad and associated infrastructure may influence the stream flow periods and peak discharges of surface water flows and impact on the natural flood flows.

A comparison of simulated baseline and altered hydrology hydrographs for the main drainage lines for 25- and 100-year ARI events has enabled a snap-shot of surface flow diversions linked to the proposed infrastructure. The predicted differences between the baseline and altered hydrology hydrographs are likely to be minor. For example:

- For a 25-year ARI flood event, the predicted and baseline hydrographs appear very similar in both shape and peak discharges. The presence of the Project infrastructure may cause a short delay in the discharges, but does not change the baseline characteristics of the flow system
- For a 100-year ARI event, the predicted and baseline hydrographs appear very similar in both shape and peak discharges. The presence of the Project infrastructure may cause a short delay in the discharges, although more so than for the 25-year ARI event, but does not cause a significant change in the baseline characteristics of the flow system.

The predicted changes to stream flow period and peak discharges may occur as long as the Project infrastructure remains in place. Notwithstanding, given the naturally sporadic, widely varied and short-term nature of the stream flow events, it is expected that actual changes and impacts may not be measurable.

Stream Flow Velocities

The presence of the Plant Pad and associated infrastructure may influence the velocity of surface water flows at a local scale. Changes to baseline stream flow velocities would tend to occur in areas where flow paths have been constricted by altered landforms, resulting in the diverting of flows to alternative watercourses. The predicted differences between the baseline and altered hydrology stream flow velocities were simulated. The modelling predicted that:

- For a 10-year ARI event, the predicted differences in simulated flow velocities are within the resolution of the model and no significant impacts are predicted
- For a 25-year ARI event, predicted differences in flow velocities occur at several locations to the east of the Plant Pad in the Hooley Creek Sub-catchment. The increased flow velocities are interpreted to be linked to encroachment of the Plant Pad embankment onto the West Hooley Creek

- For a 100-year ARI event, differences in the simulated flow velocities are further accentuated. However, these increased flow velocities would be reduced with the excavation of borrow areas 1 and 2.

Outside of the Hooley Creek Sub-catchment the impacts of altered hydrology on stream flow velocity may be linked to retardation of flows by infrastructure. Impacts may be sporadic and not measureable, particularly under designs intended to limit retardation of flows.

Changes to the flow velocities may occur as long as the Project infrastructure remains in place. The differences are likely to occur over short periods coincident with times of peak discharges. As such, the changes are interpreted to potentially impose short-term and temporary changes to the local surface water environments. It is expected that actual changes may not be measurable.

Summary

When placed in context with the widely varied baseline sub-catchment responses to rainfall and Ashburton River stream flow, it is concluded that the predicted impacts on surface water from the presence of the Project facilities pose low residual environmental risks. Stream flow events are widely varied and the local environment is ever changing. As a consequence of the described assessments, the residual environmental risk to the surface water environment from the presence of the Project facilities is considered as being "Low" - there is "Likely" to be impacts to the surface water environment, however, these impacts have been assessed to be of "Minor" consequence with the adoption of management controls and mitigation measures presented in Table 9.13.

9.4.5.5 Operations - Spills and Leaks

Residual Risk to Surface Water from Operational Spills and Leaks is	**Low**

There is potential for leaks and spills of hydrocarbons, wastes and other hazardous materials during storage, transport and transfer of products. Leaks and spills may enter the surface water environment, with transport to and fate within local watercourses and marine receiving environments, such as marine habitats.

Management of leaks and spills will focus on prevention, through provision of appropriate storage vessels, containment facilities, transfer equipment and handling methods. Spill response procedures will be developed as part of CEMP and OEMP and will carry through all phases of the Project. Appropriate equipment and training will be provided so that personnel are able to respond appropriately. Clean up and remediation will form part of the spill response procedures.

There are several scenarios during the operation of the Project that may impact on the quality of local surface water environments. These include:

- Overtopping of storm water sedimentation ponds
- Spills or leaks of contaminants such as hydrocarbons, which may be transported into the natural surface water environment during rainfall events.

Overtopping of Storm Water Sedimentation Ponds

Storm water sedimentation ponds are intended to intercept the majority of run-off from the Plant Pad and associated hardstand and sealed areas. Clean (non-contact) stormwater from non-process areas and undeveloped portions of the site will be routed to sedimentation ponds. These will be unlined and designed to only settle out rain-borne soil. Discharge will be to existing natural drainage channels leading to the ocean. Clean stormwater volumes will vary due to the erratic local rainfall patterns, but may be up to 9,600 kL/day. Potentially contaminated (contact) stormwater from general process areas will be routed to "first flush" retention basins to capture oily or other types of potential contamination from the first 25mm of rainfall on these areas. Overflow from rainfall exceeding the first 25mm will be routed to natural drainage channels leading to the ocean. The retention basins will be equipped with oil skimmer devices, and with pumps to transfer the entire contents to process wastewater treatment if significant contamination is found. Contaminated stormwater from known oily areas (pump pads, etc.) will be routed to collection sumps and pumped to process wastewater treatment. Potentially contaminated and contaminated stormwater volumes will also vary, but may be up to 3100 kL/day. Further details on the stormwater design are outlined in Section 4.6.3.

Outfall from the sedimentation ponds is being designed for a 100-year rainfall event at which time overtopping may occur. Contributions of water flow and sediment from the plant into West Hooley Creek will be insignificant compared to the flood waters generated by the Hooley Creek Catchment and Ashburton River.

Spills or Leaks of Hydrocarbon and Other Contaminants

Leaks and spills may occur during the construction, commissioning, operations and decommissioning phases of the Project. Leaks and spills are most likely to occur in association with pipeline or equipment failure, storage and handling of product, fuels and chemicals, waste storage and disposal. There is also potential for spills and leaks of hydrocarbons, wastes and other hazardous materials during transport and transfer of products.

Operational transfers of fuels, ballast water or waste material are generally small in volume. Therefore the potential impact of a spill or leak during operational transfers on the surface water flow and quality characteristics is considered to be low.

Release of contaminants into the natural environment is likely to have a negative impact on surface water quality, with potential transport and subsequent impact to terrestrial ecosystems, local watercourses and marine receiving environments.

Discharges of wastewater and brine from the reverse osmosis (RO) plant will be treated and pumped directly to sea even during the initial development of the site. This aspect is addressed in Chapter 8, *Marine Risk Assessment and Management*.

The likelihood of spills and leaks occurring in the terrestrial environment will be reduced through implementation of design controls and a program of inspection, monitoring and maintenance conducted in accordance with the Contaminated Sites Guideline Management Series. This management program will be in place for all phases of the Project. Management controls have been developed to reduce risks associated with various potential sources of leaks or spills.

The management controls for spills and leaks will include the following:

- Appropriate design, construction and maintenance of storage, handling and transfer infrastructure
- A risk-based integrity assurance program for storage vessels and pipelines
- Adequate and appropriate emergency response capability
- Spill response procedures and training
- Implementation of appropriate treatment and/or rehabilitation techniques where significant impacts to soils or landforms occurs.

These management controls will be implemented as part of the CEMP and the OEMP, which will include appropriate management plans, procedures and training requirements to facilitate management of spills and leaks.

Summary

Given the design criteria described in Chapter 2, *Project Description,* it is unlikely that spills and leaks will enter the surface water near the plant; hence the potential for impacts is anticipated to be minimal. Operational leaks from storage are likely to be generally small in volume and therefore the impact on the surface water hydrology and flow characteristics would be low.

The residual environmental risk for this potential impact was assessed as being "Low" – the most conservative risk ranking assesses the impacts of a major onshore spill or leak. It is anticipated that, with the adoption of management controls and mitigation measures presented in Table 9.13, this event would be "Unlikely", but could perceivably be of "Major" consequence.

9.4.6 Implications for Matters of National Environmental Significance

There are no matters of NES that will be affected by impacts associated with surface water.

9.4.7 Residual Risk Summary

Table 9.13 provides a summary of the aspects, activities and potential impacts to surface water as a result of Project activities. Indicative management controls and mitigating factors are also listed, along with the residual risk following implementation of the management controls.

9.4.8 Predicted Environmental Outcome

The Project is unlikely to influence the regional surface water environments. The potential changes to the regional baseline surface water environment beyond the sub-catchments of the Ashburton River Delta are unlikely to be measureable. The predicted impacts to the surface water environment linked to Project are local effects that do not propagate beyond the sub-catchments of the Ashburton River Delta if appropriately managed.

The aspects described above have the potential to impact surface water in an additive manner. The combined consequence of the aspects identified in Table 9.13 on surface water has been determined to be "Moderate". The likelihood of this consequence occurring is "Likely". The additive risk from the Project on surface water is "Medium". The key risk is linked to the potential for increased sediment loads and seepage water volume to drainage lines and creeks during construction earthworks, dredge material placement and thereafter from unstable landforms.

The greatest Project risk to the surface water environment relates to the onshore placement of dredge material.

Table 9.13: Summary of Management Options and Residual Risk for Surface Water

Aspect and Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Construction Earthworks							
Clearing and Disturbance of Surface Soils	• Increased run-off and erosion • Increased mobility of sediments • Increased sediment loads and sediment concentrations	• Manage total suspended sediment concentrations and sediment loads to design for compatibility with, and to limit potential stresses on, the baseline environments • Sedimentation traps and silt fences may be constructed on local watercourses and on the perimeters of the earthworks areas to intercept sediment that has been mobilised by the earthmoving • The Project will be designed to incorporate practical run-off and erosion control measures. These may include engineering solutions such as perimeter bunds and culverts, sedimentation ponds, use of silt fences and placement of rock at the surface water release points • A system of drains will be constructed to divert run-off from the Plant Pad to storm water sedimentation ponds • The storm water sedimentation ponds will be used in conjunction with other measures including silt fencing, stone dikes and riprap aprons to control local run-off, erosion and sedimentation	5	2	**Low**	**Reasonable** Short term monitoring results available Available information is adequate	No

Dredge Material Placement Area	• Changes to surface water quality and quantity	• The placement area has been selected to reduce the footprint used • Dredged material will be contained in a bunded area to prevent unconfined release of seawater and sediments • The bunded area incorporates a sump and associated weir boxes to intercept and manage decant seawater and sediment • The placement of material will promote trapping of fines in the settled material and reduce the amounts of fines in suspension • Where practicable, placement in the eastern half of the placement area will be preferred to limit water table mounding and seepage from the western placement areas • Bunds will be designed to withstand erosion during inundation events • Discharge of decant water during the first 18-24 months will be pumped via pipeline to a marine outfall • Surface water levels within the bunded area will be managed to avoid overtopping of the bunds, even during extreme high rainfall • A drain (with sump and pump system) will be installed on the outside perimeter of the southern embankment to collect and divert seepage away from the Ashburton River Delta • Groundwater monitoring bores will be installed to detect any alteration of groundwater environments that may indicate a potential risk to the Ashburton River Delta	4	2	**Medium**	**Reasonable** Short term monitoring results available. Available information is adequate	No
Oxidation of Potential Acid Sulfate Soils	• Oxidation resulting in generation of acid and/or mobilisation of metals	• Inform workforce of the nature and potential impacts of PASS • Review PASS Risk Map to ascertain whether PASS will be disturbed • Avoid the disturbance of PASS where possible • Refer to the CEMP for treatment and disposal strategies when disturbance is unavoidable • Management of PASS material utilising best management practice methods, as outlined in the CEMP • Where the action criteria identified in the Acid Sulfate Soils Guideline Series (Department of Environment and Conservation 2009a) are reached or exceeded, management of PASS will occur	5	3	**Low**	**High** Excellent survey data	No

Aspect and Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Operations							
Presence of the Facilities	• Changes to flood depths and flood elevations • Changes to steam flow periods and peak discharges • Changes to stream flow velocities	• Culverts are incorporated into the MIKE 21 model for drainage crossings traversed by the shared infrastructure corridor	5	2	**Low**	**Reasonable** Available information is adequate	No
Spills and Leaks	• Changes to surface water quality	• Primary and secondary containment, where appropriate • Loading alarms • Treatment of waste water at source • Monitoring of systems for early spill detection	3	4		**High** Several expert investigation/ studies	No
Additive Effects							
All of the above	All of the above	All of the above	4	2	**Medium**	**Reasonable** Short term monitoring results available. Available information is adequate	No

The preferred option is to dispose of the dredge material offshore. Regardless, with the inclusion of the risks associated with the onshore dredge placement option, the Project activities likely to impact upon the surface water environment pose a medium level of risk to the conservation values of the terrestrial assessment area and surrounds. The EPA management objective for surface water is expected to be achieved.

A framework Construction EMP (Appendix U1) has been developed which, in part, provides a high level indication of how impacts to surface water will be managed. This approach is consistent with the EPA's guidance on using a Risk-based approach in that EMPs for 'relevant environmental factors' are included with the EIS for assessment.

Prior to Project construction, a set of Subsidiary EMPs will be developed for relevant work scopes and activities, which detail the specific mitigation measures and management actions which will be implemented to limit Project related impacts to surface water. Subsidiary plans will not be submitted for regulatory review but will be developed consistent with the strategies listed in the framework Construction EMP.

9.5 Flora and Vegetation

The following sections present the assessment of impacts on terrestrial flora and vegetation associated with the Project, taking into account design modifications, mitigation methods and controls applied to reduce impacts.

9.5.1 Management Objective

The EPA defined management objective for terrestrial flora and vegetation is to maintain the abundance, diversity, geographic distribution and productivity, at species and ecosystem levels, through avoidance or management of adverse impacts.

9.5.2 Description of Factor

For the purposes of this ERMP, this chapter generally refers to terrestrial flora and vegetation not affected by marine or tidal exchange (e.g. mangroves). Details of the flora and vegetation studies conducted for the Project are provided in Chapter 6, *Overview of Existing Environment* and in the survey reports included as Appendix I1 and Appendix I2.

Thirty vegetation units have been described within the survey area during flora and vegetation studies conducted for the Project (Biota 2009a). Twenty six of these vegetation units are located within the onshore Project area. Four of the 26 vegetation units present in the Project area are considered to have some degree of local conservation significance. For the purposes of this Project, a vegetation unit is considered to be of conservation significance (as defined by Biota 2009) if it:

- Contains or potentially supports threatened flora or other flora species of interest
- Is in very good condition (relatively slight signs of damage caused by European man e.g. damage to tree trunks cause by repeated fire or the presence of relatively non-aggressive weed species)
- Is particularly susceptible to erosion and/or weed invasion following disturbance
- Has a restricted occurrence.

The vegetation in the Project area is generally described as being in very good to excellent condition; however three vegetation units (CD2, CS2 and CS4) were heavily infested with the introduced flora species buffel grass (*Cenchrus ciliaris*) and/or mesquite (*Prosopis pallida* [Biota 2009a]). Overall, there were 12 introduced flora species recorded in the Project area and, of these, five were widespread, including (Biota 2009a):

- Mesquite (*Prosopis pallida*)
- Mimosa Bush (*Vachellia farnesiana*)
- Buffel Grass (*Cenchrus ciliaris*)
- Birdwood Grass (*Cenchrus setiger*)
- Purslane (*Portulaca oleracea*).

Chapter 6, *Overview of Existing Environment* illustrates the location of the main introduced flora species infestations in and around the Project area.

Three Priority flora species (*Eremophila forrestii* subsp. *viridis* [Priority 3], *Atriplex flabelliformis* [Priority 3] and *Triumfetta echinata* [Priority 3] as listed by the DEC) were identified within the Project area. There was also one Threatened Flora species, *Eleocharis papillosa* (Dwarf Desert Spike-rush), listed as Vulnerable under the EPBC Act (Cth) and as a Priority 3 flora species, and an additional Priority flora species (*Abutilon uncinatum* ms. [Priority 1]) found in the survey area, but not in the Project area. Further detail of threatened flora in the survey and Project areas is included in Chapter 6, *Overview of Existing Environment*, and Appendix I1 and Appendix I2.

9.5.3 Assessment Framework

Table 9.14 provides a list of the guidelines specific to the management of flora and vegetation in WA.

Table 9.14: EPA Position and Guidance Statements Relevant to Flora and Vegetation

Guideline	Intent
EPA Guidance Statement No. 6 – Rehabilitation of Terrestrial Ecosystems	This Guidance Statement functions to ensure the return of biodiversity in rehabilitated areas by increasing the quality, uniformity, and efficiency of standards and processes for rehabilitation of native vegetation in Western Australia.
EPA Guidance Statement No. 51 - Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia	This Guidance Statement functions to provide guidance and information on expected standards and protocols for terrestrial flora and vegetation surveys to environmental consultants and proponents.
EPA Position Statement No. 3 - *Terrestrial Biological Surveys as an Element of Biodiversity Protection*	This Position Statement functions to encourage proponents to focus their attention on the significance of biodiversity and therefore the need to develop and implement best practice in terrestrial biological surveys. It also enables greater certainty for proponents in the EIA process by defining the principles the EPA will use when assessing proposals which may impact on biodiversity values.
EPA Position Statement No. 2 - *Environmental Protection of Native Vegetation in Western Australia – Clearing of Native Vegetation with Particular Reference to the Agricultural Area*	This Position Statement provides an overview of the EPA's position on the clearing of native vegetation in Western Australia with particular reference to clearing within the agricultural area.
The Australian Pipeline Industry Association Ltd *Code of Environmental Practice Onshore Pipelines* (2009).	This Code is intended to encapsulate the best techniques and methods presently available to mitigate or to eliminate the environmental impact of pipeline construction and operation activities.

9.5.4 Consequence Definitions

To enable assessment of risks associated with the Project, specific consequence definitions were developed. Table 9.15 provides the consequence definitions that have been used in the risk assessment of terrestrial flora and vegetation.

9.5.5 Impact Assessment and Management

Impacts to flora and vegetation will occur as a result of Project activities. The following sections summarise the aspects and activities that may directly or indirectly affect flora and vegetation in, and surrounding, the Project area. Chapter 7, *Impact Assessment Methodology* contains the risk matrix used to assess the likelihood and consequence of impacts occurring. Potential management and mitigation measures are generally provided in greater detail for those aspects that have been identified as posing a higher risk to a factor than those aspects that are expected to pose a lesser risk. Table 9.18 provides a summary of the potential impacts, management measures and residual risk to flora and vegetation as a result of Project activities.

The methodology for the assessment of the risk to the flora and vegetation from the Project is based on:

- Assessment of the results of seven Level 2 flora and vegetation surveys conducted in the area
- Interpretation of the available data to develop vegetation unit, threatened flora location and weed location maps
- Inclusion of Project description to determine likely impacts to flora and vegetation
- Development of management concepts that limit potential impacts to flora and vegetation.

9.5.5.1 Vegetation Clearing

Residual risk to flora and vegetation from vegetation clearing is	Medium

Clearing of approximately 3100 ha of terrestrial native vegetation will be required in order to facilitate the construction of the onshore Project infrastructure (refer to Chapter 2, *Project Description* for further infrastructure details). For the purpose of this impact assessment, a conservative approach has been taken by assuming that all vegetation within the Project area will be cleared ("maximum clearance scenario"). Once the dredge material disposal option has been determined (see Section 9.3.5.1) and final engineering design layouts developed, actual areas to be cleared will be known. This area of vegetation clearing is expected to be less than the "maximum clearance scenario".

Table 9.15: Consequence Definitions for Terrestrial Flora and Vegetation

Terrestrial						
Factor	**1**	**2**	**3**	**4**	**5**	**6**
	Catastrophic	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Terrestrial Flora and Vegetation	• Extinction of a species • Loss of a Threatened Ecological Community (TEC) • Extinction of a vegetation community or habitat	• Regional extinction of a species • Regional extinction of a vegetation community or habitat • Long-term impact to a TEC leading to a reduction in the viability of the community • Local extinction of a Declared Rare Flora species • Local long-term reduction in the abundance of a TEC	• Local extinction of a Commonwealth or WA Listed Flora species • Local long-term reduction in the abundance of a Declared Rare Flora species • Long-term impact on native vegetation outside the Project footprint • Local short-term reduction in the abundance of a TEC	• Local short-term reduction in the abundance of a Declared Rare Flora species • Local long-term reduction in the abundance of a Commonwealth or WA Listed Flora species • Introduction of a non-native flora species to the Project area • Short-term impact on native vegetation outside the Project area	• Local short-term reduction in the abundance of a Commonwealth or WA Listed Flora species • Increase in the abundance of an existing non-native flora species within the Project area • Local loss of a species or vegetation community • Local long-term reduction in the abundance of a species or vegetation community	Local short-term reduction in the abundance of a species or vegetation community

Impact: *direct interaction of a stressor with the environment |* ***Local area:*** *directly affected by the development and the surrounding environs (radius of 2 km from the Ashburton North site) |* ***Regional area:*** *extending to well beyond the development and surrounding environs (Carnarvon and Pilbara Bioregions) |* ***Short term:*** *<5 yrs from commencement of the construction phase |* ***Long term:*** *>5 yrs from commencement of the construction phase |* ***Viability:*** *ability of a species to persist through time.*

This clearing may have the following impacts:

- Loss of flora and vegetation (including fauna habitat)
- Loss of conservation significant flora and locally significant vegetation
- Erosion
- Spread of introduced flora
- Increase surface water run-off and velocity leading to increased sedimentation on vegetation outside of cleared area (refer to Section 9.4.5.2).

Table 9.16 lists the extent of each vegetation unit to be cleared and provides a discussion of each of the vegetation units of local conservation significance that will be impacted by clearing. Figure 9.5 provides the extent of the vegetation units. Aside from the five vegetation units of local conservation significance the other vegetation units present are considered representative of those occurring in the locality, or are substantially degraded by the invasion of Buffel Grass and Mesquite (and therefore not considered to be of significance).

The flora and vegetation surveys found five species of threatened flora in the survey area. Table 9.17 lists these species, their level of conservation significance and extent in the survey area. Further detail of threatened flora in the survey and Project areas is included in Chapter 6, *Overview of Existing Environment*.

Loss of flora and vegetation will be unavoidable in some areas; however, the vegetation units present are generally well represented within the surveyed area and the region, and the "maximum clearance scenario" loss is generally a minor proportion of the known total extent. Although some priority flora and potentially undescribed flora may have to be cleared (refer to Table 9.17), all of these flora have also been recorded outside of the Project area.

The exception is vegetation unit C3 (low *Tecticornia* shrubland in saline claypans), with over 44 per cent to be cleared in a "maximum clearance scenario" from the combined vegetation unit C3 and the vegetation units C3/CP1 mosaic. Suitable habitat for samphire (*Tecticornia* spp.) shrublands occurs from the tip of the Exmouth Peninsula to east of Port Hedland, and includes the majority of the Pilbara coast. This comprises over 39 000 ha mapped as "samphire shrublands" by Beard (1975), along with over 301 000 ha mapped as "mudflat" by Beard. While there are likely to be a number of different samphire sub-associations occurring within this habitat, it is unlikely that any samphire sub-associations occurring in the Project area would be restricted to the immediate Project area (Biota 2009).

The actual proportional clearing of vegetation unit C3 would therefore be expected to be considerably less than 40 per cent.

Management and mitigation measures to be implemented to reduce the impacts on vegetation unit C3 and threatened and undescribed flora are discussed further below. The impacts and management measures relating to mangrove vegetation, which is considered part of the marine environment in this assessment, are discussed in detail in Chapter 8 *Marine Risk Assessment and Management*.

To assist in reducing the impacts to flora and vegetation as a result of clearing, a range of management strategies will be developed and implemented for the construction phase of the Project. These controls and measures will be implemented as part of the CEMP. A brief discussion of potential management and mitigation measures follows.

An internal vegetation clearing process will be developed as part of the CEMP, which will be produced prior to commencement of construction activities. Where clearing of vegetation is unavoidable the internal clearing process would be implemented so that clearing activities are managed with the objective of reducing the impact to flora and vegetation as far as practicable. The internal clearing process will include requirements to:

- Utilise previously cleared areas where practicable
- Clearly indicate areas to be cleared and communicate this to machinery operators and supervisors
- Provide appropriate supervision of machinery operators, specifically with regards to clearing being conducted within the defined boundaries.

Management and mitigation measures regarding the clearing of flora and vegetation will be addressed in the CEMP. The management measures would provide guidance to site personnel to assist with the aim of reducing the impact to vegetation outside the designated clearing areas, and any potential impacts on EPBC listed species located within those areas. Mitigation and management measures will include:

- Implementing vehicle hygiene procedures appropriate for the site
- Development and implementation of an environmental induction to inform site personnel of the flora and vegetation management requirements.

Table 9.16: Extent of Vegetation Units within the Proposed Project Footprint

Vegetation Code	Vegetation Description	Extent Within Project Footprint (ha)	Extent Within Survey Area (ha)	Percentage of VU to be Cleared Within the Survey Area	Local Conservation Significance	Regional Context
T1	*Tecticornia* spp. scattered low shrubs on mud flats.	203.69	1394.87	14.60	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
T2	*Avicennia marina* open scrub along tidal creeks (refer to Chapter 8, *Marine Risk Assessment and Management* for discussion on clearing of mangroves).	Refer to Chapter 8 *Marine Risk Assessment and Management* for BPPH loss.				
CD1	*Acacia coriacea* subsp. *coriacea, Crotalaria cunninghamii* tall shrubland over *Spinifex longifolius*, with **Cenchrus ciliaris* open tussock grassland on foredunes.	15.04	20.22	74.38	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
CD2	*A. coriacea* subsp. *coriacea* tall shrubland over *C. cunninghamii, Trichodesma zeylanicum* var. *grandiflorum* open shrubland over *Triodia epactia* open hummock grassland with **C. ciliaris* open tussock grassland on near-coastal dunes.	68.03	121.76	55.87	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
ID1	*Grevillea stenobotrya* tall open shrubland over *C. cunninghamii, T. zeylanicum* var. *grandiflorum* open shrubland over *T. epactia* open hummock grassland on red sand dunes.	73.25	247.53	29.59	**High**	This vegetation unit is predominantly located in the LNG plant site; SIC corridor, borrow areas and northern section of the domgas pipeline. Only a relatively small percentage (29.59) of this vegetation unit will be impacted within the survey area.
ID2	*G. stenobotrya* tall open shrubland over *C. cunninghamii, Hibiscus brachychlaenus* open shrubland over *Triodia schinzii, (T. epactia)* open hummock grassland on red sand dunes.	24.20	221.58	10.92	**High**	Only a small percentage (10.92) of this vegetation unit will be impacted.
ID3	*Acacia stellaticeps* shrubland over *T. epactia* hummock grassland in swales.	11.53	162.80	7.08	Low	This vegetation unit is considered relatively representative of those occurring in the locality.

Vegetation Code	Vegetation Description	Extent Within Project Footprint (ha)	Extent Within Survey Area (ha)	Percentage of VU to be Cleared Within the Survey Area	Local Conservation Significance	Regional Context
ID4	*Grevillea stenobotrya* tall open shrubland with *Acacia stellaticeps* over *T. epactica* and **C. ciliaris* open tussock grassland.	0	12.48	0	**High**	This vegetation unit will not be impacted by the Project.
CS1	*Acacia tetragonophylla* scattered shrubs over *T. epactia* hummock grassland occurring broadly over sandy plains.	320.28	1346.65	23.78	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
CS2	*A. tetragonophylla* scattered shrubs over *T. epactia* hummock grassland with **C. ciliaris* open tussock grassland occurring on sandy plains, particularly fringing claypans.	90.58	325.01	27.87	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
CS1/CS2#	This is a mosaic of the two vegetation units CS1 and CS2 and contains approximately 50 per cent of each unit.	332.73	976.82	34.06	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
CS3	*A. tetragonophylla* scattered shrubs over *Scaevola pulchella, Indigofera monophylla* low open shrubland over *T. epactia* hummock grassland on areas of calcrete.	58.64	111.47	52.61	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
CS4	**Prosopis pallida, A. tetragonophylla, Acacia synchronicia* scattered tall shrubs over *T. epactia* very open hummock grassland and **C. ciliaris* open tussock grassland in scalded areas.	156.47	441.88	35.41	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
CS4/CS1#	This is a mosaic of the two vegetation units and contains approximately 30 per cent of CS4 and 70 per cent of CS1.	342.94	523.67	65.49	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
CS5	**P. pallida, Acacia sclerosperma* subsp. *sclerosperma, A. tetragonophylla* scattered tall shrubs over *T. epactia* and **C. ciliaris* open tussock grassland	134.36	193.80	69.33	Low	This vegetation unit is considered relatively representative of those occurring in the locality.

CS6	**P. pallida* scattered tall shrubs to open shrubland over *A. tetragonophylla*, *A. bunburyana* shrubs over *T. epactia* open hummock grassland and **C. ciliaris* open tussock grassland in scalded areas	6.62	24.71	26.80	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
C1	Bare claypan.	85.44	142.10	60.13	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
C2	*Eriachne aff. benthamii* open tussock grassland in claypans.	9.38	46.60	20.13	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
C3	*Tecticornia* spp. low shrubland in saline claypans.	482.76	1053.80	45.81	**High**	Samphire (*Tecticornia* spp.) shrublands habitat occurs from the tip of the Exmouth Peninsula to east of Port Hedland. This comprises over 39 000 ha mapped as "samphire shrublands" by Beard (1975), along with over 301 000 ha mapped as "mudflat" by Beard. It is therefore unlikely that any samphire sub-associations occurring in the Project area would be restricted to the immediate Project area.
C3/C2#	This is a mosaic of the two vegetation units and contains approximately 90 per cent of C3 and 10 per cent of C2.	0	17.18	0	**High / Low**	This vegetation unit will not be impacted by the Project.
C3/CP1*	This is a mosaic of the two vegetation units and contains approximately 80 per cent of C3 and 20 per cent of CP1.	1.40	58.42	2.40	**High / Moderate**	Only a small percentage of this mosaic will be impacted and therefore only minor impact is expected.
C4	**P. pallida, A. bunburyana* open shrubland over *T. epactia* open hummock grassland and **C. ciliaris* open tussock grassland.	0	3.71	0	Low	This vegetation unit will not be impacted by the Project.
CP1	*Sporobolus mitchellii, E.* aff. *benthamii, E. benthamii, Eulalia aurea* tussock grassland on low-lying clayey plains.	83.99	805.32	10.43	**Moderate**	Only a small percentage of this vegetation unit will be impacted and therefore only a minor impact is expected. This vegetation unit is located within the borrow areas.

Vegetation Code	Vegetation Description	Extent Within Project Footprint (ha)	Extent Within Survey Area (ha)	Percentage of VU to be Cleared Within the Survey Area	Local Conservation Significance	Regional Context
CS1/CP1#	This is a mosaic of the two vegetation units and contains approximately 70 per cent of CS1 and 30 per cent of CP1	26.63	207.69	12.82	**Low / Moderate**	Only a small percentage of this mosaic will be impacted and therefore only minor impact is expected.
CS4/CP1#	This is a mosaic of the two vegetation units and contains approximately 30 per cent of CS4 and 70 per cent of CP1	4.26	29.12	14.63	**Low / Moderate**	Only a small percentage of this mosaic will be impacted and therefore only minor impact is expected.
CP2	**P. pallida* scattered tall shrubs to tall open shrubland over *A. tetragonophylla*, **Vachellia farnesiana* shrubland over *E. aurea*, *Chrysopogon fallax*, *S. mitchellii* tussock grassland within drainage depressions in low-lying clayey plains.	48.39	89.85	53.86	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
CP3	*Acacia xiphophylla* tall shrubland over *T. epactia* open hummock grassland on clayey plains.	0.99	31.17	3.18	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
CP3/CP1#	This is a mosaic of the two vegetation units and contains approximately 70 per cent of CP3 and 30 per cent of CP1.	26.63	207.69	12.82	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
CP4	*A. xiphophylla* tall shrubland over *Triodia lanigera* open hummock grassland on elevated areas of clayey plains.	23.61	124.88	18.91	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
CP5	*A. xiphophylla* tall open shrubland over *Triodia brizoides* very open hummock grassland.	0	0	0	Low	This vegetation unit only occurs within the survey area in a mosaic (CP5/CP4).
CP5/CP4#	This is a mosaic of the two vegetation units and contains approximately 50 per cent of CP4 and 50 per cent of CP5.	38.65	246.47	15.68	Low	This vegetation unit is considered relatively representative of those occurring in the locality.

IS1	*Corymbia hamersleyana* scattered low mallees over *Acacia ancistrocarpa*, *A. bivenosa* shrubland over *T. lanigera hummock* grassland occurring broadly over inland sandy plains.	349.65	2784.31	12.56	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
IS2	*Acacia inaequilatera* tall open shrubland over *A. ancistrocarpa* open shrubland over *T. lanigera* open hummock grassland on slightly elevated areas of inland sandy plains.	47.94	366.74	13.07	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
H1	*A.inaequilatera* tall open shrubland over *T. lanigera*, *T. brizoides* open hummock grassland on stony hills.	0.11	6.20	1.77	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
D1	*Eucalyptus victrix* open forest over *E. aurea*, **C. ciliaris* tussock grassland in tributary of Ashburton River.	0	2.74	0.00	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
D2	*E. victrix* scattered low trees over *A. synchronicia*, *A. bivenosa* shrubland over *T. epactia* hummock grassland in broad ill-defined drainage through clayey plain.	15.84	31.95	49.58	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
D3	*Corymbia hamersleyana* scattered low mallees over *Acacia tumida* var. *pilbarensis*, *Grevillea wickhamii* subsp. *hispidula* tall open shrubland over *A.ancistrocarpa* open shrubland over *T. epactia*, *T. lanigera* open hummock grassland.	13.32	103.77	12.84	Low	This vegetation unit is considered relatively representative of those occurring in the locality.
D4	*E, victrix* low trees over *A. tetragonophylla*, *A. synchronica tall shrubland over Hibiscus brachychlaenus* shrubland over tussock grassland of **C. ciliaris*.	0	18.88	0	Low	This vegetation unit will not be impacted by the Project.
Beach	No vegetation	25	34.35	72.78	Low	No vegetation

These combined vegetation units are mosaics of the two vegetation units which could not be delineated further.

* Denotes introduced species

An additional 20.12 ha of already cleared land (tracks and roads) exists in the Project footprint, of a total of 165.22 ha of cleared land in the survey area

Vegetation clearing will potentially cause increased surface water run-off, which may impact on vegetation outside the Project area as a result of erosion and/or increased sedimentation. However, the vegetation outside the Project area is not expected to be significantly impacted due to the natural variation in surface water flow and sedimentation in the area. Management of surface water is discussed in Section 9.4.

Where practicable, vegetation and flora within the Project area will be retained should clearing not be essential. Disturbed areas not required for future activities will be progressively rehabilitated upon completion of activities where practicable (e.g. following construction of the domgas pipeline), with rehabilitation procedures identified as part of the CEMP to facilitate this process.

Of the 3100 ha (approximately) of native vegetation to be cleared for the Project, approximately 439 ha will be cleared from within the DEC's proposed extension to the Cane River Conservation Park (CRCP [Chapter 6, *Overview of Existing Environment* illustrates the CRCP and domgas pipeline route]). At this stage, the final location of the domgas pipeline has not been determined. Therefore, a conservative approach has been taken by assuming a 100 m wide section of the domgas pipeline corridor will be cleared: in reality, once a final location has been determined, only a 30 m wide corridor (where practicable) will be cleared. A total clearing area (439 ha) has been calculated using this conservative approach.

Chevron will also implement additional mitigation and management measures within the proposed CRCP extension to manage impacts to its conservation values. Examples of these measures include:

- Pending investigations by Chevron, the domgas pipeline corridor clearing width may be reduced from 30 m outside of the proposed CRCP extension to 20 m within the extension. However, at some locations within the proposed CRCP extension additional cleared area may be required for activities such as staging of pipes and turning of vehicles
- The domgas pipeline will be buried where practicable, with the objective of rehabilitation of a large proportion of the corridor at the completion of construction of the domgas pipeline. A cleared access road for light vehicle will need to be maintained.

Management of the domgas pipeline corridor will be conducted taking into account the measures described in The Australian Pipeline Industry Association Ltd *Code of Environmental Practice Onshore Pipelines* (2009).

Summary

The vegetation units and flora within the Project area are generally well represented throughout the local area and region or not restricted to the Project area. As such, the residual environmental risk for this potential impact was assessed as being "Medium" – impacts to flora and vegetation are "Likely" to occur as a result of the Project, however, with the adoption of the management controls and mitigation measures presented in Table 9.18 the impact is expected to be of "Moderate" consequence.

9.5.5.2 Earthworks

Residual risk to flora and vegetation from earthworks is	**Low**

Earthworks will be required throughout the onshore Project area to prepare the site for construction and installation of infrastructure. The earthworks component of site development is expected to include significant addition of fill material to the plant site, as well as compaction and excavation activities. Earthworks may have adverse impacts to flora and vegetation adjacent to the Project footprint through:

- The introduction and/or spread of introduced flora
- Dust generation
- Changes to topography causing changes in tidal inundation and surface drainage patterns
- Exposure of PASS.

Management strategies will be developed as part of the CEMP to reduce the impacts of construction on flora and vegetation.

Introduced Flora

Measures to be introduced with the objective of combating the introduction and spread of introduced flora species will include:

- Implementing vehicle hygiene procedures appropriate for the site
- Developing and implementing a weed management procedure that includes monitoring and eradication as appropriate.

Dust

Earthworks may produce dust emissions that could have adverse impacts to the health of adjacent vegetation. The likelihood of significant impacts to flora and vegetation are

Table 9.17: Extent of Disturbance to Threatened Flora and Undescribed Flora

Species	Conservation Level	Number of species within the Project Footprint	Number of species within the Survey Area (outside of the Project footprint)	Regional Distribution
Eremophila forrestii subsp. *viridis*	Priority 3 (EP Act [WA])	This species may be impacted at twelve locations in the LNG plant area, and SIC and accommodation village areas. The number of individuals has not been determined however they are scattered throughout these locations at less than 1 per cent cover.	There are eight locations scattered throughout survey area with the majority recorded as providing less than 1 per cent cover. Two of these recordings included 13 plants south of the LNG plant, and > 60 plants outside the domgas pipeline route.	Although this species has a broad distribution throughout Western Australia, the subspecies appears to be restricted to the Pilbara, and has been located in the Onslow locality, Hamersley Range and Canning Stock Route. *E. forrestii* subsp. *viridis* has also been recorded from two additional locations approximately three km north of the Minderoo Station turnoff (Biota unpublished data).
Atriplex flabelliformis	Priority 3 (EP Act [WA])	This species may be impacted at one location in the SIC.	This species was also identified at four other locations. Three populations were recorded south of the LNG plant area and one population was located near the SIC.	This species has been recorded at several locations within the Pilbara and Kimberley regions.
Triumfetta echinata	Priority 3 (EP Act [WA])	This species may be impacted at 12 locations in the LNG plant area, within the domgas pipeline and in the SIC.	This species was recorded at 18 locations with a total record of 52 plants. Forty-eight of these plants were located south of the Accommodation Village in 13 locations. The remaining five locations were located south of the LNG plant area and south of the SIC.	This species has a distribution restricted to approximately 40 km^2 surrounding Onslow. An outlying population has been recorded approximately 100 km south of Onslow and another at Varoo Station. This species is relatively widespread throughout the Onslow locality; however, it is not common and is restricted to red sand dunes (Biota 2009a).

Species	Conservation Level	Number of species within the Project Footprint	Number of species within the Survey Area (outside of the Project footprint)	Regional Distribution
Eleocharis papillosa	Vulnerable (EPBC Act [Cth]) Priority 3 (EP Act [WA])	This species has not been found within the Project area.	One location (scattered along creek within samphire shrubland in a tidal creek crossed by the Onslow Road)	The most current records indicate that this species has a considerably broader distribution than previously thought, extending from the north of the Northern Territory through to northern South Australia and into the west of WA. It is likely that this species has been poorly collected in the past due to its small size and ephemeral nature (Biota 2009a).
Abutilon uncinatum ms	Priority 1 (EP Act [WA])	This species has not been found within the Project area.	This species has been identified at one location (<1 per cent density), south of the domgas pipeline, 10.7km southeast of the Peedamulla Station turn-off along the Onslow Road.	Although not common this species is relatively widespread within the Onslow locality (Biota 2009a). The known distribution of this low shrub extends over 40 km^2 in the north-western corner of the Pilbara bioregion, with outlying populations approximately 120 km south-southwest of the Project area in the Carnarvon bioregion, and on Yarraloola Station, which is approximately 80 km east of the Project area in the Pilbara bioregion.
Aenictophyton aff. *reconditum* (Onslow)	Undescribed	This species may be impacted at one location (<1per cent density) in the SIC.	This species has been identified at six other locations. Populations were recorded north of the SIC. It was also recorded south of the LNG plant.	This undescribed pea appears to be restricted to sand dune habitats in the Onslow locality. This taxon has also been recorded at several other locations in the Onslow locality, though is not common in the area.
Tecticornia spp. (samphires).	Undescribed	An undescribed taxa were recorded from 12 locations; within the plant site and Borrow site 2 in the Project area.	The undescribed taxa have not been recorded outside of the Project area.	The undescribed taxa appear to be within the species complex designated as *T. halocnemoides* sens. lat. "large seed aggregate". It is likely that many new species will be recognised from this complex. These species have no records outside of the project area.

Abutilon sp.	Undescribed	This species may be impacted at six locations in the SIC and domgas pipeline.	*Abutilon sp.* was recorded from an additional six locations, near the domgas pipeline, north of the SIC and south of the Accommodation Village. These populations occur at <1 per cent cover.	This taxa was matched to an indeterminate specimen at the WA Herbarium, also previously recorded near Onslow.
Bonamia aff. *linearis**	Undescribed	This species was recorded in two locations within the domgas pipeline corridor. This species occurs as <1 per cent cover.	Recorded from seven locations at <1 per cent cover at each location south of the LNG plant, and near the domgas pipeline corridor and SIC.	This possibly new species has not been located outside of the survey area.
Stemodia sp. Onslow	Undescribed	Located at one location within the north-eastern section of the LNG plant with 2 per cent cover recorded.	This species was not recorded outside the Project area.	This species has been recorded at several locations within the Pilbara, Gascoyne and Carnarvon regions.

* *This taxa had winged seeds, which is supposedly not a characteristic of* B. linearis (*Jessop 1981*).
Note: Where a percentage is provided, this relates to percentage cover within a 60 X 60m or 50 X 50m quadrat or relevee

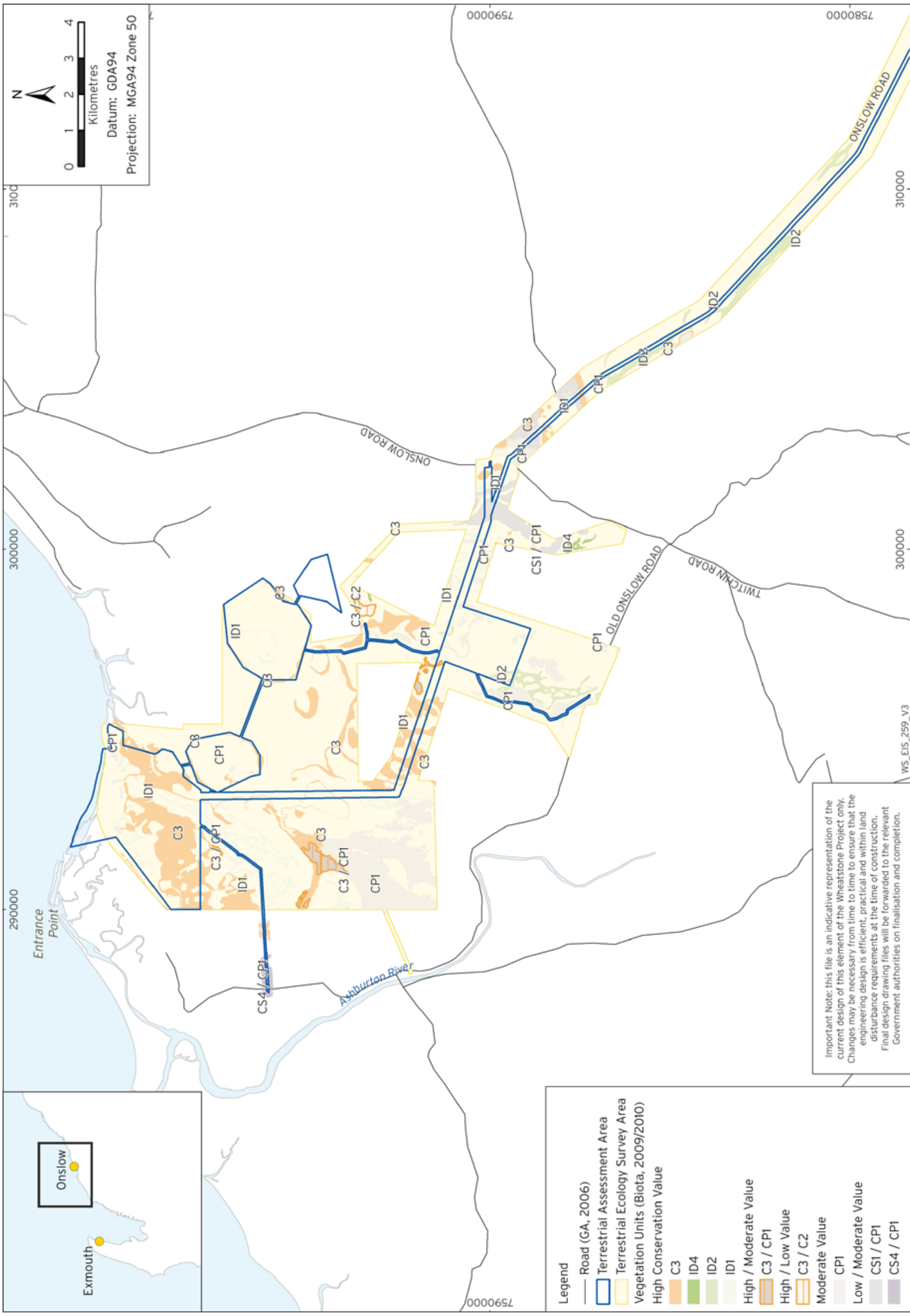

Figure 9.5: Vegetation Units of Moderate or High Local Conservation Significance

low. Dust will be managed with the objective of reducing impact. Refer to Section 9.8 for further information.

Topography

The development of the Project is likely to impact on the natural hydrology and drainage of the Project area and may also change tidal inundation such that areas become more or less inundated. Changes to topography may also change infiltration patterns and may adversely impact vegetation as a result of changes to the volume of water received. Changes to surface hydrology could also change the sediment regime of the area, with increases in surface water velocity representing an increase in scour and sediment erosion and a potential deposition of sediment. Changes to surface drainage patterns and tidal inundation will be managed with engineering controls such as site drainage, sediment traps and bunds. These engineering designs will be implemented with the aim of replicating natural drainage patterns where practicable. Refer to Section 9.4 for further detail on management of surface water impacts.

Potential Acid Sulfate Soils

The PASS study undertaken for the Project has established that there is PASS material found at 1 to 3 mbgl at various locations around the Project area (Appendix H1). Earthworks may expose PASS and, if not managed correctly, the resulting acidity in surface water, groundwater and soils could adversely impact flora and vegetation outside the Project area. Earthworks that occur in high PASS risk areas will require management procedures. Section 9.2 provides further detail of PASS risks and management.

Summary

The majority of vegetation will be cleared from within the Project area, and potential impacts from earthworks to flora and vegetation outside of the Project area are not believed to be significant. Therefore, the residual environmental risk for this potential impact was assessed as being "Low" - impacts to flora and vegetation are "Likely" to occur as a result of the Project earthworks; however, with the adoption of the management controls and mitigation measures presented in Table 9.18 the impact is expected to be of "Minor" consequence.

9.5.5.3 Vehicular Activity

Residual risk to flora and vegetation from vehicular activity is	**Very Low**

Increased vehicle activity associated with the Project has the potential to adversely impact flora and vegetation through:

- Direct impact as a result of off-road driving
- Spreading introduced flora species
- Causing erosion
- Increasing dust emissions
- Causing fires.

Off-road driving could cause damage to, or loss of, threatened flora or conservation significant vegetation units. Construction workers will not operate, for recreational purposes, all terrain or four wheel drive vehicles within project work areas and access corridors under Chevron's control outside of designated tracks or designated unsealed roads and will be expected to follow Australian laws and regulations covering the operation of a motor vehicle.

The spread of introduced flora species will be managed through the mitigation measures discussed early in this section, sub-sections Vegetation Clearing and Earthworks.

The potential for erosion resulting from vehicle activity will be managed through the use of designated access routes during clearing and earthworks. Temporary access routes will be constructed in a manner that reduces the potential for erosion.

Dust generated by vehicles can adversely impact vegetation, particularly along the verges of unsealed access routes. It can also be a safety hazard. To prevent impact during clearing and earthworks, dust suppression will be undertaken on unsealed roads, access tracks and hardstand areas as required.

A vehicle travelling through vegetation, particularly grassland, can cause fires when plant material comes in contact with the vehicle exhaust system. The use of designated routes, cleared of vegetation, will reduce the potential for vehicles to cause fires during the early stages of site development. The potential will be further reduced on roads that have been sealed.

Summary

The majority of vegetation will be cleared from within the Project area, and potential impacts from vehicular activity to flora and vegetation outside of the Project area are not believed to be significant. It is unlikely that vehicular will result in impacts to the flora and vegetation of the region. Therefore, the residual environmental risk for this potential impact was assessed as being "Very Low" - impacts to flora and vegetation are "Possible" as a result of the vehicular activity associated with the Project; however, with the adoption of the management controls and mitigation measures presented in Table 9.18 the impact is expected to be of "Negligible" consequence.

9.5.5.4 Fire

Residual risk to flora and vegetation from fire is	Very Low

Increased vehicle, machinery and activity of personnel in and around the Project area will increase the risk of fire. Conversely, a reduction in the severity or duration of naturally occurring fires is also likely as fires adjacent to the Project will be prevented or rapidly extinguished. This may potentially impact on the fuel load available and therefore future fire intensities and seed store/vegetation recovery adjacent to the Project. Both an increase in the risk of anthropogenic fire and a reduction in the severity or duration of naturally occurring fires have the potential to affect the natural fire regime in the area and may impact on the composition and structure of vegetation communities.

Mitigation and management measures will be implemented with the objective of preventing fires caused by Project activities, including:

- Maintaining adequate fire breaks (areas of cleared vegetation) around the plant area inside the Project area
- Fire fighting and fire awareness training for Project personnel.

Chevron may also need to assist in rehabilitating burnt areas adjacent the Project should areas require this due to extremely severe fires or top soil and seed stores becoming unviable due to the length of time since fire. Chevron will liaise with the DEC and may develop progressive rehabilitation management measures as a part of the CEMP and the OEMP should this become necessary.

Summary

The majority of vegetation will be cleared from within the Project area, and potential impacts from fire to flora and vegetation outside of the Project area are not believed to be significant. It is unlikely that fire will result in impacts to the flora and vegetation of the region. Therefore, the residual environmental risk for this potential impact was assessed as being "Very Low" - impacts to flora and vegetation are "Unlikely" as a result of fire, however, with the adoption of the management controls and mitigation measures presented in Table 9.18 any impact is expected to be of "Minor" consequence.

9.5.5.5 Air Emissions

Residual risk to flora and vegetation from air emissions is	Very Low

The air emissions assessment (Appendix C1) examined changes to air quality and subsequent impacts to vegetation from both dust and atmospheric emissions generated by the Project. A summary of the key findings of the assessment is provided below. Further details of the potential impacts and management measures for air emissions are included in Section 9.8, Chapter 4, *Emissions, Discharges and Wastes*, and Chapter 10, *Social Risk Assessment and Management*.

Dust

Smothering of vegetation by dust can cause abrasive effects to leaf surfaces or blockages of leaf stomata, which can prevent adequate uptake of moisture and sunlight, eventually resulting in vegetation loss.

It is anticipated that dust generation will be at its greatest during vegetation clearing and earthworks, but it will also occur due to vehicle movements and it is expected that any impacts will mainly occur to vegetation adjacent to haul roads. A range of management controls and monitoring procedures will be implemented to reduce generation of dust. Section 9.2 provides likely management and mitigation measures.

Atmospheric Pollutants

Native vegetation can be adversely affected by exposure to oxides of nitrogen (NO_x – the collective term for nitric oxide [NO], nitrogen dioxide [NO_2] and nitrous oxide [N_2O]) and ozone (O_3), which can cause retarded growth rates and damage to leaf surfaces.

The majority of atmospheric pollutants from the Project are likely to come from the LNG and domgas plant. Expected emissions and discharge rates are discussed in Chapter 4, *Emissions, Discharges and Wastes*. Atmospheric pollutants from the plant are expected to contribute to a relatively small increase in predicted ground-level concentrations of O_3, NO_2 and particulate matter. An assessment of deposition of NO_2 for the region surrounding the Project area, incorporating all emissions associated with existing sources and the LNG and domgas processing facility, indicates that 'typical high' NO_2 deposition rates in the region around

Onslow will be 3.7 kg/ha/annum. These levels are well under World Health Organisation (WHO) (2000) guidelines for assessing the risks of impacts on vegetation. WHO guidelines predict that NO_2 concentrations of 49 to 66 kg/ha/yr may adversely impact vegetation health. Chapter 6, *Overview of Existing Environment* provides detail of the WHO criteria and existing levels of atmospheric pollutants in the Project area and surrounding region. Section 9.8.5 discusses the impacts and management of atmospheric pollutants.

Summary

The majority of vegetation will be cleared from within the Project area, and potential impacts from air emissions to flora and vegetation outside of the Project area are not believed to be significant. It is unlikely that air emissions will result in impacts to the flora and vegetation of the region. Therefore, the residual environmental risk for this potential impact was assessed as being "Very Low" - impacts to flora and vegetation are "Unlikely" as a result of the air emissions associated with the Project. However, with the adoption of the management controls and mitigation measures presented in Table 9.18 any impact is expected to be of "Negligible" consequence.

9.5.5.6 Surface Water Diversion

Residual risk to flora and vegetation from surface water diversion is	Low

Diversion of natural surface water drainage lines will be required to develop the Project area. This may also change infiltration patterns and may adversely impact vegetation as a result of changes to the volume of water received. Changes to surface hydrology could also change the sediment regime of the area, with increases in surface water velocity representing an increase in scour and sediment erosion, and a potential deposition of sediment. Further discussion on potential impacts to surface water hydrology due to the Project, and management measures aimed at reducing the impact of the Project on the existing surface water environment are discussed further in Section 9.4.

To reduce the impacts to flora and vegetation resulting from altered surface water (and stormwater) flows, potential barriers such as roads and pipelines will be designed to allow flows to continue unimpeded, where practicable. Where this is not practicable, structures such as diversion drains, sediment ponds and spillways will if necessary be incorporated into the design with the objective of preventing surface water accumulation and to manage erosion and sedimentation.

Monitoring of vegetation within areas of significantly altered surface water volumes and stormwater discharge points will be implemented where appropriate, to determine whether vegetation is being adversely impacted. Appropriate measures to address adverse impacts will be developed and implemented if required.

Summary

It is possible that surface water diversion will result in impacts to the flora and vegetation outside of the Project area through Project related alterations to natural drainage lines. The residual environmental risk for this potential impact was assessed as being "Low" - impacts to flora and vegetation are "Possible" as a result of any surface water diversion associated with the Project, however, with the adoption of the management controls and mitigation measures presented in Table 9.18 the impact is expected to be of "Minor" consequence.

9.5.5.7 Dust Suppression

Residual risk to flora and vegetation from dust suppression is	Low

Dust suppression may be required on unsealed areas during the construction phase of the Project to reduce impacts to flora and vegetation from dust, and to address safety concerns.

Avoiding overspray of dust suppressants onto fringing vegetation will be a key management measure in preventing the impacts. Use of appropriately-sized equipment, regular inspection of road verges and education of operators will reduce the incidence of overspray.

A subsidiary management plan will be developed as part of the CEMP with the key objective to manage the generation of dust. A range of management controls and monitoring procedures will be applied as part of this management plan during key activities at the onshore development area. Specific dust control measures would also be implemented as part of the standard operation of the concrete batching plant.

A monitoring program commenced within the Project area in April 2009. This monitoring is establishing a baseline ambient dust concentration that can be used as a comparison. This baseline study will form the basis for the development of trigger levels in any management plan.

Summary

It is possible that dust suppression will result in impacts to the flora and vegetation outside of the Project area. Therefore, the residual environmental risk for this potential impact was assessed as being "Low" - impacts to flora and vegetation are "Possible" as a result of the dust suppression activities associated with the Project, however, with the adoption of the management controls and mitigation measures presented in Table 9.18 any impact is expected to be of "Minor" consequence.

9.5.5.8 Operational Leaks and Spills

Residual risk to flora and vegetation from leaks and spills is	Low

There is potential for leaks and spills of hydrocarbons, wastes and other hazardous materials during storage, transport and transfer of products. Leaks and spills may adversely impact vegetation through direct contact, or indirectly through contamination of surface water, groundwater and soil. The severity of a direct leak or spill is largely dependent on the volume and nature of the chemical and the proximity of the spill to flora and vegetation. The severity of the impact to flora and vegetation from contamination of surface water, groundwater and soil may also be dependent on the transit time and length of exposure time.

Management of leaks and spills will focus on prevention, through provision of appropriate storage vessels, containment facilities, transfer equipment and handling methods. Spill response procedures will be developed and will carry through all phases of the Project. Appropriate equipment and training will be provided so that personnel are able to respond appropriately. Clean up and remediation will form part of the spill response procedures. The CEMP will outline basic management strategies for leaks and spills. The potential impacts to surface and groundwater are discussed in Sections 9.4 and 9.3 respectively.

Potentially contaminated (contact) stormwater from general process areas will be routed to "first flush" retention basins to capture oily or other types of potential contamination from the first 25mm of rainfall on these areas. Overflow from rainfall exceeding the first 25mm will be routed to natural drainage channels leading to the ocean. The retention basins will be equipped with oil skimmer devices, and with pumps to transfer the entire contents to process wastewater treatment if significant contamination is found. Contaminated stormwater from known oily areas (pump pads, etc.) will be routed to collection sumps and pumped to process wastewater treatment.

Summary

It is expected that leaks and spills will occur during the life of the Project; however, incorporating appropriate facilities and equipment into the Project design will limit the majority of these leaks and spills to minor volumes that will be readily contained. Therefore, the residual environmental risk for this potential impact was assessed as being "Low". The most conservative risk ranking assesses the impacts of a major onshore spill or leak. It is anticipated that, with the adoption of management controls and mitigation measures presented in Table 9.13, this event would be "Unlikely", but should it occur, of "Moderate" consequence to flora and vegetation outside the Project area.

9.5.5.9 Dredge Material Placement Area

Residual risk to flora and vegetation from secondary impacts of the dredge material placement area is	Low

The Project considers two placement options for material dredged from the MOF, PLF and ship channel. The preferred option (assessed in Chapter 8, *Marine Risk Assessment and Management*) includes all dredged material being placed offshore. The onshore placement of dredged material would involve dredged material being transported hydraulically and discharged through a pipeline into a purpose built placement area located within the Plant footprint. As part of the onshore dredge material placement option, decanted seawater will be discharged to a marine outfall during placement operations. The location of the onshore dredged material placement area is depicted in Figure 9.1. Further details of the characteristics and operation of the placement area are in included in Chapter 2, *Project Description* and Chapter 8, *Marine Risk Assessment and Management*.

Seepage of saline water from the placement area and groundwater mounding (refer to Section 9.3) have the potential to directly impact flora and vegetation, and contaminate surface water, groundwater and soils, indirectly impacting flora and vegetation.

Seepage from the placement area is likely to occur. Monitoring bores will be installed around the placement area to monitor the groundwater levels, and hence the rate of seepage from the placement area. Seepage of water through the placement area will be managed. Discussion of the potential impacts to groundwater (e.g. mounding) and surface water as a result of the placement area is included in Sections 9.3 and 9.4 respectively.

Summary

It is possible that secondary impacts caused by the dredge material placement area will result in impacts to the flora and vegetation outside of the Project area. Therefore, the residual environmental risk for this potential impact was assessed as being "Low" - impacts to flora and vegetation outside of the Project area are "Possible" as a result of secondary impacts caused by the onshore placement of dredge material, however, with the adoption of the management controls and mitigation measures presented in Table 9.18 any impact is expected to be of "Minor" consequence.

9.5.6 Implications for Matters of National Environmental Significance

One threatened flora species—the Dwarf Desert Spike-rush (*Eleocharis papillosa*), listed as Vulnerable under the EPBC Act (Cth), was recorded from a single location within a creek line habitat within the northern section of the domgas pipeline corridor; however, there were no threatened flora species recorded in the Project area. There is potential for the species to be present within the proposed Project footprint, particularly within this particular creek line habitat, and a search for additional individuals of this species within this habitat was conducted by OEC in September 2009. No individuals were located; however, the search was not conducted during the preferred season for species identification, and its small size and seasonal growth habit can make it very difficult to observe.

Pre-clearance threatened flora surveys will be conducted and should *E. papillosa* be found in the Project area the domgas pipeline alignment may be altered, or plants moved, in liaison with the DEWHA. However, it is likely that *E. papillosa* has been poorly collected in the past due to its small size and ephemeral nature and it probably has a broader distribution than was originally understood (Biota 2009a).

Given the widespread distribution of *E. papillosa* (refer to Chapter 6, *Overview of Existing Environment*) and the fact that it has not been recorded in the Project area; it is considered highly unlikely that the Project will affect its conservation status.

9.5.7 Residual Risk Summary

Table 9.18 provides a summary of the aspects, activities and potential impacts to flora and vegetation as a result of Project activities. Indicative management controls and mitigating factors are also listed, along with the residual risk following implementation of the management controls.

9.5.8 Predicted Environmental Outcome

With the proposed controls in place, the Project is expected to result in the following outcomes to flora and vegetation:

- The construction of the Project will require the clearing of approximately 3100 ha of vegetation (maximum clearance scenario), a proportion of which will be rehabilitated after completion of construction of the domgas pipeline
- Approximately 580 ha of high local conservation significance vegetation will be cleared
- Disturbance of three known Priority 3 species—*E. forrestii* subsp. *viridis*, *A. flabelliformis* and *T. echinata*—may be necessary.

The aspects described above have the potential to impact flora and vegetation in an additive manner. The combined consequence of all aspects on flora and vegetation has been determined to be "Moderate". The likelihood of this consequence occurring is "Likely". The additive risk from the Project on flora and vegetation is "Medium". This additive risk is strongly based on the impacts of the initial clearing activities on flora and vegetation.

Flora and vegetation present in the Project area are generally widespread and well represented in the surrounding region. However, Project activities are likely to impact upon the flora and vegetation and pose a medium level of risk to the conservation values of the Project area and surrounds. Consistent with the EPA objective for terrestrial flora and vegetation the abundance, diversity, geographic distribution and productivity, at species and ecosystem levels, will be maintained through avoidance or management of adverse impacts.

An Outcome Based Condition (OBC) has been developed for Vegetation and Flora, and is presented in Chapter 12, *Environmental Management Program*. In order to meet the OBC, a framework Construction EMP (Appendix U1) has been developed which, in part, provides a high level indication of how impacts to vegetation and flora will be managed. Prior to Project construction, a Subsidiary (internal) EMP will be developed that specifies the management and mitigation measures and actions which will be implemented to limit Project related impacts to vegetation and flora.

This process is designed to achieve the OBC, and is consistent with the EPA's Guidance Statement No. 4 - Towards Outcome-based Conditions. This approach is also consistent with the EPA's guidance on using a Risk-based approach in that factors containing High or Medium risks are addressed through the development of an OBC and/or

Table 9.18: Summary of Management Controls and Residual Risk for Flora and Vegetation

Aspect and Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Vegetation Clearing							
Site Preparation and Site Access	• Loss of flora and vegetation • Erosion • Spread of introduced flora • Over-clearing • Increase surface water run-off and velocity leading to increased sedimentation on vegetation outside of cleared area	• Implement vegetation clearing process • Limit clearing to designated areas and clearly mark these areas • Use previously cleared areas where practicable • Provide appropriate supervision of machinery operators, specifically with clearing being conducted within defined boundaries • Develop and implement vehicle hygiene procedures appropriate for the site • Develop and implement an employee environmental education program/induction • Develop flora and vegetation management as part of the CEMP • Where practicable, vegetation and flora within the Project area will be retained should clearing not be essential • Where practicable rehabilitate disturbed areas upon completion of activities • Develop and implement a weed management procedure which includes monitoring and eradication as appropriate	4	2	**Medium**	**High** Several Expert investigations/ studies Excellent survey data	No

Earthworks							
Site Preparation and Trenching	• Introduction and/or spread of introduced flora • Changes to natural drainage patterns and groundwater infiltration resulting in adverse impacts to vegetation • Increased dust production resulting in smothering of undisturbed vegetation • Mobilisation of acids and metals from oxidisation of PASS	• Implement vehicle hygiene procedures appropriate for the site • Weed management procedures • Surface water management such as drains, settlement ponds etc • Dust suppression as required • Implement PASS management measures	5	2	**Low**	**High** Several Expert investigations/ studies Excellent survey data	No
Vehicular Activity							
Site Access, Construction Vehicles on Site and Haulage Vehicles	• Introduction or spread of introduced flora species • Increased erosion leading to loss of remnant or off-site vegetation • Unauthorised disturbance of vegetation (short cuts) • Dust emissions resulting in smothering of remnant or surrounding flora	• Dust suppression as required • Clearly mark authorised access tracks and roads • Construct access routes in a manner that reduces potential for erosion • Construction workers will not operate, for recreational purposes, all terrain or four wheel drive vehicles within project work areas and access corridors under Chevron's control outside of designated tracks or designated unsealed roads and will be expected to follow Australian laws and regulations covering the operation of a motor vehicle	6	3	**Very Low**	**High** Several Expert investigations/ studies Excellent survey data	No

Aspect and Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk C	Residual Risk L	Residual Risk RR	Confidence Level	Matters of NES
Fire							
Vehicle and Machinery Activity and Employee Activity (e.g. smoking)	• Increased risk of fire resulting from increased vehicle and machinery activity • Altered fire regimes resulting from increased incidence of fire leading to regional impact on species abundance and diversity	• Appropriate fire fighting equipment on site, training of site personnel • Maintain adequate fire breaks by maintaining vegetation clearance across the site and around works areas where required	5	4	**Very Low**	**High** Several Expert investigations/ studies Excellent survey data	No
Air Emissions							
Plant Operations and Vehicle Movements	• Detriment to vegetation as a result of air emissions from the processing facility • Dust emissions resulting in smothering of remnant or surrounding flora	• Management of the processing operation to reduce polluting emissions as low as reasonably practicable • Regular maintenance of equipment for good performance and reduced emissions • Planning of non-routine (planned) maintenance shutdowns to reduce emissions, where practicable • Ongoing monitoring of emissions from the facility to determine the level of polluting emissions • Implementation of remedial action should emission levels exceed agreed levels	6	4	**Very Low**	**High** Several Expert investigations/ studies Excellent survey data	No
Alteration of Surface Water Movement							
Site Preparation, Earthworks and Presence of infrastructure	• Detriment to vegetation due to changes in surface drainage patterns • Alterations to groundwater infiltration • Increased erosion leading to downstream impacts on remnant vegetation	• Retain natural drainage where practicable. Where this is not practicable, structures such as diversion drains, sediment ponds and spillways will if necessary be incorporated into the design • Monitor down-stream vegetation for signs of impact and address as required	5	3	**Low**	**High** Several Expert investigations/ studies Excellent survey data	No

Dust Suppression							
Application of saline water or other suppres-sants for dust control	• Detriment to vegetation due to overspray or run-off of saline water used for dust suppression • Increased nutrient loading • Increased potential for weed growth on disturbed ground because of availability of nutrients	• Fringing vegetation monitoring • A management plan will be developed as part of the CEMP with the key objective to manage the generation of dust • Specific dust control measures would also be implemented as part of the standard operation of the concrete batching plant	5	3	**Low**	**High** Several Expert investigations/ studies Excellent survey data	No
Operational Leaks and Spills							
Vehicle Refuelling, Breakdowns and Plant Operations	• Detriment to vegetation due to changes to surface water and groundwater quality • Direct impact of spills on vegetation	• Appropriate storage vessels, containment facilities, transfer equipment and handling methods. • Capture and treatment of run-off from operational areas, fuel farms and bunded areas • Appropriate spill response equipment, emergency response training and spill contingency planning	4	4	**Low**	**High** Several Expert investigations/ studies Excellent survey data	No
Dredge Material Placement Area							
Seepage from Placement Area	• Detriment to vegetation outside the plant footprint due to changes in surface and groundwater quality and quantity	• Monitoring bores • Monitoring and management program as a part of the CEMP • Containment and controlled release strategies including sediment ponds • Discharge via a control point (e.g. weir box) • Installation of a drainage ditch to collect and divert seepage	5	3	**Low**	**High** Several Expert investigations/ studies Excellent survey data	No
Additive Effects							
All of the Above	All of the above	All of the above	4	2	**Medium**	**High** Several Expert investigations/ studies Excellent survey data	No

EMP. In this case, the EMPs which have been developed for the High/Medium Risk Factors will also include mitigation relevant to the associated Low risk factors.

9.6 Terrestrial Fauna

The following sections present the assessment of impacts on terrestrial fauna associated with the Project, taking into account design modifications, mitigation methods and controls applied to reduce impacts.

9.6.1 Management Objective

The EPA management objective for terrestrial fauna is to maintain the abundance, diversity, geographic distribution and conservation status of terrestrial fauna, at species and ecosystem levels, through avoidance or management of adverse impacts.

9.6.2 Description of Factor

For the purposes of this report, terrestrial fauna is defined as species that are not restricted to (or predominantly dependent upon) marine or inter-tidal habitats. Details of the terrestrial fauna studies conducted for the Project are included in Chapter 6, *Overview of Existing Environment* and in the survey reports, included as Appendices I2, J1, K1, L1 and M1.

9.6.2.1 Fauna Habitat

Ten main fauna habitat units were identified within, and adjoining, the Project area (Biota 2009b). These habitats were distinguished on the basis of differences in substrate, vegetation, soils and landform. None of the habitats present in the Project area are listed as TECs; however, the mangrove communities adjoining the Project area are considered 'ecosystems at risk' at a subregional scale. Impacts to mangrove communities are discussed further in Chapter 8 *Marine Risk Assessment and Management*. The remaining terrestrial fauna habitats within the Project area are well represented in the locality and wider region and not of conservation significance (Biota 2009b).

A study focussing on migratory waterbirds concluded that the Project area and surrounds does not provide habitat supporting significant numbers of migratory waterbirds (Bamford 2009). This study also observed 20 Plumed Whistling Ducks (*Dendrocygna eytoni*) on a freshwater marsh along Onslow Road (Bamford 2009). This is potentially of regional interest as the plumed whistling ducks were observed on the edge of their normal range. The species is abundant further north and the ducks were considered likely to be a group passing through the area (Bamford 2009). This freshwater marsh is on the boundary of the domgas pipeline corridor.

9.6.2.2 Vertebrate Fauna

The terrestrial fauna study for the Project was conducted by Biota (2009b). The following six threatened vertebrate fauna species (or signs of these species) were recorded in the Project and surrounding area during the study:

- Little Northern Freetail Bat (*Mormopterus loriae cobourgensis* [Priority 1])
- Australian Bustard (*Ardeotis australis* [Priority 4])
- Western Pebble-mound Mouse (*Pseudomys chapmani* [Priority 4])
- Rainbow Bee-eater (*Merops ornatus* [Migratory])
- Fork-tailed Swift (*Apus pacificus* [Migratory])
- White-bellied Sea Eagle (*Haliaeetus leucogaster* [Migratory]).

The three Migratory species are listed under the EPBC Act (Cth) and therefore are considered matters of NES. These are discussed further in Section 9.6.6.

Database searches of the DEC's Threatened Fauna Database, the NatureMap database of the WA Museum and the EPBC Act (Cth) Protected Matters database were conducted for the Project. Based on these database searches, an additional nine threatened species and an additional ten migratory bird species may potentially occur within the Project area and surrounding area. These additional species are discussed further in Appendix K1. No threatened reptile or amphibian species were located, nor would potentially occur, within the survey area. Three introduced mammal species were also recorded; the house mouse (*Mus musculus*), the feral cat (*Felis catus*) and domestic cattle (*Bos taurus*).

Based on the migratory waterbird study and the review of relevant databases by Bamford (2009), up to 38 migratory waterbird species may frequent the Onslow locality. Bamford (2009) has recorded 26 of the 38 species in the Onslow locality, and those not recorded are likely to only occur as vagrants. Appendix K1 contains further details on the survey, and the migratory species and habitats identified. Bamford (2009) concluded that the Project area and surrounds does not support significant numbers of migratory waterbirds.

9.6.2.3 Invertebrate Fauna

Claypan Ephemeral Invertebrate Fauna

The claypan ephemeral invertebrate fauna study recorded a total of 59 taxa of zooplankton and 82 taxa of macro-invertebrates, including 12 classes and 21 orders of invertebrate fauna (Biota and Timms 2009). Four previously uncollected and undescribed species were recorded during the study. Only one of these, the clam shrimp *Limnadia* n. sp., was collected from within the Project area. This species was found within the domgas pipeline corridor at site CWP01 (see Chapter 6, *Overview of Existing Environment*). Site CWP01 is an artificial man-made water body located adjacent to Onslow Road.

Analysis of the claypan survey results suggest that the claypan fauna within the study sites in the Project area contain effectively equivalent diversity of invertebrate fauna to those represented in the nearby reference sites. This result appears consistent with landscape-scale processes (e.g. large flood events) that occur in the area. Overall, this suggests a relatively reduced risk of species isolation to individual claypans within the Project area at this local scale (Biota and Timms 2009).

Short Range Endemics (SRE)

Despite thorough searching of suitable habitat for invertebrate groups considered to support SRE taxa, no SRE invertebrate fauna were identified within the Project area (Biota 2009b).

9.6.3 Assessment Framework

Table 9.19 provides a list of guidance statements relevant to the management of terrestrial fauna in WA.

9.6.4 Consequence Definitions

To enable assessment of risks associated with the Project, specific consequence definitions were developed. Table 9.20 provides the consequence definitions that have been used in the risk assessment of terrestrial fauna.

9.6.5 Impact Assessment and Management

Impacts to terrestrial fauna will occur as a result of Project activities. The following sections summarise the aspects and activities that may directly or indirectly affect terrestrial fauna in, and surrounding, the Project area. Chapter 7, *Impact Assessment Methodology* contains the risk matrix used to assess the likelihood and consequence of impacts occurring. Potential management and mitigation measures are generally provided in greater detail for those aspects that have been identified as posing a higher risk to a factor than those aspects that are expected to pose a lesser risk. Table 9.21 provides a summary of the potential impacts, management measures and residual risk to terrestrial fauna as a result of Project activities.

The methodology for the assessment of the risk to the terrestrial fauna from the Project is based on:

- Assessment of the results of a Level 2 terrestrial fauna survey conducted in the Project area
- Assessment of the results of two migratory bird surveys conducted in the Project area and surrounds
- Assessment of the results of three claypan invertebrate fauna surveys in the Project area and surrounds
- Desktop assessment of the results of nine other terrestrial fauna surveys conducted in the Project area and in the general Onslow locality
- Inclusion of Project description to determine likely impacts to terrestrial fauna
- Development of management concepts that limit potential impacts to terrestrial fauna.

Table 9.19: EPA Position and Guidance Statements Relevant to Terrestrial Fauna

Legislation or Guideline	Intent
EPA Guidance Statement No. 56 - Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia	This Guidance Statement functions to provide direction and information on general standards and protocols for terrestrial fauna surveys to environmental consultants and proponents engaged in EIA activities.
EPA Position Statement No. 3 - Terrestrial Biological Surveys as an Element of Biodiversity Protection	This Position Statement functions to encourage proponents to focus their attention on the significance of biodiversity and therefore the need to develop and implement best practice in terrestrial biological surveys. It also enables greater certainty for proponents in the EIA process by defining the principles the EPA will use when assessing proposals which may impact on biodiversity values.
The Australian Pipeline Industry Association Ltd Code of Environmental Practice Onshore Pipelines (2009).	This Code is intended to encapsulate the best techniques and methods presently available to mitigate or to eliminate the environmental impact of pipeline construction and operation activities.

Table 9.20: Consequence Definitions for Terrestrial Vertebrate Fauna

Terrestrial						
Factor	**1**	**2**	**3**	**4**	**5**	**6**
	Catastrophic	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Terrestrial Vertebrate Fauna	Extinction of a species	Regional extinction of a species	Regional long-term reduction in the abundance of a Commonwealth or WA Listed Fauna species	• Local long-term reduction of a Commonwealth or WA Listed Fauna species • Regional long-term reduction in abundance of a species • Local long-term increase in the abundance of an introduced animal	• Local loss of a species • Local short-term reduction in the abundance of a Commonwealth or WA Listed Fauna species • Local short-term increase in the abundance of an introduced animal	Local short-term reduction in abundance of a species

Impact: *direct interaction of a stressor with the environment |* ***Local area:*** *directly affected by the development and the surrounding environs (radius of 10 km from the Ashburton North site) |* ***Regional area:*** *extending to well beyond the development and surrounding environs (Carnarvon and Pilbara Bioregions) |* ***Short term:*** *<5 yrs from commencement of the construction phase |* ***Long term:*** *>5 yrs from commencement of the construction phase*

9.6.5.1 Vegetation clearing

Residual risk to terrestrial fauna from vegetation clearing is	**Low**

Approximately 3100 ha of terrestrial fauna habitat will be cleared to facilitate the construction of the onshore Project infrastructure. Removal of suitable habitat is likely to be the main impact on the terrestrial fauna (and potentially the six threatened species) occurring within the Project area. However, in all cases, none or only a small proportion of local habitat suitable for these threatened species would be cleared relative to their wider distributions in the region, and all of the terrestrial fauna habitat types to be cleared in the Project area are well represented in the locality and wider region, and are not of elevated conservation significance (Biota 2009b). As a result, the clearing of terrestrial fauna habitat would not be expected to affect the conservation status of these species.

The loss of terrestrial fauna habitat is expected to result in the loss of some individuals of small or non-mobile fauna, such as invertebrates. However, it is anticipated that many of the birds and larger mammals and reptiles will be able to relocate and avoid direct impacts from clearing activities. Indirect impacts from clearing activities to relocated terrestrial fauna may occur through territorial conflicts associated with the competition for food, resources, shelter and breeding sites. These conflicts would resolve over time and populations would naturally stabilise.

Vegetation clearing within the Project area in general will be managed through the development and implementation of a vegetation clearing process, discussed further in Section 9.5. Where practicable, cleared areas will also be rehabilitated upon completion of activities (e.g. post construction of the domgas pipeline), with rehabilitation management measures outlined in the CEMP. Cleared areas will be inspected immediately for presence of injured animals.

Up to 439 ha of terrestrial fauna habitat will be cleared from within the DEC's proposed extension to the CRCP. Chapter 6, *Overview of Existing Environment* provides detail of the domgas pipeline route relative to the CRCP. Chevron will implement additional mitigation and management measures within the proposed CRCP extension to manage impacts to its conservation values.

Summary

The terrestrial fauna habitats within the Project area are well represented throughout the local area and surrounding region, and not of conservation significance. Therefore, the residual environmental risk for this potential impact was assessed as being "Low" - impacts to terrestrial fauna as a result of vegetation clearing for the Project are "Possible", however, with the adoption of the management controls and mitigation measures presented in Table 9.21 any impact is expected to be of "Minor" consequence.

9.6.5.2 Earthworks

Residual risk to terrestrial fauna from earthworks is	**Low**

After clearing of native vegetation, earthworks will be required throughout the onshore Project area to prepare the site for construction and installation of infrastructure. The earthworks component of site development is expected to include significant addition of fill material to the plant site, as well as compaction and excavation activities. Earthworks may directly impact on terrestrial fauna through contact with machinery or vehicles (discussed in Section 9.6.5.1) or indirectly impact on terrestrial fauna through loss of habitat (including damage to burrows) and fauna entrapment in trenches.

A range of strategies will be developed as part of the CEMP to reduce the indirect impacts of earthworks on terrestrial fauna. Strategies for limiting impact to fauna during the domgas pipeline trenching operations will be prepared taking into account The Australian Pipeline Industry Association Ltd *Code of Environmental Practice Onshore Pipelines* (2009). These strategies may include:

- Conducting inspections of open trenches to remove trapped fauna
- Providing escape routes from trenches, or fencing trenches off, particularly during the night
- Having personnel who are appropriately trained to handle fauna conducting the above inspections
- Limiting access to dams and ponds.

Summary

Prior to earthworks occurring, vegetation will have been cleared in accordance with the vegetation clearing approvals and the authorisation process (see Section 9.5). With this habitat removed, most terrestrial fauna are not expected to occur in the area where earthworks are taking place. Therefore, the residual environmental risk for this potential impact was assessed as being "Low" - impacts to terrestrial fauna as a result of earthworks for the Project are "Possible", however, with the adoption of the management controls and mitigation measures presented in Table 9.21 any impact is expected to be of "Minor" consequence.

9.6.5.3 Fire

Residual risk to terrestrial fauna from fire is	**Very Low**

The increased vehicle, machinery and site-based personnel activity in and around the Project area will increase the risk of fire, which could impact terrestrial fauna directly though injury or death, or indirectly through loss of terrestrial fauna habitat. Conversely, a reduction in the severity or duration of naturally occurring fires is also likely, as fires adjacent to the Project will be prevented or rapidly extinguished. Both changes have potential to affect the natural fire regime in the area and may impact terrestrial fauna directly or indirectly.

Management measures will be implemented with the aim of preventing fires caused by Project activities. In addition, fire fighting equipment will be on hand and training will be provided to deal with fires caused by Project activities, or that pose a threat to Project infrastructure or personnel. Continuous firebreak will be established around the perimeter of the LNG plant by maintaining vegetation clearance around the main plant area to the fence line. Construction and operations will be conducted in cleared areas, where practicable. Vehicle activity will be carefully managed in high risk areas (e.g. long grass). Fire management procedures will be developed as part of the CEMP and the OEMP and communicated to site personnel by way of the environmental induction.

Summary

Fire is not expected to result in impacts to the terrestrial fauna of the Project area. Therefore, the residual environmental risk for this potential impact was assessed as being “Very Low” - impacts to terrestrial fauna as a result of fire are “Unlikely”, however, should a fire occur, any impact is expected to be of “Minor” consequence with the adoption of the management controls and mitigation measures presented in Table 9.21.

9.6.5.4 Vehicular Activity

Residual risk to terrestrial fauna from vehicular activity is	**Low**

Vehicle activity associated with the Project has the potential to impact on terrestrial fauna directly through impact with vehicles (road-kill), indirectly through the introduction and spread of new pest species and adverse impacts to terrestrial fauna habitat. There will also be increased vehicle activity outside of the Project area (e.g. Onslow Road and North West Coastal Highway) and there is the potential for direct impact to terrestrial fauna in these areas, including in the proposed extension to the CRCP.

Road-kill has the potential to decrease the abundance of terrestrial fauna species at a local level, including threatened fauna such as the DEC listed Australian Bustard (*Ardeotis australis*). Road-kill also attracts scavengers, and increased road-kill is likely to attract increased numbers of scavengers which may then also be hit by vehicles.

Vehicles have the potential to introduce new pest species to the area and to increase pest numbers. Pests will compete for resources, such as food and shelter with endemic fauna. Pest species may also prey on native species.

In order to reduce potential impacts to terrestrial fauna from the increased traffic, the following mitigation measures will be implemented:

- Construction workers will not operate, for recreational purposes, all terrain or four wheel drive vehicles within project work areas and access corridors under Chevron’s control outside of designated tracks or designated unsealed roads and will be expected to follow Australian laws and regulations covering the operation of a motor vehicle
- Reduced vehicle speeds and enforcement of speed limits
- The employee environmental education program/ induction will be developed and implemented and include discussion on vehicle activity and fauna.

Summary

As the terrestrial fauna within the Project area are generally well represented throughout the local area and region, the potential loss of individuals due to increased vehicle activity is not expected to significantly impact upon the abundance, diversity, geographic distribution and conservation status of any fauna populations. Therefore, the residual environmental risk for this potential impact was assessed as being “Low” - impacts to terrestrial fauna as a result of vehicular activity for the Project are “Likely”, however, with the adoption of the management controls and mitigation measures presented in Table 9.21 any impact is expected to be of “Minor” consequence.

9.6.5.5 Flaring

Residual risk to terrestrial fauna from flaring is	**Very Low**

Flaring will occur from the flare stack as part of the Project. The flare stacks may potentially provide artificial roosting locations for birds, such as the EPBC listed White-bellied Sea Eagle (*Haliaeetus leucogaster*). It is expected that significant bird fatalities from birds roosting on, or flying through, the flare during operation will be highly unlikely, due to:

- The height of the stacks
- Residual heat of the stacks when not flaring
- Continuously operating pilot flame that may discourage birds from landing
- Heat, noise and visible flame during flaring.

Summary

It is considered highly unlikely that flaring will significantly affect the abundance, diversity, geographic distribution and conservation status of terrestrial fauna. Therefore, the residual environmental risk for this potential impact was assessed as being "Very Low" - impacts to terrestrial fauna as a result of flaring are "Remote", however, any impact is expected to be of "Negligible" consequence with the adoption of the management controls and mitigation measures presented in Table 9.21.

9.6.5.6 Noise Emissions

Residual risk to terrestrial fauna from noise emissions is	**Low**

The construction and operation of the Project will produce noise that is likely to contribute to terrestrial fauna disturbance. Appendix E1 provides a detailed discussion of the noise levels expected during the Project. Noise from the Project is likely to cause temporary localised terrestrial fauna behavioural changes adjacent to the plant; initially terrestrial fauna may move away from the plant site but then become more accustomed to the noise levels and relocate back into the area.

To comply with Environmental Protection (Noise) Regulations 1997 and environmental objectives for noise emissions during construction activities, management and mitigation measures will be developed and implemented as part of the CEMP. The current Project design and implementation of industry standard management measures enable noise levels to comply with government regulations.

Summary

Noise emissions are not expected to significantly affect the abundance, diversity, geographic distribution and conservation status of terrestrial fauna at and surrounding the Project. Therefore, the residual environmental risk for this potential impact was assessed as being "Low" - impacts to terrestrial fauna as a result of noise emissions from the Project are "Possible", however, with the adoption of the management controls and mitigation measures presented in Table 9.21 any impact is expected to be of "Minor" consequence.

9.6.5.7 Operational Leaks and Spills

Residual risk to terrestrial fauna from leaks and spills is	**Very Low**

There is potential for leaks and spills of hydrocarbons, wastes and other hazardous materials during storage, transport and transfer of products. Further details on waste production and management are presented in Chapter 4, *Emissions, Discharges and Wastes*. Leaks and spills could potentially impact terrestrial fauna through direct contact and subsequent toxic effects or indirectly impact terrestrial fauna through loss or damage to terrestrial fauna habitat.

Management of leaks and spills will focus on prevention, through provision of appropriate storage vessels, containment facilities, transfer equipment and handling methods. Spill response procedures will be developed as part of the CEMP and will carry through all phases of the Project. Appropriate equipment and training will be provided so that personnel are able to respond appropriately. Clean up and remediation will form part of the spill response procedures. Capture and treatment of run-off from operational areas, fuel farms and bunded areas will be implemented. Additionally, any potentially contaminated stormwater will be treated as appropriate prior to discharge.

Summary

It is expected that leaks and spills will occur during the life of the Project; however, incorporating appropriate facilities and equipment into the Project design will limit the majority of these to minor volumes. Therefore, the residual environmental risk for this potential impact was assessed as being "Very Low" - impacts to terrestrial fauna as a result of leaks and spills are "Unlikely", however, should impacts occur they are expected to be of "Minor" consequence with the adoption of the management controls and mitigation measures presented in Table 9.21.

9.6.5.8 Light Emissions

Residual risk to terrestrial fauna from light emissions is	Low

Light emissions from the LNG plant site and accommodation village may cause behavioural changes in localised terrestrial fauna populations. Light sources will attract insects and terrestrial fauna that feed on insects may alter their feeding habits when light emissions occur. This increase in the availability of food for certain species may then lead to changes in the local faunal assemblage. Increased concentrations of terrestrial fauna around the plant site area may also have secondary impacts such as increased incidence of road-kill on Project roads.

In order to limit impacts to terrestrial fauna from light emissions, lighting and light spill will be reduced wherever practicable and safe to do so. Where practicable, the following mitigation measures may be implemented to achieve this:

- Light intensity will be limited to that necessary for the safe operation of the plant
- Use of lighting that limits insect attraction (e.g. sodium fixtures).

Summary

Light emissions are not expected to significantly affect the abundance, diversity, geographic distribution and conservation status of terrestrial fauna at and surrounding the Project. Therefore, the residual environmental risk for this potential impact was assessed as being "Low" - impacts to terrestrial fauna as a result of light emissions from the Project are "Likely", however, with the adoption of the management controls and mitigation measures presented in Table 9.21 any impact is expected to be of "Minor" consequence.

9.6.5.9 Waste Handling and Storage

Residual risk to terrestrial fauna from waste handling and storage is	Very Low

The Project will generate a variety of waste materials including scrap metal, tyres, hydrocarbons, domestic wastes and processing wastes from the LNG and domgas plants. Some wastes may be incinerated on-site while some will be sent to landfill or recycled. Wastes may be stored on-site in a central waste storage area.

These waste facilities have the potential to impact on terrestrial fauna due to the attraction of fauna to these facilities and/or associated behavioural changes. There may be a direct impact to terrestrial fauna due to entrapment in waste facilities, particularly in stormwater ponds. In addition, an increased number of terrestrial fauna within the Project area may result in an increased incidence of road-kill and may also attract predatory feral animals, potentially causing a localised decrease in abundance of certain native terrestrial fauna species.

Waste management actions will be implemented with the objective of reducing native and introduced fauna access to waste storage areas and thereby reduce impacts on native fauna. These shall include the following:

- Solid waste receptacles will be in good condition and have covers where practicable
- Temporary containment facilities will be available to store waste where practicable during the early construction phases
- Waste reduction measures such as recycling will be implemented, where practicable
- Regular disposal of waste to reduce accumulation
- Management measures will be used to limit fauna access to stormwater ponds.

Summary

Waste handling and storage will occur in order to manage these aspects of the Project; however, incorporating appropriate facilities, equipment and procedures into the Project design will limit the impact of these necessary activities. Therefore, the residual environmental risk for this potential impact was assessed as being "Very Low" - impacts to terrestrial fauna as a result of waste handling and storage are "Unlikely", however, should impacts occur they are expected to be of "Minor" consequence with the adoption of the management controls and mitigation measures presented in Table 9.21.

9.6.5.10 Physical Presence of Infrastructure

Residual risk to terrestrial fauna from the physical presence of the infrastructure is	Low

Construction of the pad for the LNG plant, accommodation village and access road will involve the addition of significant fill to the site (refer to Chapter 2, *Project Description*). This will impact and modify the surface water flow, quantity and quality of these catchments. These changes may subsequently impact on terrestrial fauna and fauna habitat due to changes in vegetation community composition and the drying out or inundation of different areas (e.g. claypans).

Infrastructure will be designed to retain natural drainage features where practicable. This may be achieved through appropriate placement of the infrastructure and through engineering and design solutions such as culverts, sedimentation ponds, a silt fence around the construction area and placement of rock at surface water release points to reduce erosion (refer to Section 9.4).

The physical presence of infrastructure may provide roosting sites for birds. Migratory waterbirds are known to feed and roost close to and within industrial areas in many parts of the world and appear unaffected by these conditions. The physical presence of infrastructure may also provide an opportunity for introduced fauna to colonise infrastructure locations and then impact on native fauna through competition for resources. Introduced fauna will be managed with quarantine procedures. Where practicable, ponds will be located within the fenced plant area and have floats and/or fauna egress mats to enable fauna to exit these water bodies.

Summary

The physical presence of infrastructure is not expected to significantly affect the abundance, diversity, geographic distribution and conservation status of terrestrial fauna at and surrounding the Project. Therefore, the residual environmental risk for this potential impact was assessed as being "Low" - impacts to terrestrial fauna as a result of the physical presence of infrastructure are "Possible", however, with the adoption of the management controls and mitigation measures presented in Table 9.21 any impact is expected to be of "Moderate" consequence.

9.6.6 Implications for Matters of National Environmental Significance

Three EPBC Act (Cth) listed Migratory species were observed within the Project area and surrounds (Biota 2009b), and according to the EPBC Act (Cth) Protected Matters database, a further ten Migratory species may occasionally frequent the area. The three observed Migratory species comprise:

- Rainbow Bee-eater (*Merops ornatus*)
- Fork-tailed Swift (*Apus pacificus*)
- White-bellied Sea Eagle (*Haliaeetus leucogaster*).

These species are described in further detail in Chapter 6, *Overview of Existing Environment*. None of the database-listed Migratory species are associated with or dependent on the terrestrial habitats of the Project area (Biota 2009b) and it is therefore considered highly unlikely that impacts from the Project will significantly affect EPBC Act (Cth) listed fauna species at and surrounding the Project.

9.6.7 Residual Risk Summary

Table 9.21 provides a summary of the aspects, activities and potential impacts to flora and vegetation as a result of Project activities. Indicative management controls and mitigating factors are also listed, along with the residual risk following implementation of the management controls.

9.6.8 Predicted Environmental Outcome

The Project is expected to result in the following outcomes to terrestrial fauna:

- Six threatened fauna species, or signs of these species, were recorded within the study area. However, they are all highly mobile (with the exception of the Western Pebble-mound Mouse) and it is expected that the majority of individuals will move away from the Project area at the commencement of the construction phase
- No species listed under the EPBC Act (Cth) are likely to be affected by the Project
- It is considered highly unlikely that the Project will affect the conservation status of any fauna species
- The Project will require the "maximum clearance scenario" clearing of up to 3100 ha of terrestrial fauna habitat, a proportion of which will be rehabilitated after completion of construction of the domgas pipeline
- Removal of suitable habitat is likely to be the main impact on the six threatened terrestrial fauna species recorded within the Project area. However, all of the terrestrial fauna habitats to be cleared in the Project area are well represented in the locality and wider region, and are not of elevated conservation significance
- Large areas of claypans exist on the Ashburton floodplain within the Project area. These seasonally ephemeral freshwater systems are highly interconnected at a landscape scale during floods and invertebrate species contained therein are not expected to be restricted to the claypans of the Project area.

The aspects described above have the potential to impact terrestrial fauna in an additive manner. The combined consequence of the aspects identified above on terrestrial fauna has been determined to be "Moderate". The likelihood of this consequence occurring is "Possible". The additive risk from the Project on

Table 9.21: Summary of Management Controls and Residual Risk for Terrestrial Fauna

Aspect and Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Vegetation Clearing							
Site Preparation	• Loss or alteration of terrestrial fauna habitat • Loss of populations • Direct impact with machinery • Fragmentation of terrestrial fauna habitat resulting in reduced area of habitat, altered behavioural patterns etc	• Development and implementation of a vegetation clearing process • Where practicable cleared areas will be rehabilitated upon completion of activities • Inspect cleared areas immediately for presence of injured animals • Develop and implement an employee environmental education program/induction	5	3	**Low**	**High** Several Expert investigations/ studies Excellent survey data Long-term monitoring results available	No
Earthworks							
Site Preparation and Construction	• Modification or destruction of habitat • Entrapment in trenches and bunds • Direct impact with machinery	• Conduct inspection of all open trenches and remove any trapped fauna using appropriately trained personnel • Provide escape routes from trenches, or fencing trenches off, particularly during the night • Develop and implement an employee environmental education program/induction • Limit fauna access to dams and ponds	5	3	**Low**	**High** Several Expert investigations/ studies Excellent survey data Long-term monitoring results available	No
Fire							
Vehicle and Machinery Activity and Employee Activity (e.g. smoking)	• Increased risk of fire resulting from increased vehicle and machinery activity • Altered fire regimes resulting from increased incidence of fire leading to regional impact on species abundance and diversity	• Appropriate fire fighting equipment on site, training of site personnel • Establish a firebreak around the perimeter of the LNG plant through vegetation clearance • Conduct construction and operations in cleared areas, where practicable • Carefully manage vehicle activity in high risk areas (e.g. long grass) • Develop and implement an employee environmental education program/induction	5	4	**Very Low**	**High** Several Expert investigations/ studies Excellent survey data Long-term monitoring results available	No

Vehicular Activity							
Site Access and On-site Movements	• Direct impact with vehicles • Increased road kill resulting in attraction of scavengers (e.g. raptors) leading to more road kill	• Construction workers will not operate, for recreational purposes, all terrain or four wheel drive vehicles within project work areas and access corridors under Chevron's control outside of designated tracks or designated unsealed roads and will be expected to follow Australian laws and regulations covering the operation of a motor vehicle • Reduced vehicle speeds, apply speed limits • Develop and implement an employee environmental education program/induction	5	2	**Low**	**High** Several Expert investigations/ studies Excellent survey data Long-term monitoring results available	No
Flaring							
Plant Operations	• Direct impact to birds roosting in infrastructure	• Height of the stacks • Residual heat of the stacks when not flaring • Continuous pilot that may discourage birds from landing • Heat and visible flame during flaring	6	5	**Very Low**	**High** Several Expert investigations/ studies Excellent survey data Long-term monitoring results available	No
Noise Emissions							
Plant Operations and Vehicle Movements	• Temporary localised behavioural changes (e.g. movement away from the plant site)	• Limit noise emissions where practicable • To comply with Environmental Protection (Noise) Regulations 1997 and environmental objectives for noise emissions during construction activities, management and mitigation measures will be developed and implemented as part of the CEMP • The current Project design and implementation of industry standard management measures enable noise levels to comply with government regulations	5	3	**Low**	**High** Several Expert investigations/ studies Excellent survey data Long-term monitoring results available	No

Aspect and Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Operational Leaks and Spills							
Vehicle Refuelling, Breakdowns and Plant Operations	• Loss of habitat as a result of impact to vegetation • Direct impact due to contact with toxic substances or changes to surface water quality	• Appropriate storage vessels, containment facilities, transfer equipment and handling methods • Capture and treatment of run-off from operational areas and bunded areas • Spill response equipment, emergency response training and spill contingency planning • Remove and remediate contaminated soil • Develop and implement an employee environmental education program/induction	5	4	**Very Low**	**High** Several Expert investigations/ studies Excellent survey data Long-term monitoring results available	No
Light Emissions							
Plant and General Operations, Accommodation Village	• Changes to behaviour of local terrestrial fauna populations • Attraction to light sources as a result of insect accumulation resulting in increased incidence of road kill • Long-term changes to terrestrial faunal assemblage as a result of increased food source • Attraction of feral species (e.g. cats, wild dogs)	• Light intensity will be limited to that necessary for the safe operation of the plant	5	2	**Low**	**High** Several Expert investigations/ studies Excellent survey data Long-term monitoring results available	No

Waste Handling and Storage							
Plant and General Operations, Landfill, Accommodation Village	• Attraction of terrestrial fauna to waste resulting in increased incidence of road kill • Increases in feral animal population (e.g. cats, wild dogs) • Direct impact due to terrestrial fauna becoming trapped in waste facilities	• All solid waste receptacles will have covers where practicable and will be in good condition • Temporary containment facilities will be available to store waste during the early construction phases • Waste reduction measures to be implemented where practicable • Regular disposal of waste to avoid accumulation • Management measures will be used to limit fauna access to stormwater ponds.	5	4	**Very Low**	**High** Several Expert investigations/ studies Excellent survey data Long-term monitoring results available	No
Physical Presence of Infrastructure (Surface Water Drainage)							
Construction of Road/Causeway, Location of Plant Pad	• Changes to surface water volume and flows resulting in impacts to fauna habitat • Impacts on fauna and fauna habitat due to changes in vegetation community composition and the drying out or inundation of areas • The physical presence of infrastructure may provide roosting sites for birds • The physical presence of infrastructure may provide an opportunity for introduced fauna to colonise infrastructure locations and then impact on native fauna through predation or competition for resources • Fauna and in particular birds may enter and become entrapped within sedimentation and other water collection ponds	• Retain natural drainage where practicable • Engineering and design solutions such as culverts, sedimentation ponds, a silt fence around the construction area and placement of rock at surface water release points to reduce erosion • Quarantine procedures will be implemented for the Project • Where practicable, ponds will be located within the perimeter fence and have floats and/or fauna egress mats to enable fauna to exit these water bodies	4	3	**Low**	**High** Several Expert investigations/ studies Excellent survey data Long-term monitoring results available	

Aspect and Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Additive Effects							
All of the Above	All of the above	All of the above	4	3	**Low**	**High** Several Expert investigations/ studies Excellent survey data Long-term monitoring results available	No

terrestrial fauna is "Low". The Project is considered to have an overall low residual risk of having a significant impact on terrestrial fauna of the region after the implementation of appropriate mitigation controls. Consistent with the EPA objective for terrestrial fauna, the abundance, diversity, geographic distribution and productivity, at species and ecosystem levels, will be maintained through avoidance or management of adverse impacts.

An Outcome Based Condition (OBC) has been developed for terrestrial fauna, and is presented in Chapter 12. In order to meet the OBC, a framework Construction EMP (Appendix U1) has been developed which, in part, provides a high level indication of how impacts to terrestrial fauna will be managed. Prior to Project construction, a Subsidiary (internal) Management Plan will be developed that specifies the management and mitigation measures and actions which will be implemented to limit Project related impacts to terrestrial fauna.

This process is designed to achieve the Outcome Based Condition, and is consistent with the EPA's Guidance Statement No. 4 - Towards Outcome-based Conditions. This approach is also consistent with the EPA's guidance on using a Risk-based approach in that factors containing High or Medium risks are addressed through the development of an OBC and/ or EMP. In this case, the EMPs which have been developed for the High/Medium Risk Factors will also include mitigation relevant to the associated Low risk factors.

9.7 Subterranean Fauna

The following sections present the assessment of impacts on subterranean fauna associated with the Project, taking into account Project design modifications, mitigation methods and controls applied to reduce impacts.

9.7.1 Management Objective

The EPA management objective for subterranean fauna is to maintain the diversity, geographic distribution and conservation status of subterranean fauna through avoidance of adverse impacts to their habitats and to bio-physical processes that support them.

9.7.2 Description of Factor

A subterranean fauna study was conducted for the Project (Biota 2009c), focussing on the area of the processing facility, which has the most potential for subterranean disturbance. Sampling was conducted in June, July, September and October 2009. Additionally, a desktop assessment of the likelihood of subterranean fauna being found within this area and within the SIC (hereafter referred to as the survey area) was conducted. Due to its proximity to the survey area, it is believed that the results of the study are representative of the accommodation village area. The study did not include the domgas pipeline corridor as this area will have limited subterranean disturbance.

Details of the subterranean fauna study conducted for the Project are summarised below, with further details provided in Chapter 6, *Overview of Existing Environment* and in the study report included as Appendix M1.

No troglobitic fauna were recovered from any of the 96 traps within the 18 bore holes that were sampled. The desktop assessment concluded that there is a low likelihood that the survey area would support a significant troglobitic community as the landforms, stratigraphy and the small amount of habitat space available between the ground surface and the water table are not conducive to troglobitic fauna (Biota 2009c).

Two stygofauna taxa were collected from three of the 27 bores sampled within, or adjacent to, the LNG and domgas plant area. Stygal taxa collected comprised:

- *Phyllopodopsyllus thiebaudi* (copepod)
- *Enchytraeidae* sp. 1 (oligochaete worm).

P. thiebaudi is a widespread species that has been previously recorded from several locations including Barrow Island (Biota 2007). The *Enchytraeidae* sp.1 specimens collected were both juvenile; therefore identification to species level was not possible. It was determined from the morphological nature of this taxa that it is unlikely that the species is only restricted to the survey area (Biota, 2009c).

The survey results suggest that a diverse or significant stygal community does not occur in the aquifers beneath the survey area (Biota 2009c), and this is most likely to also be the case within the accommodation village area.

9.7.3 Assessment Framework

Table 9.22 outlines the guidance and position statements relevant to the management of subterranean fauna and the terrestrial environment guidelines and legislation.

9.7.4 Consequence Definitions

To enable assessment of risks associated with the Project, specific consequence definitions were developed. Table 9.23 provides the consequence definitions that have been used in the risk assessment of subterranean fauna.

Table 9.22: EPA Position and Guidance Statements Relevant to Subterranean Fauna

Legislation or Guideline	Intent
EPA Guidance Statement No. 54 – Sampling of Subterranean Fauna in Groundwater and Caves.	This Guidance Statement functions as a general guide to EIA when there is a likelihood of subterranean fauna occurring in groundwater or caves.
EPA Draft Guidance Statement No. 54a – Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia	This Guidance Statement specifically addresses survey design and sampling methods for subterranean fauna. It provides information which the EPA will consider when assessing proposals where subterranean fauna is a relevant environmental factor in an assessment.
EPA Position Statement No. 3 - Terrestrial Biological Surveys as an Element of Biodiversity Protection	This Position Statement functions to encourage proponents to focus their attention on the significance of biodiversity and therefore the need to develop and implement best practice in terrestrial biological surveys. It also enables greater certainty for proponents in the EIA process by defining the principles the EPA will use when assessing proposals which may impact on biodiversity values.

9.7.5 Impact Assessment and Management

Due to the absence of troglofauna within the survey area, the low likelihood of any communities being present within the survey area and the accommodation village, and there being very limited subterranean disturbance within the domgas pipeline corridor, the Project will not have any impact upon troglofauna populations. Therefore, the impacts to troglofauna and their habitat will not be assessed further in this section.

Impacts to stygofauna and their habitat are likely to occur to some extent as a result of Project activities. However, this disturbance is not expected to have an impact on the two stygofaunal species on a population level as both species recorded during field surveys, and the nature of the subterranean habitats, suggest a low level of risk that any stygal species would be restricted to the survey area.

The following sections summarise the aspects and activities that will potentially affect stygofauna. Chapter 7, *Impact Assessment Methodology* contains the risk matrix used to assess the likelihood and consequence of impacts occurring. Potential management and mitigation measures are generally provided in greater detail for those aspects that have been identified as posing a higher risk to a factor than those aspects that are expected to pose a lesser risk. Table 9.24 provides a summary of the potential impacts, management measures and residual risk to stygofauna as a result of Project activities.

The methodology for the assessment of the risk to the subterranean fauna from the Project is based on:

- Desktop assessment of the likelihood of subterranean fauna being found within Ashburton North and within the SIC
- Assessment of the results of four subterranean fauna surveys conducted within Ashburton North and within the SIC
- Inclusion of Project description to determine likely impacts to subterranean fauna
- Development of management concepts that limit potential impacts to subterranean fauna.

9.7.5.1 Vegetation Clearing and Earthworks

Residual risk to stygofauna from vegetation clearing is	**Very Low**
Residual risk to stygofauna from earthworks is	**Very Low**

Clearing of vegetation is likely to alter the quality and quantity of surface water and groundwater infiltration in the cleared area and the surrounding area. The earthworks component of site development is expected to include significant addition of fill material to the plant site, as well as compaction and excavation activities. The potential impacts of these two aspects to stygofauna are likely to occur through the subsequent alteration in quantity and quality of surface water and groundwater and potential alteration of stygofauna habitat.

Clearing of vegetation will also potentially indirectly impact stygofauna through a reduction in the amount of detritus from root systems available to stygofauna. It is believed that detritus may be a food source for stygofauna. Vegetation clearing and earthworks within the Project area will be managed as per the mitigation measures outlined in Section 9.4.8.

Table 9.23: Consequence Definitions for Subterranean Fauna

Terrestrial						
Factor	**1**	**2**	**3**	**4**	**5**	**6**
	Catastrophic	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Subterranean Fauna	Extinction of a subterranean fauna species	Significant reduction in the population of a subterranean fauna species resulting in a threat to the viability of the species	• Loss of majority of subterranean fauna habitat at a local scale • Long-term decrease in the abundance of a subterranean fauna species	Loss of a substantial proportion of local subterranean fauna habitat, no threat to the survival of the species	Local loss of a small proportion of subterranean fauna habitat	Short-term impact to subterranean fauna habitat, full recovery expected

Impact: *direct interaction of a stressor with the environment |* ***Local area:*** *directly affected by the development and the surrounding environs (radius of 2 km from the Ashburton North site) |* ***Regional area:*** *extending to well beyond the development and surrounding environs (Carnarvon and Pilbara Bioregions) |* ***Short term:*** *<5 yrs from commencement of the construction phase |* ***Long term:*** *>5 yrs from commencement of the construction phase |* ***Viability:*** *ability of a species to persist through time.*

Summary

Given that only two species of stygofauna were found, and both species are likely to be widespread throughout the Pilbara, the residual environmental risk for the potential impacts of these aspects was assessed as being "Very Low" –impacts to stygofauna as a result of vegetation clearing and earthworks for the Project are "Possible", however, with the adoption of the management controls and mitigation measures presented in Table 9.24 any impact is expected to be of "Negligible" consequence.

9.7.5.2 Dredge Material Placement Area

Residual risk to stygofauna from the dredge material placement areas is	**Very Low**

Should the onshore dredge material placement option be chosen, seepage into the groundwater system is likely to occur, causing groundwater mounding and changes in groundwater quantity and quality. This may potentially modify or contaminate any stygofauna habitat and have direct adverse impacts to stygofauna present. However, as discussed previously, the area does not contain a significant stygofaunal community, only two species of stygofauna were found and both species are likely to be widespread throughout the Pilbara, and the area does not appear to contain significant stygofaunal habitat.

Summary

As the landforms, stratigraphy and the small amount of habitat space available between the ground surface and the water table are not conducive to troglobitic fauna, the residual environmental risk for this potential impact was therefore assessed as being "Very Low" – impacts to stygofauna as a result of the onshore dredge material placement option are "Possible", however, with the adoption of the management controls and mitigation measures presented in Table 9.24 any impact is expected to be of "Negligible" consequence.

9.7.5.3 Operational Leaks and Spills

Residual risk to stygofauna from leaks and spills is	**Very Low**

There is potential for leaks and spills of hydrocarbons, wastes and other hazardous materials during storage, transport and use of products. Leaks and spills have the potential to impact on stygofauna indirectly through impacts to groundwater quality and therefore stygofauna habitat.

Management of leaks and spills will focus on prevention, through provision of appropriate storage vessels, containment facilities, transfer equipment and handling methods. Spill response procedures will be developed as part of the CEMP and the OEMP and will carry through all phases of the Project. Appropriate equipment and training will be provided allow personnel to respond appropriately. Clean up and remediation will form part of the spill response procedures. Additionally, any potentially contaminated stormwater will be treated prior to discharge.

Summary

It is expected that leaks and spills may occur during the life of the Project; however, incorporating appropriate facilities and equipment into the Project design will limit the majority of these to minor volumes. With implementation of spill response procedures, detrimental impacts to stygofauna habitat are highly unlikely, especially given that the Project area does not support a diverse stygofauna community. Therefore, the residual environmental risk for this potential impact was assessed as being "Very Low" - impacts to stygofauna as a result of leaks and spills are "Remote", however, should impacts occur they are expected to be of "Minor" consequence with the adoption of the management controls and mitigation measures presented in Table 9.24.

9.7.5.4 Physical Presence of Infrastructure

Residual risk to stygofauna from the physical presence of infrastructure is	**Very Low**

Construction of the pad for the LNG plant, accommodation village and access road will involve the addition of significant fill to the site (refer to Chapter 2, *Project Description*). This will impact and modify the surface water flow, quantity and quality of these catchments. These changes may subsequently impact on stygofauna habitat, through alterations in the quantity and quality of groundwater infiltration.

Infrastructure will be designed to retain natural drainage features where practicable. This may be achieved through appropriate placement of the infrastructure and through engineering and design solutions such as culverts, sedimentation ponds, a silt fence around the construction area and placement of rock at surface water release points to reduce erosion (refer to Section 9.4).

Summary

It is considered highly unlikely that impacts from the physical presence of infrastructure will significantly affect the diversity, geographic distribution and conservation status of stygofauna at and surrounding the Project. Therefore, the residual environmental risk for this potential impact was assessed as being Very Low – impacts to stygofauna from the physical presence of infrastructure are "Possible", however, with the adoption of the management controls and mitigation measures presented in Table 9.24 any impact is expected to be of "Negligible" consequence.

9.7.6 Implications for Matters of National Environmental Significance

There are no matters of NES related to subterranean fauna that are likely to be impacted by the Project.

9.7.7 Residual Risk Summary

Table 9.24 provides a summary of the aspects, activities and potential impacts to flora and vegetation as a result of Project activities. Indicative management controls and mitigating factors are also listed, along with the residual risk following implementation of the management controls.

9.7.8 Predicted Environmental Outcome

Due to the absence of troglofauna within the survey area, the low likelihood of any communities being present within the survey area and the accommodation village, and there being very limited subterranean disturbance within the domgas pipeline corridor, the Project will not have any impact upon troglofauna populations. Therefore, the impacts to troglofauna and their habitat will not be assessed further in this section.

Impacts to stygofauna and their habitat are likely to occur to some extent as a result of Project activities. However, this disturbance is not expected to have an impact on the two stygofaunal species on a population level as both species recorded during field surveys, and the nature of the subterranean habitats, suggest a low level of risk that any stygal species would be restricted to the survey area.

The aspects described above have the potential to impact subterranean fauna in an additive manner. The combined consequence of the aspects identified above on subterranean fauna has been determined to be "Minor". The likelihood of this consequence occurring is "Unlikely". The additive risk from the Project on subterranean fauna is "Very Low".

Overall, the Project is considered to have an overall very low residual risk of having a significant impact on the subterranean fauna of the Project area after the implementation of appropriate mitigation controls. Consistent with the EPA objective for subterranean fauna, the diversity, geographic distribution and conservation status of subterranean fauna will be maintained through avoidance of adverse impacts to their habitats and to bio-physical processes that support them.

9.8 Air Quality

The following sections present the assessment of impacts on air quality associated with the Project, taking into account design modifications, mitigation methods and controls applied to reduce impacts.

9.8.1 Management Objective

The EPA's air quality management objective is based on ensuring that emissions do not adversely affect environment values or the health, welfare and amenity of people and land users by meeting statutory requirements and acceptable standards (See Chapter 4, *Emissions, Discharges and Wastes*).

9.8.2 Description of Factor

The baseline characteristics of the receiving terrestrial environment were assessed through the studies described in Chapter 6, *Overview of Existing Environment*. This assessment is based on the findings of the technical report and dispersion modelling work prepared by SKM for the Project, which is included as Appendix C1. The potential emissions from both onshore and offshore components of the Project are discussed in detail in Chapter 4, *Emissions, Discharges and Wastes*. This chapter also considers the potential greenhouse gas (GHG) emissions associated with Project.

This assessment examines the air quality impacts from:

- Dust emissions and the potential affect on human health, safety, amenity and vegetation, predominantly generated during the construction phase of the Project
- Air emissions specifically relating to process emissions during the operations phase of the project and the potential affect on deterioration of local and regional air quality with associated health and vegetation impact.

These were identified during the Project scoping exercise, submitted to the EPA in March 2009, as being the key air quality issues associated with the Project.

Table 9.24: Summary of Management Options and Residual Risk for Stygofauna

Aspect and Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Vegetation Clearing							
Site Preparation and Site Access	• Loss of habitat • Localised changes to the subterranean fauna habitat due to changes in the hydrology and hydrogeology of the area	• Implement vegetation clearing process • Limit clearing to designated areas and clearly mark these areas • Develop and implement an employee environmental education program/induction • Develop flora and vegetation management as part of the CEMP • Where practicable, vegetation and flora within the Project area will be retained should clearing not be essential • Where practicable rehabilitate disturbed areas upon completion of activities • Retain natural drainage where practicable	6	3	**Very Low**	**High** Excellent survey data	No
Earthworks							
Site Preparation	• Loss of habitat due to compaction	• Retain vegetation wherever practicable • Bunds to prevent tidal inundation • Surface water management such as drains, settlement ponds etc • Dust suppression as required • Implement PASS management measures	6	3	**Very Low**	**High** Excellent survey data	No

Dredge Material Placement Area							
Dewatering of Dredge Material	• Direct impacts due to changes in groundwater quality • Localised changes to the subterranean fauna habitat due to changes in the hydrology and hydrogeology of the area	• The placement area has been selected to reduce the footprint used • Dredged material will be contained in a bunded area to prevent unconfined release of seawater and sediments • Where practical, placement in the eastern half of the placement area will be preferred to limit water levels in (and seepage from) the western half of the placement area • Bunds will be designed to withstand erosion during inundation events • Discharge of decant water during the first 18 to 24 months will be pumped via pipeline to a marine outfall • Water levels within the bunded area will be managed to avoid overtopping of the bunds, even during extreme high rainfall • A drainage ditch (with sump and pump system) will be installed to collect and divert seepage away from the Ashburton Delta system • Groundwater monitoring bores will be installed to detect any alteration of groundwater conditions that may indicate a potential risk to the Ashburton Delta system	6	3	**Very Low**	**High** Excellent survey data	No
Operational Leaks and Spills							
Vehicle Refuelling and Breakdowns, Plant Operations	• Direct impacts due to changes in groundwater quality	• Appropriate storage vessels, containment facilities, transfer equipment and handling methods. • Capture and treatment of run-off from operational areas, fuel farms and bunded areas • Appropriate spill response equipment, emergency response training and spill contingency planning • Develop and implement an employee environmental education program/induction	5	5	**Very Low**	**High** Excellent survey data	No
Physical Presence of Infrastructure							
Construction of Road/ Causeway, Location of Plant Pad	• Changes to surface water flows resulting in potential impacts to subterranean habitat	• Retain natural drainage where practicable • Engineering and design solutions such as culverts, sedimentation ponds, a silt fence around the construction area and placement of rock at surface water release points to reduce erosion	6	3	**Very Low**	**High** Excellent survey data	No
Additive Effects							
All of the Above	All of the above	All of the above	5	4	**Very Low**	**High** Excellent survey data	No

9.8.2.1 Dust Emissions

Dust is the common term for airborne particulate matter. The extent to which receptors are affected by particulate matter is dependent on the particle size, composition and the duration of the exposure. Particles with an aerodynamic diameter of 2.5 microns ($PM_{2.5}$) and 10 microns (PM_{10}) are the typical measures for pollutant particulates. This is due to the health effects associated with particles of this size. Particles of this size having the potential to penetrate deep into the lungs, which can create respiratory problems. This is discussed further in Chapter 10.

Dust can be generated from numerous sources, including; combustion of hydrocarbons, sea spray, fires, wind generated dust, excavation and earth moving, land clearing, harvesting, and vehicles passing over unsealed roads amongst many others.

For humans, the larger particulates have the tendency to be more of a nuisance than a health issue because the majority of particles greater than 10 microns tend not to pass further than the nose or throat. High levels of larger particulates can reduce visibility, can cause staining and accumulate on property. Under comparable weather conditions, larger particulates do not remain suspended for as long as $PM_{2.5}$ or PM_{10} and therefore do not travel as far from the source. However, under strong turbulent wind conditions Total Suspended Particulates (TSP) (<50 µm) can travel significant distances.

The larger particulates drop out of the air sooner than the smaller particles, the distance of deposition is highly variable and dependent on:

- The frequency at which dust generating activities take place
- Meteorological conditions, such as wind speed, direction, humidity etc.
- Composition of dust, including particle size distribution (particle density and moisture content).

While larger particles primarily prompt amenity nuisance issues, deposition on vegetation can have an adverse effect on vegetation health. Within close proximity to unsealed tracks or site preparation activities, smothering of vegetation can occur. This can cause blockages of leaf stomata which can prevent adequate uptake of moisture and sunlight, thereby adversely affecting vegetation health.

Existing Sources

Due to the absence of major anthropogenic dust-generating sources at the Ashburton North site, the existing sources of dust are primarily due to wind-blown dust. Minor anthropogenic sources of dust include tourist and local vehicles visiting areas near the Ashburton River and the Old Onslow heritage area. Chevron are currently (since April 2009) undertaking an air quality monitoring assessment to determine the existing air quality in the Onslow area. This monitoring is ongoing; however data for the first 12 months are presented in Chapter 6.

Air Emissions

Based on known emissions from similar projects, typical emissions are likely to include airborne particulates as described above and key emissions including; NO_x, O_3, sulfur dioxide (SO_2) and volatile organic compounds (VOCs).

Oxides of Nitrogen

NO_x is the collective term for NO, NO_2 and N_2O, amongst others. Lightning and the oxidation of ammonia can form NO_x naturally, whilst a major anthropogenic source (the main source) of NO_x is from the combustion of fossil fuels. In urban areas, this occurs from automobiles and electricity production. Combustion of fuel gas is likely to be the dominant source for the Project. NO is colourless and odourless but can oxidise in the atmosphere to form NO_2 and NO_3^- (nitrate ions). For most sources, NO_2 ultimately accounts for approximately 90 per cent of NO_x with NO contributing the remaining 10 per cent of emissions. For brevity, only NO_2 emissions are presented in this study. The full NO_x emissions are included in the modelling.

NO_2 is a pungent, brown, acidic, highly corrosive gas and in high concentrations has the potential to have significant effects on human health. NO_2 can have detrimental effects on the human respiratory tract, leading to increased susceptibility to asthma and respiratory infections. NO_3^- oxidises iron in the blood rendering it incapable of carrying oxygen.

Vegetation can be adversely affected by prolonged exposure to elevated NO_x levels, in the form of retarded growth rates and reduced crop yields. N_2O is a GHG, trapping longwave radiation emitted by the earth and warming the atmosphere. NO_x gases are also some of the main contributors to O_3 production and can also contribute to acid rain through the formation of nitrous and/or nitric acid in airborne water droplets.

Ozone

O_3 is a colourless gas that is naturally found in the upper atmosphere and in the troposphere. O_3 is also formed as a secondary pollutant at ground-level by the reaction of NO_2 and sunlight which forms NO and a single oxygen atom (O).

This oxygen atom then combines with molecular oxygen (O_2) to form O_3.

Photochemical smog is formed by the reaction of NO_x and VOCs in sunlight. It can form a layer of visible, brown or white haze in the sky. Photochemical smog is a regional, and not localised, phenomenon as reactions occur over several hours after exposure to sunlight (Carter *et al.* 1995). Maximum O_3 concentrations therefore tend to occur downwind of the main source of emissions.

The human health effects of exposure to elevated concentrations of O_3 include irritation of the eyes and exacerbation of respiratory issues such as asthma and bronchitis.

O_3 is a strong oxidant and can affect plants, including the retardation of growth and damage to leaf surfaces.

Sulfur Dioxide

SO_2 is a colourless gas with an irritating odour that can contribute to, or exacerbate respiratory illnesses (such as asthma or bronchitis), especially in elderly or very young people. SO_2 has also been linked with the aggravation of existing heart and lung diseases.

The gas can also have detrimental effects on the environment by contributing to the formation of acid rain which can damage vegetation and infrastructure.

Emissions of SO_2 will occur from the processing operations when incoming raw gas contains hydrogen sulfide (H_2S).

Volatile Organic Compounds

Trace amounts of pollutants such as VOCs may be emitted as fugitives from the facility. VOC species such as benzene, toluene, ethylbenzene and xylene (known as the BTEX group) pollutants are among a wide variety of VOCs that typically exist in relatively low concentrations in ambient air. These are anticipated to represent a small percentage of compounds emitted (see Chapters 4 and Appendix C1).

A review of Hurley et al. (2003 and 2003a) regarding atmospheric dispersion modelling of existing and proposed emissions on the Burrup Peninsula indicates that the emission of VOCs is unlikely to cause significant air quality impacts. This was confirmed during the Burrup Peninsula Air Pollution Study where field monitoring determined that there was little enhancement of benzene adjacent to industrial areas when compared with the background monitoring sites. These findings can be expected to be representative of the Onslow region, where there is currently minimal existing infrastructure contributing to air pollutants.

9.8.2.2 Receptors of interest

Vegetation and human receptors are the focus for this assessment. The identified receptors are defined in Table 9.25, which also presents the receptor's relative position to the site. Figure 9.6 shows the position of the receptors with respect to the site.

9.8.3 Assessment Framework

The air quality assessment framework is based on EPA Guidance, National Environmental Protection Measure (NEPM) Standards, and best practice. Legislation and guidelines relating to air quality are listed in Table 9.26. The assessment criteria proposed for use during the Project are summarised in Table 9.27.

9.8.4 Consequence Definitions

To enable assessment of risks associated with the Project, specific consequence definitions were developed. Table 9.28 provides the consequence definitions that have been used in the risk assessment of air quality.

Table 9.25: Receptors Sensitive to Changes in Air Quality

Receptor ID	Receptor Description	Distance and direction from plant footprint boundary (all distances approximate)
1	Onslow Salt	4 km east
2	Four Mile Creek BBQ area	4 km east
3	Five Mile Pool	10 km south-west
4	Old Onslow Heritage Site	5 km west
5	Area of mangrove vegetation	From 0.5 km to 3 km north-west of site boundary
6	Onslow town centre	12 km north-east
7	Ten Mile Dam South (south of proposed accommodation village site)	12 km south

Figure 9.6: Position of Identified Receptors

Table 9.26: Legislation and Guidelines Relevant to Air Quality

Legislation or Guideline	Intent
National Environmental Protection Measure for Ambient Air Quality	This measure was created to provide a benchmark which ensures that people throughout Australia have protection from the potential health effects of air pollution.
World Health Organisation (WHO). Air Quality Guidelines 2005.	This European guidance provides critical loads for deposition of nitrogen and acid on vegetation. No specific equivalent Australian data exists.
State Environmental (Ambient Air) Policy 2009 – Draft for public and stakeholder comment.	This Policy is intended to provide the basis on which ambient air quality in Western Australia is to be protected. The policy includes guidelines, framework and criteria for ambient air quality.
Environmental Protection (Kwinana) (Atmospheric Wastes) Regulations (1992)	As there are no guidelines for levels of total suspended particulates, these Regulations are used to provide emission criteria.

Table 9.27: Summary of the National Environment Protection Standards used as Assessment Criteria

Pollutant	Averaging Period	Maximum Concentration	Outcome
Nitrogen dioxide	1 hour	120 ppb	Protection of human health
	1 year	30 ppb	
	1 year	49-66 kg/ha as NO_2	Protection of vegetation
Photochemical oxidants (as ozone)	1 hour	100 ppb	Protection of human health
	4 hours	80 ppb	
Particles as PM_{10}	1 day	50 µg/m^3	Protection of human health

Source: Modified from NEPC 2003

9.8.5 Impact Assessment and Management

Air quality may be impacted as a result of Project activities. The following sections summarise the aspects and factors that may directly and indirectly affect air quality in, and surrounding, the Project area. Whilst the focus of this section is on the process emissions during the operations phase, the assessment qualitatively assesses the potential effects from dust generation from onshore activities, which may arise from site preparation and construction activities.

Chapter 7, *Impact Assessment Methodology* contains the risk matrix used to assess the likelihood and consequence of impacts occurring. The potential impacts and the management measures to be implemented are discussed in detail in Table 9.30. Section 9.8.7 provides a summary of the potential impacts, management measures and residual risk as a result of Project activities.

Chapter 2, *Project Description*, describes the construction and operational activities associated with the Wheatstone Development. Some of these activities have the potential to impact on the terrestrial environment. These activities are discussed in more detail in this section.

Dust Generation

It is anticipated that site works will be most likely to generate elevated levels of dust due to vegetation clearing and handling of soil and dredge material. A significant increase in vehicle activity during the construction phase also has the potential to generate high levels of dust. Removal of vegetation will expose soil to wind, which potentially results in wind erosion. A concrete batching plant will also be in operation during the construction phase and has the potential to generate dust, primarily through handling and mixing of the raw materials used to produce concrete. The plant site is likely to require import of fill material from onshore sources.

Dust generated by construction activities could be deposited on vegetation, potentially leading to vegetation loss or reduced viability as a result of impeded photosynthesis.

Dust management measures may include; wetting down and covering / protecting exposed areas, limiting the extent of cleared areas, and the covering of material during transportation or stockpiling, where necessary.

Table 9.28: Consequence Definitions for Ambient Air Quality

Terrestrial						
Factor	**1**	**2**	**3**	**4**	**5**	**6**
	Catastrophic	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Ambient Air Quality	• Regional long-term change in air quality • Continuous exceedences of national ambient air quality standards (NEPM) over a wide population area	Frequent exceedences of NEPM over a wide population area	Occasional exceedences of NEPM over a wide population area	Ground level concentrations at identified sensitive receptors represent a significant increase over the baseline conditions or reduce the remaining air-shed capacity for a particular key pollutants	• Local short-term and minor exceedence of standards • Ground-level concentrations at identified sensitive receptors represent a small increase over the baseline conditions	No measurable air quality impacts

Impact: *direct interaction of a stressor with the environment |* ***Local area:*** *directly affected by the development and the surrounding environs (radius of 12 km from the Ashburton North site) |* ***Regional area:*** *extending to well beyond the development and surrounding environs |* ***Short term:*** *<5 yrs from commencement of the construction phase |* ***Long term:*** *>5 yrs from commencement of the construction phase*

The possible import of dredged material is likely to have minimal dust generation associated with it. For the majority of the material handling operations, dust emissions are not expected to be a significant issue. This is due to the high moisture content of a material that consists largely of coarse fractions, which is therefore not prone to wind erosion or dust generation. As the material dries out, there may be the need during specific weather conditions (i.e. such as prevailing winds in the direction of the sensitive receptor) to apply a dust suppressant.

The wind roses presented in Chapter 6, *Overview of Existing Environment* shows the annual and seasonal wind directions from the Onslow Airport. The typical onsite wind behaviour varies dependent on the season and the figure shows that annually there is a significant south, south westerly component. The dry season tends to be dominated by a southerly wind pattern, with a west-south-west wind pattern dominant during the wet season.

This qualitative dust assessment uses the wind patterns and the distance to a sensitive receptor as a basis for screening the likelihood of a receptor being affected by dust during the construction phase. Receptor 5 (the area of mangroves to the northwest of the project area) is considered the most likely to be sensitive to windblown dust. However, the wind roses indicate that the prevailing winds are likely to carry dust away from this area. Indeed, the south-easterly wind pattern represents no more than 8 per cent of winds throughout the year and of this, an even smaller proportion are associated with dust lift-off (winds of velocity greater than 8 m/s).

A subsidiary management plan will be developed as part of the CEMP with the key objective to manage the generation of dust. A range of management controls and monitoring procedures will be applied as part of this management plan during key activities at the onshore development area. Specific dust control measures would also be implemented as part of the standard operation of the concrete batching plant.

9.8.5.1 Dust Generation – Vegetation Clearing

Residual risk to air quality from vegetation clearing is	**Low**
Residual risk to air quality from wind erosion of bare surfaces	**Very Low**

The site will require clearing and grading as part of the construction process. The clearing of vegetation and the grading (filling) of the site will create expose surfaces. These surfaces will include unconsolidated soils, rocks and aggregates, which have the potential to become source for dust generation.

Dust has the potential to impact flora and fauna without careful management. A dust management plan will be developed as part of the CEMP.

A monitoring program commenced in April 2009. This monitoring is establishing a baseline ambient dust concentration that can be used as a comparison. This will form the basis and provide trigger levels in any management plan. Specific dust management controls and mitigation factors are presented in Table 9.30.

Summary

It is possible that dust may impact flora and fauna beyond the boundary of the proposed development site. However, following the implementation of appropriate management and contingency plans as presented in Table 9.30, the residual risk ranking was considered to have a likelihood of "Likely" and a Consequence of "Minor". This provides and overall ranking of "Low".

9.8.5.2 Dust Generation – Vehicle Activity

Residual risk to air quality from vehicle activity	**Very Low**

The movement of vehicles on unsealed roads has the potential to generate dust. This dust can impact flora and fauna within close proximity to the road. This dust also has the potential to create safety issues as visibility may be reduced.

Due to the potential safety and environmental implications of dust generation from unsealed roads, dust generation will be managed. A dust management plan will be developed as part of the CEMP. This dust management may include:

- Limiting speeds on unsealed roads
- Early sealing of site access roads, where practicable
- Dust suppression, when necessary.

Summary

It is possible that dust generated from vehicles on unsealed roads may impact flora and fauna. However, following the implementation of appropriate management and contingency plans as presented in Table 9.30, the residual risk ranking was considered to have a likelihood of "Unlikely" and a Consequence of "Negligible" due to the limited spatial extend of the impact and the proposed mitigation measures in place. This provides and overall ranking of "Very Low".

9.8.5.3 Dust generation – Concrete Batching Plant

Residual risk to air quality from the concrete batching plant	**Low**

Concrete will be required during construction of the facilities. It is proposed that this concrete is manufactured onsite by a concrete batching facility. These facilities use aggregate (course and fine), cement and other materials to manufacture concrete.

Particulate matter, consisting primarily of cement and some aggregate and sand, are generally considered to be the primary pollutants of concern. The main issues are associated with fugitive emissions from stockpiles and point source emissions from transfer of material to the silos. This particulate matter could impact flora and fauna in an around the development area.

The concrete batching plant will require a works approval. This works approval will provide details of the proposed dust management measure for the plant, which may include fabric filters (socks), dust suppression systems, covers etc.

Summary

It is possible that dust generated from concrete batching may impact flora and fauna. However, following the implementation of appropriate management and controls as presented in Table 9.30, the residual risk ranking was considered to have a likelihood of "Unlikely" and a Consequence of "Moderate". This provides and overall ranking of "Low".

9.8.5.4 Dust generation – Transport of Material

Residual risk to air quality from transport of material	**Very Low**

The transportation of fill material, aggregate for fill, and materials for the concrete batching plant have the potential to generate dust. This dust has the potential to impact flora and fauna along the transportation route.

Fine aggregates and material are the main area of concern as they can readily be blown from the back of vehicles. Vehicles transporting materials that can generate large amounts of dust will be covered to minimise the potential impact of dust. The covering and containing of potentially dust generating material will be included as part of the dust management plan, which is a subsidiary plan to the CEMP.

Summary

It is possible that dust may be generated by vehicles transporting fill and aggregates.. However, following the implementation of appropriate management and controls as presented in Table 9.30, the residual risk ranking was considered to have a likelihood of "Remote" and a Consequence of "Moderate". This provides and overall ranking of "Very Low".

9.8.5.5 Other Atmospheric Emissions during Construction (excluding dust)

Residual risk to air quality from other atmospheric emissions (excluding dust)	**Very Low**

The construction of the facility has the potential to generate emissions other than dust. These emissions may be from a variety of temporary sources, which may be stationary or mobile. The majority of these sources will be short term and minor.

Emissions will be managed as part of the CEMP. In additional all equipment will be maintained in accordance with Australian Standards and Regulations.

There may be some emissions associated with the temporary power generation equipment, which could elevate ambient ground level concentrations of atmospheric pollutants. Details of the temporary power generating equipment are currently being determined. It is, however, envisaged that these emissions will be considerably smaller than the power generation for the 25 MTPA facility, which has been modelled and has a limited impact (see Appendix C1).

Summary

It is possible that emissions from the construction phase (excluding dust) may impact flora and fauna. However, following the implementation of appropriate management and controls as presented in Table 9.30, the residual risk ranking was considered to have a likelihood of "Remote" and a Consequence of "Moderate". This provides and overall ranking of "Very Low".

9.8.5.6 Air Emissions during Operations

Residual risk to air quality from air emissions during operations	**Low**

The onshore facility will be from multiple point sources. This section is based on the technical report prepared by SKM (included as Appendix C1). The technical detail used for the model input data are included in Appendix C1. A description of the model used (TAPM) is provided in Chapter 4, *Emissions, Discharges and Wastes*.

The most significant air emissions from the Project will be from the combustion of fuel gas in the gas turbines and from flaring. The main products of combustion of fuel gas in gas turbines are CO and NO_x. However, the key air pollutants in terms of risk are NO_2, PM_{10} and subsequent formation of O_3.

Atmospheric emissions from the Project will vary depending on the operating and vessel loading conditions, and the dispersion modelling has modelled the following scenarios. These are:

- Normal plant operations (with and without ship loading)
- Plant start up
- Emergency shutdown of a single train
- Cumulative impacts of additional gas processing facilities on adjacent sites.

In the absence of suitable monitoring in the area, the model also used existing contributions from non-industrial sources to establish existing air quality conditions.

It is expected that normal conditions will predominate, occurring in excess of 90 per cent of the time. Details of anticipated operating scenarios, including shutdowns are included in Chapter 2, *Project Description* and discussed in Chapter 4, *Emissions, Discharges and Wastes*.

The prospect of cumulative impacts has been addressed later in this section.

Results of Modelled Scenarios

The results from the air quality modelling undertaken for the Project are described in Chapter 4, *Emissions, Discharges and Wastes* and discussed in detail in Appendix C1. Table 9.29 provides a summary of the results from the modelling. Contour plots are provided in Chapter 4, *Emissions, Discharges and Wastes*.

Potential Impact on Vegetation from Deposition

Native vegetation can be adversely affected by exposure to a number of atmospheric pollutants or combinations of pollutants. However, no Australian ecosystem specific criteria have been established. WHO has established the following critical levels and loads as being pertinent to the European environment, which also includes (WHO 2000):

- 20 $\mu g/m^3$ for SO_2 as an annual and winter average. However this critical level is predicated on the observation that the most significant impacts from sulfur dioxide occur when winter mists are turned acidic by the presence of SO_2 in the air. Such climatic conditions rarely exist in the north of Western Australia.
- 30 $\mu g/m^3$ for NO_x and 8 $\mu g/m^3$ for NH_3 as annual averages. These critical levels are based on the impact that these plant appear to have in relation to the growth behaviour of plants and is separate to acid deposition (discussed later). They were established as being protective of all plants under all conditions and so may be suitable for Australia.
- Ozone is assessed as the cumulative hours above 40 ppb. The critical level is identified as 10 ppm/h. This is calculated by adding together all the concentrations over 40 ppb over a six month period. If the result is greater than 10 ppm (10 000 ppb) there is likely to be some impact on plant growth.
- Acidity impacts are strongly dependent on receiving soils and relate to the potential acidification of soils leading to releases of cations into the receiving environment (e.g. aluminium). Critical loads are established on the basis of soil type.
- Similarly nitrogen loads depend greatly on the receiving environment and whether eutrophic conditions are nitrogen or phosphorous constrained. The WHO identifies critical loads for typical ecosystems as being between 15 to 22 kg N/ha/annum or the equivalent of 49 to 66 kg NO_2/ha/annum.

Based on the modelling undertaken:

- SO_2 is not expected to exceed 2 $\mu g/m^3$ well below the 20 $\mu g/m^3$ guide
- Maximum annual NO_2 concentrations were identified as being 5.73 $\mu g/m^3$ well below the 30 $\mu g/m^3$ for NO_x
- Maximum nitrogen loads were predicted to be 3.8 kg NO_2/ha/annum well below the guideline.

In view of this air emissions from the Project are not expected to adversely impact the abundance, diversity, geographic distribution, productivity and conservation status of terrestrial flora and vegetation surrounding the Project and are therefore considered to be a very low risk.

Summary

The Project will increase atmospheric emissions compared to existing concentrations. Each of the phases of construction, commissioning, and operation will contribute differently to the local and regional airshed. However,

Table 9.29: Summary of Modelled Maximum Predicted Ground Level Concentrations of Air Pollutants

Pollutant	Modelled Grid	Averaging Period	Unit	NEPM Criteria	Maximum on Grid		Percentage of Criteria	
					On Grid	Onslow	On Grid	Onslow
Existing Environment								
NO_2	1 km	1-hour	ppb	120	1.2	0.8	1.0%	0.6%
		Annual	ppb	30	0.1	0.1	0.3%	0.2%
O_3	3 km	1-hour	ppb	100	23.8	19.5	23.8%	19.5%
		4-hour	ppb	80	21.8	19.5	27.2%	24.4%
Future - Normal Operations								
NO_2	1 km	1-hour	ppb	120	39	24	32%	20%
		Annual	ppb	30	3	0.4	9%	1%
PM_{10}	1-km	24-hour	µg/m³	50	27	25	53%	50%
SO_2	1-km	1-hour	ppb	200	3.5	0.7	1.7%	0.3%
		24-hour	ppb	80	1.1	0.1	1.4%	0.1%
		Annual	ppb	20	0.6	0.0	2.8%	0.1%
O_3	3 km	1-hour	ppb	100	44	38	44%	38%
		4-hour	ppb	80	40	34	50%	43%
Future - Ship Loading Conditions								
NO_2	1 km	1-hour	ppb	120	39	24	32%	20%
		Annual	ppb	30	2.8	0.4	9%	1%
SO_2	1-km	1-hour	ppb	200	3.5	0.7	1.7%	0.3%
		24-hour	ppb	80	1.1	0.1	1.4%	0.1%
		Annual	ppb	20	0.6	0.0	2.8%	0.1%
PM_{10}	1-km	24-hour	µg/m³	50	27	25	53%	50%
O_3	3 km	1-hour	ppb	100	44	38	44%	38%
		4-hour	ppb	80	40	34	50%	43%
Future - Start-up (Condition 1)								
NO_2	1 km	1-hour	ppb	120	39	24	32%	20%
SO_2	1-km	1-hour	ppb	200	3.3	0.6	1.6%	0.3%
PM_{10}	1-km	24-hour	µg/m³	50	28	25	55%	50%
O_3	3 km	1-hour	ppb	100	43	38	43%	38%
Future - Emergency Shutdown (Condition 2)								
NO_2	1 km	1-hour	ppb	120	36	23	30%	19%
SO_2	1-km	1-hour	ppb	200	2.2	0.6	1.1%	0.3%
PM_{10}	1-km	24-hour	µg/m³	50	44	25	87%	50%
O_3	3 km	1-hour	ppb	100	44	37	44%	37%

the results from the modelling of air pollutants have not identified any exceedences of the recognised air quality standards, therefore no additional management actions are deemed necessary. Therefore, residual environmental risk for this potential impact was assessed as being "Very Low" – impacts to air quality as a result of Project operations activities are "Unlikely", however, should impacts occur they are expected to be of "Minor" consequence with the adoption of the management controls and mitigation measures presented in Table 9.30.

9.8.6 Implications for Matters of National Environmental Significance

There are no matters of NES in the Project area likely to be affected by air quality.

9.8.7 Residual Risk Summary

The following table provides a summary of the aspects, activities and potential impacts to air quality as a result of Project activities. Indicative management controls and mitigating factors are also listed, along with the residual risk following implementation of the management controls.

9.8.8 Predicted Environmental Outcome

The location for the proposed processing facility is currently being considered as a potential 'processing hub' and, as such, there is the potential for additional gas processing facilities to be located at Ashburton North. Exxon proposes to construct a facility with capability to process approximately 6 MTPA of LNG each year (not yet referred to EPA). BHP Billiton is proposing to construct a domgas plant (referred December 2008). Both of these proposed facilities would be located immediately to the south of the Project onshore facilities.

The potential emissions from the proposed Exxon facility have been taken as similar to that of the fifth train at the Wheatstone facility. The potential emissions from the BHP Billiton domgas facility were assumed to be similar to that used in the air quality assessment of the proposed third party gas supplier's facility at Devil Creek (SKM 2008).

It is important to note that this modelling has only been conducted to provide an indication of the reasonably foreseeable potential ground-level concentrations of pollutants with these additional gas processing facilities. Table 9.31 provides indicative ground level concentrations of NO_2, PM_{10} and O_3 from the three facilities at Ashburton North. Further dispersion modelling will have to be conducted by the proponents of these facilities with more detailed emission characteristics.

After the implementation of controls and with consideration of mitigating factors, the impacts from dust are rated low to very low risk and are likely to affect the surrounding environment in a very localised area, primarily during the site vegetation clearance activities when preparing the site.

This air quality assessment concludes with the following key findings:

- Normal and non-routine emissions from the proposed Project operations are not expected to cause any significant air quality impacts within the study area.
- Throughout the year, no exceedences of the relevant air quality standards are expected for any of the pollutants studied.
- Being mindful that further scientific work is required to determine uncertainties for modelling depositions, this assessment has determined that the deposition of NO_2 from the proposed gas processing facility would be insignificant.
- Referring to the Chevron Risk Assessment approach to the air quality assessment, all pollutants modelled in this assessment are considered to have a negligible consequence of impact, thereby no discernable impact on identified receptors.

Consistent with the EPA objective for air quality management, Project related emissions will meet statutory requirements and acceptable standards, and not adversely affect environment values or the health, welfare and amenity of people and land users.

A summary of the potential impacts, management controls, and residual risk for dust is presented in Table 9.30. A framework Construction EMP (Appendix U1) has been developed which, in part, provides a high level indication of how impacts to air quality will be managed. Prior to Project construction, a Subsidiary (internal) Environmental Management Plan (EMP) will be developed that specifies the management and mitigation measures and actions which will be implemented to limit Project related impacts to air quality. This approach is consistent with the EPA's guidance on using a Risk-based approach in that factors containing low risks are addressed through the development of an EMP.

Table 9.30: Summary of Management Options and Residual Risk for Air Quality

Aspect and Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Dust generation – vegetation clearing	Dust deposition leading to vegetation loss.	• Dust control measures will be undertaken during site clearance. These control measures will be implemented on a case by case basis and will be dependent on the activity involved and the prevailing weather conditions. • A management plan will be developed as part of the CEMP with the key objective to manage the generation of dust. A range of management controls and monitoring procedures will be applied as part of this management plan during key activities at the onshore development area.	5	2	**Low**	**High** Long term monitoring results available	No
Dust generation – vehicle activity	Dust deposition leading to vegetation loss.	• Speed limits will be used in the construction area. This will assist in reducing dust generated by vehicle movements. • Early sealing of the site access roads will be investigated to assist in minimising dust generation caused by vehicle traffic. • A management plan will be developed as part of the CEMP with the key objective to manage the generation of dust. A range of management controls and monitoring procedures will be applied as part of this management plan during key activities at the onshore development area.	6	4	**Very Low**	**High** Long term monitoring results available	No
Dust generation – concrete batching plant	Dust deposition leading to vegetation loss.	• Batching plant will be located away from sensitive receptors, where practicable. Standard dust control measures from batching plants will be implemented. • Specific dust control measures may be implemented as part of the standard operation of the concrete batching plant. • A management plan will be developed as part of the CEMP with the key objective to manage the generation of dust. A range of management controls and monitoring procedures will be applied as part of this management plan during key activities at the onshore development area.	4	4	**Low**	**Reasonable** Available information is adequate	No

Dust generation - transport of material	Dust deposition leading to vegetation loss	• Speed limits will be in place in construction areas. Any material with the potential to generate windblown dust during transportation to and from the construction area will be covered. • A management plan will be developed as part of the CEMP with the key objective to manage the generation of dust. A range of management controls and monitoring procedures will be applied as part of this management plan during key activities at the onshore development area.	5	4	**Very Low**	**High** Long term monitoring results available	No
Dust generation – wind erosion of bare surfaces	Dust deposition leading to vegetation loss.	• Ground clearance leading to the exposure of bare surfaces will be avoided, where practicable. • Stockpiles, if required, will have appropriate dust control measures. Stockpiles will be located, wherever practicable, away from sensitive receptors. • A management plan will be developed as part of the CEMP with the key objective to manage the generation of dust. A range of management controls and monitoring procedures will be applied as part of this management plan during key activities at the onshore development area.	5	4		**High** Long term monitoring results available	No
Other atmospheric emissions	Reduction of air quality leading to human health and environmental impacts.	• All equipment will be well maintained and comply with Australian Standards and Regulations. • Clearing activities will be minimised, where practicable.	6	5		**Low** No modelling conducted	No

Aspect and Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Operations							
Air emissions	Reduced air quality as a result of emission of pollutants from the facility during processing leading to impacts on human health and the environment.	• Management of the processing operation to reduce polluting emissions as low as reasonably practicable. • Regular maintenance of equipment for good performance and reduced emissions. • Planning of non-routine (planned) maintenance shutdowns to reduce emissions, where practicable. • Ongoing monitoring of emissions from the facility to determine the level of polluting emissions. • Implementation of remedial action should emission levels exceed agreed levels.	5	4	**Very Low**	**Reasonable** Available information is adequate	No
Additive effects							
All of the above	All of the above	All of the above	5	2	**Low**	**Reasonable** Available information is adequate	No

Table 9.31: Maximum Predicted Future Ground-level Concentration for Cumulative Impacts under Normal Operating Conditions

Pollutant	Modelled Grid	Averaging Period	Unit	NEPM Criteria	Maximum on Grid		Percentage of Criteria	
					On Grid	Onslow	On Grid	Onslow
NO_2	1 km	1-hour	ppb	120	42	26	35%	21%
		Annual	ppb	30	3.2	0.5	11%	2%
SO_2	1-km	1-hour	ppb	200	3.5	0.8	1.8	0.4
		24-hour	ppb	80	1.3	0.1	1.6	0.2%
		Annual	ppb	20	0.6	0.0	3.0%	0.1
PM_{10}	1-km	24-hour	$\mu g/m^3$	50	27	25	54%	50%
O_3	3 km	1-hour	ppb	100	44	38	44%	38%
		4-hour	ppb	80	41	35	51%	44%

10.0

Social Risk Assessment and Management

10.0 Social Risk Assessment and Management

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10.0 Social Risk Assessment and Management

10.1 Introduction

The Wheatstone Project (Project) Environmental Scoping Document (Scoping Document) identified potential impacts of the Project on the Onslow community. Impacts of particular concern to the community included the need to preserve the unique character of Onslow and effectively manage any impacts on the commercial fishing industry, recreational activities and heritage values in the area.

Onslow supports a population of between 600 and 900 people depending on the season. Compared to other Pilbara towns, it is relatively untouched by resource industries and the only large industrial company is Onslow Salt Pty Ltd. As a small and isolated community, there are concerns about the impacts of a large temporary construction workforce and the potential population growth that may result due to project development in the locality.

This chapter assesses the potential impacts of the Project on European cultural heritage, Aboriginal cultural heritage, local fishing and pearling, recreational users, public amenity (noise emissions, air emissions and visual impacts) and the health and wellbeing of the Onslow community, including public health risks from vehicular traffic and LNG plant upset conditions. It discusses the design and management measures proposed to assist in reducing these impacts. An assessment of the effectiveness of these measures and the residual risk associated with construction, commissioning, operation and decommissioning of the Project is also included.

Following guidance from the Environmental Protection Authority (EPA), a risk assessment was conducted for each relevant aspect on four of the social factors listed in Table 10.1. Chapter 7, *Impact Assessment Methodology* provides more detail on the processes used in assessing the risks associated with development of the Project.

The predicted impacts, controls and residual risks for social factors are discussed in the following sections and presented in summary tables.

The key legislation for the factors listed in Table 10.1 are presented in Table 10.2. Additional legislation and guidelines relevant to specific factors or aspects are discussed in the following sections.

Development of the Project requires construction of the following marine and terrestrial infrastructure:

- Offshore production facilities with a nominal capacity of 9 MTPA LNG, including wells, subsea installations and offshore platforms
- An export pipeline (trunkline) to provide feed gas from the offshore production infrastructure to the onshore gas processing facility
- A gas processing and export facility, including 25 MTPA LNG processing facility and domestic gas processing plant, LNG and condensate product storage, power generation, water supply, waste disposal, and associated support facilities
- Marine facilities including a shipping channel, turning basin, Materials Offloading Facility (MOF) and Product Loading Facility (PLF)
- A multi-purpose infrastructure corridor, which will incorporate an access road to the site as well as the domestic gas pipeline connecting to the existing Dampier-to-Bunbury Natural Gas Pipeline (DBNGP)
- An accommodation village, access roads and supporting infrastructure.

Table 10.1: Social Factors and Aspects

Factors	Aspects
European cultural heritage (Section 10.2) Aboriginal cultural heritage (Section 10.3) Local fishing and pearling (Section 10.4) Disturbance to other recreational use (Section 10.5) Public amenity (Section 10.6) Public health and wellbeing (including public risk) (Section 10.7)	Vegetation clearing Construction activities (including installation of subsea pipeline) Construction earthworks Dredging (including placement of dredge material) Physical presence of marine infrastructure Physical presence of infrastructure Acoustic emissions during operations and construction Dust emissions Air emissions Visual impact (including light emissions) Vehicular activity Vessel movements

Table 10.2: Legislation and Guidelines Relevant to the Social Environment

Legislation or Guideline	Intent
EPA Guidance Statement No.33 (EPA 2008)	This guidance statement is to ensure that: • Changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation • Existing and planned recreational uses are not compromised • Aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable • Risk from the proposal is as low as reasonably achievable and complies with acceptable standards and EPA criteria.
Heritage of Western Australia Act 1990 (WA)	This State Act provides a legal framework: • To identify, conserve and where appropriate enhance those places within Western Australia which are of significance to the cultural heritage • In relation to any area, to facilitate development that is in harmony with the cultural heritage values of that area • To promote public awareness as to the cultural heritage, generally.
Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Cth)	This Commonwealth Act provides a legal framework to preserve and protect from injury or desecration of areas and objects in Australia and in Australian waters, being areas and objects that are of particular significance to Aboriginals in accordance with Aboriginal tradition.
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act [Cth])	This Commonwealth Act provides a legal framework for the protection and conservation of heritage, and to enhance the protection and management of important natural and cultural places.
Aboriginal Heritage Act 1972 (AH Act [WA])	This State Act provides a legal framework for the preservation on behalf of the community of places and objects customarily used by or traditional to the original inhabitants of Australia or their descendants, or associated therewith, and for other purposes incidental thereto.
EPA Guidance Statement No. 41: *Assessment of Aboriginal Heritage 2004* (WA) (EPA 2004a)	This guidance statement provides for the consideration of Aboriginal heritage matters to the extent that they may be affected by a development proposal on the physical or biological surroundings, and to ensure that changes to the environment do not adversely affect matters of heritage significance to Aboriginal people.
Shire of Ashburton Municipal Heritage Inventory (WA)	This inventory aims to conserve any object or place of heritage significance.
State Planning Policy 2.6 – State Coastal Planning Policy (WAPC 2003a)	This policy aims to: • Protect, conserve and enhance coastal values, particularly in areas of landscape, nature conservation, indigenous and cultural significance • Provide for public foreshore areas and access to these on the coast • Ensure the identification of appropriate areas for the sustainable use of the coast for housing, tourism, recreation, ocean access, maritime industry, commercial and other activities • Ensure that the location of coastal facilities and development takes into account coastal processes including erosion, accretion, storm surge, tides, wave conditions, sea level change and biophysical criteria. (Cont'd)

Legislation or Guideline	Intent
Shire of Ashburton Town Planning Scheme No 7 (DPI 2005)	This planning scheme provides guidance that all planning approvals should consider: • The impact of the development on the amenity of the locality • Any social issues that have an effect on the amenity of the locality • Specifically, Council will assess any social issues which that have an effect on the amenity of the locality • The capacity of the site and surrounding locality to support the development (including access, traffic generated, need for public transport services, services infrastructure and community services, amenity impacts on the locality) • Compatibility of the proposed use within its setting • Potential loss of community benefit or service resulting from the planning approval.
Fish Resources Management Act (1994) (DoF 1994)	This State Act provides a legal framework to conserve, develop and share the fish resources of the State for the benefit of present and future generations. In particular the objectives are to: • Conserve fish and to protect their environment • Ensure that the exploitation of fish resources is carried out in a sustainable manner • Enable the management of fishing, aquaculture and associated industries, aquatic eco-tourism and other tourism reliant on fishing • Foster the development of commercial and recreational fishing and aquaculture including the establishment and management of aquaculture facilities for community or commercial purposes • Achieve the optimum economic, social and other benefits from the use of fish resources • Enable the allocation of fish resources between users of those resources • Provide for the control of foreign interests in fishing, aquaculture and associated industries • Enable the management of fish habitat protection areas and the Abrolhos Islands reserve.
Shire of Ashburton Local Planning Policy 20 – Social Impact Assessment (Shire of Ashburton 2009)	This policy seeks to provide: • A framework for the identification of issues arising from development proposals that may impact on the social structure of the Shire • A consistent and thorough approach to the assessment of issues associated with proposals • A description of issues and means to address those issues for the consideration of the community and the Shire • Information and support for community input into the decision making process • Minimisation of negative impacts and maximisation of positive outcomes • Integration of expertise in the decision making process • The consideration of a wide range of issues that have social implications, including: infrastructure, resource issues, heritage impacts, landform impacts, economic and fiscal impacts, community impacts, cultural impacts, indigenous rights impacts, demographic impacts, transport impacts and other relevant considerations.

Further descriptions of the above infrastructure and facilities are found in Chapter 2, *Project Description*.

10.2 European Cultural Heritage

The following section presents the assessment of impacts on European cultural heritage associated with the Project, taking into account design modifications, mitigation methods and controls applied to reduce impacts.

10.2.1 Management Objective

The EPA objective for this assessment is to ensure that changes to the biophysical environment do not adversely affect historical and cultural associations, and that developments comply with relevant heritage legislation.

10.2.2 Description of Factor

The baseline characteristics of the receiving social environment are described in Chapter 6, *Overview of Existing Environment*. Sources of data included:

- The existing Old Onslow Townsite (3444) Conservation Management Plan
- An archaeological survey report from 1991
- Two archaeological and historical surveys conducted in 2009
- A review of literature and archival documents relevant to the Old Onslow township and marine archaeology in the vicinity.

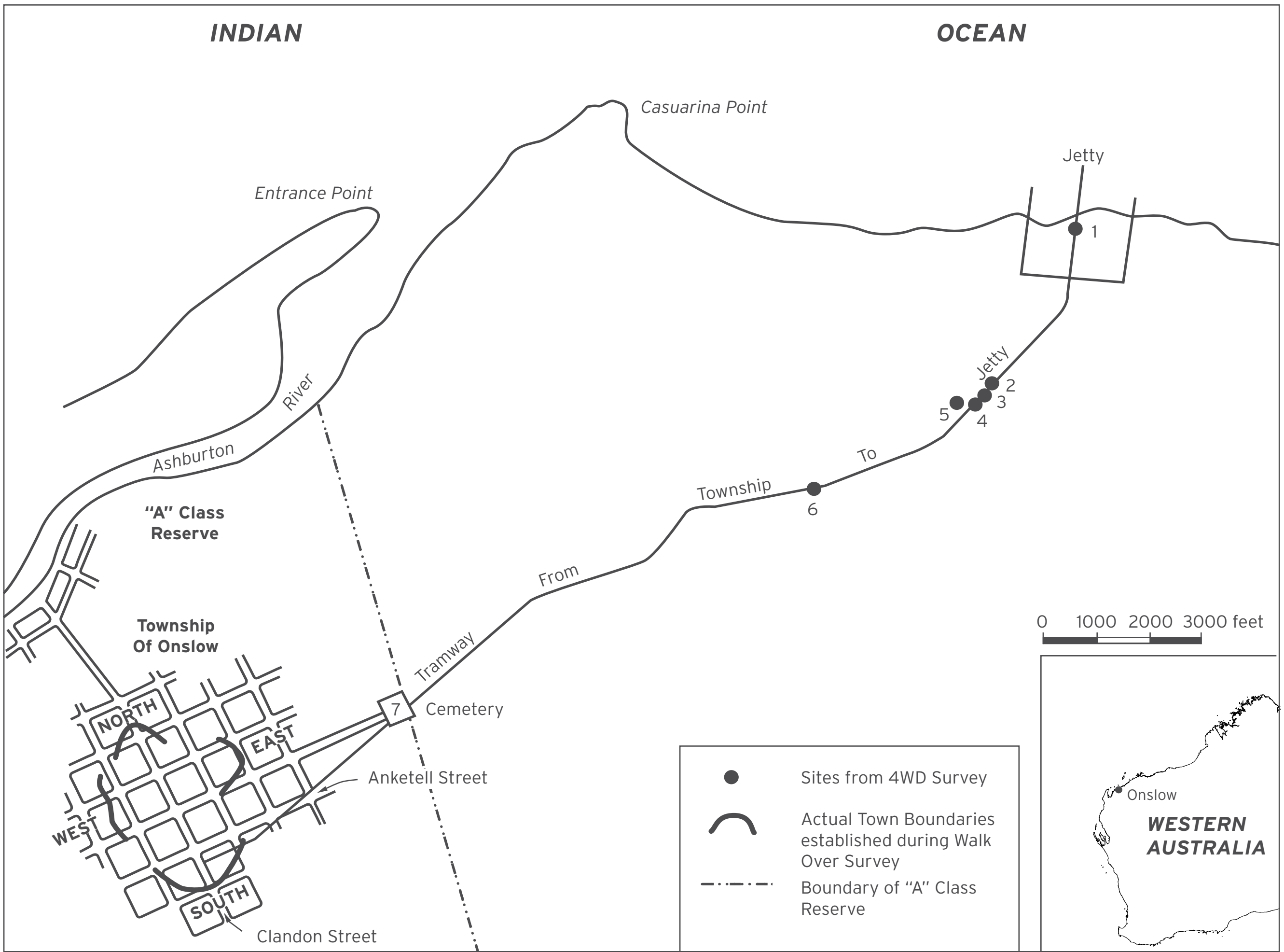

Figure 10.1: Site Location Plan Showing Sites Outside of Old Onslow

Source: Nayton 1991.

Table 10.3: Legislation and Guidelines Specific to European Cultural Heritage

Legislation or Guideline	Intent
EPA Guidance Statement No.33 (EPA 2008)	This guidance statement aims to ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.
Heritage of Western Australia Act 1990 (WA)	This State Act provides a legal framework: • To identify, conserve and where appropriate enhance those places within Western Australia which are of significance to the cultural heritage • In relation to any area, to facilitate development that is in harmony with the cultural heritage values of that area • To promote public awareness as to the cultural heritage, generally.
Historic Shipwrecks Act 1976 (Cth)	This Commonwealth Act provides a legal framework to protect shipwrecks and relics.
Maritime Archaeology Act 1973 (WA)	This State Act provides a legal framework for the preservation on behalf of the community of the remains of ships lost before the year 1900, and of relics associated therewith, and for other purposes incidental thereto.
Shire of Ashburton Town Planning Scheme No. 7 (DPI 2005)	The intent of this planning scheme in relation to heritage is: • To facilitate community input into planning for the appropriate balance between economic and social development, conservation of the natural environment, heritage structures and places, and improvement is lifestyle and amenity • To facilitate the conservation of any place, area, building, object or structure of heritage value • To afford the opportunity for existing traditional uses to be continued or allow for the approval of alternative uses which are compatible with the heritage values and character of the locality • To ensure that development within or adjacent to places of heritage value has due regard to the value of the heritage place and is in harmony with the character of the locality • To establish and maintain an Inventory of buildings, objects, structures and places considered by the Local Government to be of heritage significance worthy of conservation.
Shire of Ashburton Municipal Heritage Inventory (WA)	The purpose of the inventory is to conserve any object or place of heritage significance.
Shire of Ashburton Local Planning Policy 20 – Social Impact Assessment (Shire of Ashburton 2009)	This policy seeks to provide: • A framework for the identification of issues arising from development proposals that may impact on the social structure of the Shire • A consistent and thorough approach to the assessment of issues associated with proposals • A description of issues and means to address those issues for the consideration of the community and the Shire • Information and support for community input into the decision making process • Minimisation of negative impacts and maximisation of positive outcomes • Integration of expertise in the decision making process • The consideration of a wide range of issues that have social implications, including: infrastructure, resource issues, heritage impacts, landform impacts, economic and fiscal impacts, community impacts, cultural impacts, indigenous rights impacts, demographic impacts, transport impacts and other relevant considerations.

The Old Onslow Townsite is registered as place 3444 on the Western Australian Register of Heritage Places. The Heritage Council of Western Australia (HCWA) conservation area consists of a town site area, the line of a former tramway and jetty area. The registered area associated with the former jetty consists of both land and sea bed areas. The site is also listed on the Shire of Ashburton's municipal inventory and is highly valued by Onslow residents. A description of the factor is contained in Chapter 6, *Overview of Existing Environment*.

The tramway, telegraph line and jetty sites fall within the Ashburton North SIA. The "A" class reserve, which contains both the Old Onslow Townsite and Old Onslow Cemetery, falls outside of Ashburton North SIA. Figure 10.1 shows the key European cultural heritage features within the area in relation to the Old Onslow Townsite and can be viewed with Figure 10.2 for geographical context.

10.2.3 Assessment Framework

Relevant assessment framework for European cultural heritage exists at Commonwealth, State and Local Government levels. Specific policy and framework documents relating to European cultural heritage are identified in Table 10.3.

Risk-based Approach to Assessing Impacts on European Cultural Heritage

The risk-based approach to assessing Project impacts on European cultural heritage was discussed with representatives from HCWA in November 2009 (HCWA 2009). It was decided a risk-based approach was not appropriate for assessing European cultural heritage issues and the existing HCWA process for assessing heritage impacts was more suitable.

Chevron Australia Pty Ltd. (Chevron) will demonstrate to HCWA prior to construction how it intends to manage European cultural heritage matters. This will be achieved through the development of an Old Onslow Townsite (3444) Development Impact Mitigation Plan, the provisions of which will be prepared in consultation with HCWA, the Shire of Ashburton and the Western Australian Maritime Museum as key stakeholders in the heritage of the area. HCWA will evaluate the Old Onslow Townsite (3444) Development Impact Mitigation Plan in accordance with its standard practices.

10.2.4 Impact Assessment and Management

Impacts to European cultural heritage will occur to some extent as a result of Project activities. The following sections summarise the aspects and activities that may directly and indirectly affect European cultural heritage in, and surrounding, the Project area. The potential impacts and the management measures to be implemented are discussed in detail.

A heritage archaeologist undertook an archaeological and historical study to identify the Project's possible impacts on European cultural heritage (Appendix V). The study's findings in regard to heritage values and level of significance are listed in Table 10.4. It should be noted that the table reflects the level of significance assessed in 2009, not the level assessed in 1991 on which the HCWA classified the whole HCWA conservation area as being of "exceptional significance".

Figure 10.2 shows the proposed Project development footprint in relation to the HCWA conservation area. The diagram shows that the Project will have an impact on the northern part of the HCWA conservation area.

Impacts to European cultural heritage will occur as a result of Project activities and are unavoidable under the present Project design. The Project fence line is approximately 2.5 kilometres from the Old Onslow town and one kilometre from the Old Onslow cemetery. Although there will be no ground disturbance work undertaken in the Old Onslow town or cemetery, an existing access track, which runs through the south-east corner of the HCWA conservation area, may be widened and upgraded to allow temporary road access to support construction activities. The main heritage impact of the Project will be to the archaeological heritage of the 1901 to 1925 sea jetty and port, and associated tramway and telegraph line. There will also be some impacts on former pastoral sites; however, these have little archaeological significance.

The areas on which the Project will have the most impact are currently classified as being of "exceptional significance". This classification was based on studies completed in 1991; however, recent site visits[1] revealed that many key features found in the 1991 study no longer exist. As a result, a recommendation has been made to HCWA to reclassify the site from "exceptional significance" to "considerable significance".

1 Note: Gaye Nayton, the heritage archaeologist who completed the current study, was the archaeologist who did the 1991 site study upon which the "exceptional significance" status was recommended. Her recent visit to the site has resulted in a recommendation to downgrade the significance from "exceptional" to "considerable", and in the case of pastoral areas, a downgrade to "little" significance.

Table 10.4: Levels of Heritage Value Significance

Level of Significance	Description/Detail
Exceptional significance	**Old Onslow Townsite** The main area of the Old Onslow Townsite, including the 1879–1901 landing place and cemetery, is a significant heritage asset for the region. The town played an important role as a frontier town in the colonisation of the North-West and it contains a wealth of undisturbed archaeological sites. The Old Onslow Townsite is located outside of the Ashburton North SIA and will not be affected by the Project. However, there is potential for visual impacts on the views from the town site.
Considerable significance	**1901-1925 Port Area** Six areas with archaeological materials were located within the Port area, with most material associated with the store, tram stop and well. The only evidence of the 1901 jetty was cut-out features, isolated artefacts and one artefact spread associated with the sand pad foundation. There was no evidence of the 1897 jetty.
	1901 Poles and Anchor Points Eight standing telegraph poles, one fallen pole and associated anchor points were mapped. All the evidence is located in the northern half of the study area.
	1901 Tramway Causeway In areas where the tramway overlaps with four-wheel drive (4WD) tracks, there is little evidence remaining. On sections where it is located away from 4WD tracks, there is some evidence of metal objects such as railway spikes and iron straps. There is no evidence left of timber sleepers or tram rails except where they are used as fence posts.
	1909 Large Timber Bridge The central section of the bridge is still standing; however there is considerable damage to both end sections.
	Any artefact spread associated with the 1901-1925 jetty Although the study did not locate any artefact material associated with the use of the 1901–1925 sea jetty, it is possible some may be located during construction works.
	Any historic shipwreck located within the study area The marine surveys undertaken in the area did not show evidence of any historic shipwrecks. Although shipwrecks were known to occur in the region, current evidence suggests it is unlikely that historic shipwrecks will be located in the study area.
Some significance	Telegraph Pole Anchor Point located in Area 3.
Little significance	**Pastoral sites** A series of crop marks were identified within four areas along the tramway. They had little surface or sub-surface artefact material and have low archaeological potential. **Isolated finds** It is possible some isolated finds of unknown archaeological potential may be located during the construction or operational phases of the Project.

10.2.4.1 Impact on European Cultural Heritage Sites and Artefacts

Chevron will endeavour to protect the European cultural heritage in the Project area as far as reasonably practicable; however, some sites and their associated artefacts will be affected by construction and operational activities.

The main expected impacts on European cultural heritage sites and their associated artefacts are outlined in the following:

- The construction of retaining walls may affect European cultural heritage sites and associated artefacts located within the work area of the wall construction
- Dredging the sea bed or installing pipe lines adjacent to the 1901-to-1925 jetty is likely to affect artefacts still existing in the area
- Filling over the tramway causeway using heavy machinery may affect artefacts
- Construction activities may bury some European cultural heritage sites and associated artefacts. However, these sites will be buried deep enough to protect them
- Existing telegraph poles will be either partially or completely buried, although not deep enough to protect them.

All impacts on European cultural heritage sites and artefacts will be managed in accordance with relevant legislative requirements and the Old Onslow Townsite (3444) Development Impact Mitigation Plan.

10.2.4.2 Impact on European Cultural Heritage Values

There will be no ground disturbance in the Old Onslow Townsite or the Old Onslow cemetery, which are the most significant areas of heritage value in the locality. However, the physical presence of the plant will have some visual impacts; construction-related traffic along the existing access track may increase noise and dust in the south-east

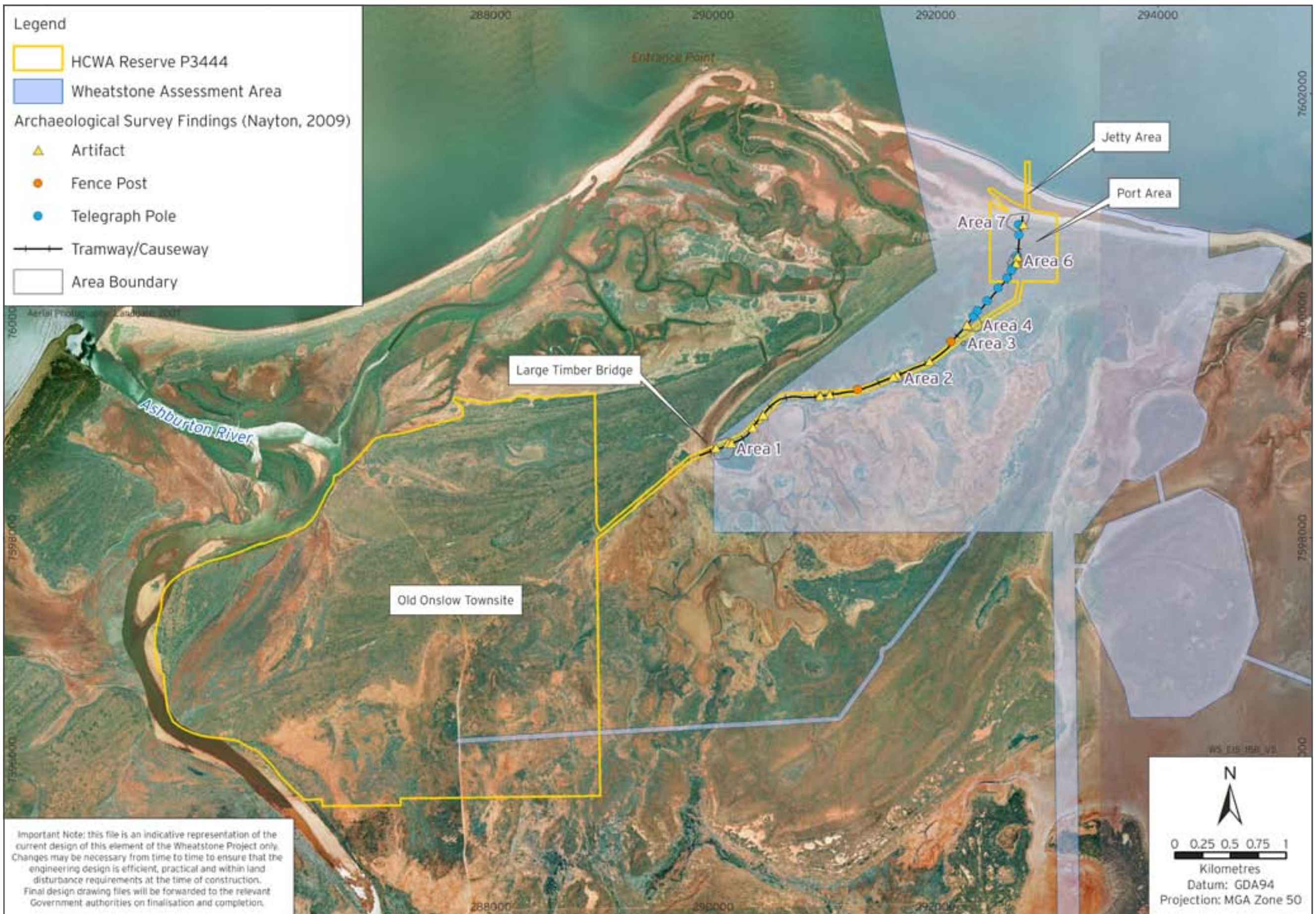

Figure 10.2: Proposed Project Footprint in Relation to HCWA Conservation Area

Source: Nayton 1991

corner of the HCWA conservation area; and there will be an increase in noise levels during emergency flaring and when weather conditions carry noise from the LNG Plant further than normal. The Project will also affect the 1901-to-1925 sea jetty and port, and associated tramway and telegraph line. Therefore, there will likely be an impact on the heritage value of the overall area.

It is unlikely that Chevron can reduce visual or noise impacts on the Old Onslow Townsite heritage area through Project engineering design. In addition, there may be irreversible damage to the 1901-to-1925 sea jetty and port area, and associated tramway and telegraph line. Chevron will outline key strategies for managing the overall impact on European cultural heritage values in the Old Onslow Townsite (3444) Development Impact Mitigation Plan, which will be developed in consultation with HCWA, the Shire of Ashburton, and the Western Australian Maritime Museum. Strategies to enhance heritage values will also be described in this Plan.

10.2.5 Implications for Matters of National Environmental Significance

There are no matters of NES directly attributable to European cultural heritage.

10.2.6 Predicted Environmental Outcome

There will be some Project impacts on European cultural heritage as a result of construction activities; however, these impacts will comply with relevant heritage legislation. Chevron shall consult with HCWA, the Shire of Ashburton, and the Western Australian Maritime Museum in regard to managing impacts. The EPA management objective for European cultural heritage is expected to be achieved.

10.3 Aboriginal Cultural Heritage

The following section presents the assessment of impacts on Aboriginal cultural heritage associated with the Project, taking into account design modifications, mitigation methods and controls applied to reduce impacts.

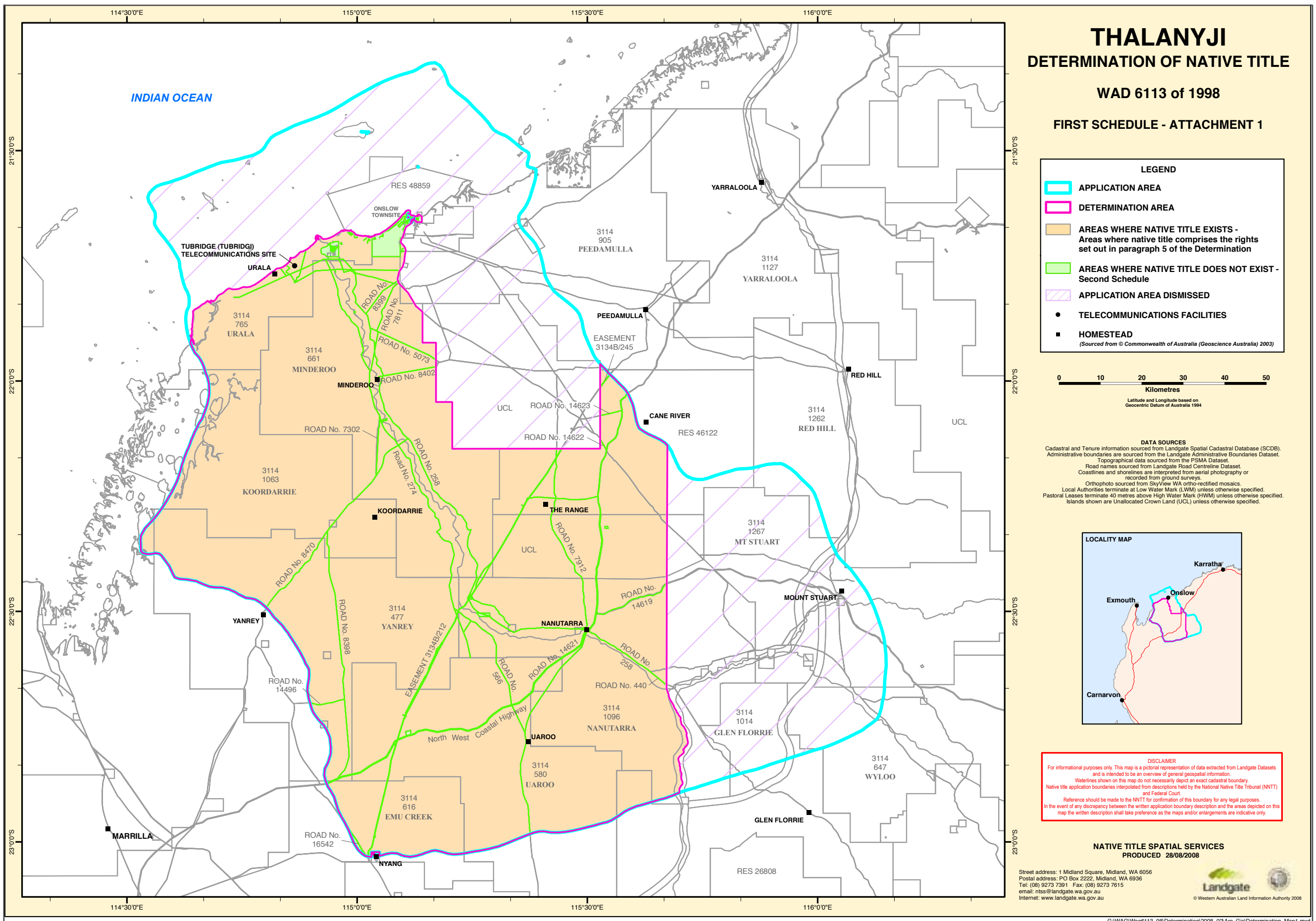

Figure 10.3: Thalanyji Determination of Native Title

Source: Federal Court of Australia 2008

10.3.1 Management Objective

The EPA objective for this assessment is to ensure that changes to the biophysical environment do not adversely affect historical and cultural associations, and that developments comply with relevant heritage legislation.

10.3.2 Description of Factor

The baseline characteristics of the receiving social environment are described through the studies described in Chapter 6, *Overview of Existing Environment*. Sources of data included:

- Detailed archaeological and ethnographic Aboriginal heritage surveys
- A review of Western Australian Department of Indigenous Affairs (DIA) sites
- A review of records held by the Western Australian Museum.

Aboriginal heritage encompasses both physical and social aspects of heritage significance. It includes sacred, spiritual or ceremonial sites; cultural materials (artefacts); and places of historical, anthropological or ethnographical interest that are, or were, associated with Aboriginal people. Under the *Western Australian Environmental Protection Act 1986* (EP Act [WA]), it can also include the preservation of natural environments for use in social and traditional activities, such as hunting.

Table 10.5: Legislation and Guidelines Specific to Aboriginal Cultural Heritage

Legislation or Guideline	Intent
Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Cth)	This Commonwealth Act provides a legal framework to preserve and protect from injury or desecration of areas and objects in Australia and in Australian waters, being areas and objects that are of particular significance to Aboriginals in accordance with Aboriginal tradition.
EPBC Act (Cth)	This Commonwealth Act provides a legal framework to provide for the protection and conservation of heritage, and to enhance the protection and management of important natural and cultural places.
AH Act (WA)	This State Act provides a legal framework to make provision for the preservation on behalf of the community of places and objects customarily used by or traditional to the original inhabitants of Australia or their descendants, or associated therewith, and for other purposes incidental thereto.
Aboriginal Heritage Regulations 1974 (WA)	These regulations apply to any Aboriginal site or protected area or land held subject to a covenant in favour of the Minister in relation to which the Minister has a duty under the *Aboriginal Heritage Act 1972 (WA)*. The regulations specify the types of activities (such as ground disturbing activities) that require approval under the regulations.
Heritage of Western Australia Act 1990 (WA)	This State Act provides a legal framework: • To identify, conserve and where appropriate enhance those places within Western Australia which are of significance to the cultural heritage • In relation to any area, to facilitate development that is in harmony with the cultural heritage values of that area • To promote public awareness as to the cultural heritage, generally.
Coroner Act 1996 (WA)	This State Act provides a legal framework to investigate reportable deaths (may include Aboriginal remains).
EPA Guidance Statement No. 41: *Assessment of Aboriginal Heritage* 2004 (WA) (EPA 2004a)	This guidance statement aims to consider Aboriginal heritage matters to the extent that they may be affected by a development proposal on the physical or biological surroundings, and to ensure that changes to the environment do not adversely affect matters of heritage significance to Aboriginal people.
Shire of Ashburton Municipal Heritage Inventory (WA)	The purpose of the inventory is to conserve any object or place of heritage significance. (Cont'd)

Legislation or Guideline	Intent
Shire of Ashburton Local Planning Policy 20 – Social Impact Assessment (Shire of Ashburton 2009)	This policy seeks to provide: • A framework for the identification of issues arising from development proposals that may impact on the social structure of the Shire • A consistent and thorough approach to the assessment of issues associated with proposals • A description of issues and means to address those issues for the consideration of the community and the Shire • Information and support for community input into the decision making process • Minimisation of negative impacts and maximisation of positive outcomes • Integration of expertise in the decision making process • The consideration of a wide range of issues that have social implications, including: infrastructure, resource issues, heritage impacts, landform impacts, economic and fiscal impacts, community impacts, cultural impacts, indigenous rights impacts, demographic impacts, transport impacts and other relevant considerations.

Figure 10.4: Aboriginal Heritage Survey Extent at Ashburton North SIA

In September 2008 the Thalanyji people became the determined native title holders of land in the Onslow area, including Ashburton North SIA. In December 2008 Chevron signed a Heritage Agreement with the Buurabalayji Thalanyji Association Incorporated (BTAI), for and on behalf of the Thalanyji people. Figure 10.3 shows the determination of Native Title Area for the Thalanyji.

10.3.3 Assessment Framework

Relevant assessment framework for Aboriginal cultural heritage exists at Commonwealth and State levels. Specific policy and framework documents relating to Aboriginal cultural heritage are identified in Table 10.5.

Risk-based Approach to Assessing Impacts on Aboriginal Cultural Heritage

The risk-based approach to assessing Project impacts on Aboriginal cultural heritage was discussed with representatives from the BTAI in July 2009 (BTAI 2009). The BTAI representatives did not believe a risk-based approach was appropriate for Aboriginal cultural heritage issues, and therefore a risk-based approach has not been adopted for this factor. Instead, Chevron will develop a Wheatstone Project Cultural Heritage Management Plan (CHMP) in consultation with BTAI and DIA, which is expected to be finalised in 2010. The CHMP will be subject to the conditions of approvals and any approval to the CHMP itself. Chevron proposes to utilise the CHMP and relevant legislation to manage risks to Aboriginal cultural heritage during all phases of the Project.

10.3.4 Impact Assessment and Management

Impacts to Aboriginal cultural heritage will occur to some extent as a result of Project activities. The following sections summarise the aspects and activities that may directly and indirectly affect Aboriginal cultural heritage in, and surrounding, the Project area.

The archaeological cultural heritage studies being completed for the EIS/ERMP will identify both terrestrial Aboriginal cultural and heritage sites the Project may impact. The heritage studies are being conducted in accordance with the principles outlined in the EPA Draft Guidance Statement No. 41 for the assessment of Aboriginal Heritage and the requirements set out under the AH Act (WA).

The methodology adopted for assessment of Aboriginal cultural heritage impacts includes:

- A review of DIA sites and records held by the Western Australian Museum to identify known or heritage issues from an archaeological perspective
- Archaeological and ethnographic heritage surveys, including the identification of archaeological and ethnographic sites of indigenous significance.

A preliminary ethnographic and archaeological survey of 21 proposed stygofauna monitoring bore sites was undertaken in January 2009 and involved the Thalanyji and their heritage consultants. One bore hole was relocated to avoid a newly identified shell and stone artefact scatter (WH09-01). No ethnographic sites were reported.

During 2009 and 2010, seven comprehensive heritage surveys of the proposed plant site and surrounding areas were completed which involved Thalanyji representatives and their heritage consultants. Seventy-eight previously unrecorded archaeological sites were located during the course of these surveys. The sites identified contain shell scatters, shell middens, evidence of grinding activities and artefacts. No ethnographic sites were identified in the survey area. Three previously recorded sites (Amethyst 05, 06 and 07 – DIA 15846 to 15848) have been re-recorded during the course of the surveys.

Additional surveys will be performed to investigate other areas identified by Chevron that could be potentially affected. Figure 10.4 shows a map of the extent of Aboriginal heritage surveys completed by June 2010 in the Ashburton North SIA.

The assessment has found that some Aboriginal cultural heritage sites will be affected during the life of the Project. All impacts to these sites and any future impacts on Aboriginal cultural heritage values will be managed in accordance with Section 18 Notices (AH Act).

10.3.5 Implications for Matters of National Environmental Significance

There are no matters of NES directly attributable to Aboriginal cultural heritage.

10.3.6 Predicted Environmental Outcome

There will be some Project impacts on Aboriginal cultural heritage values due to disturbance of certain identified Aboriginal heritage sites. Chevron will manage all impacts to these sites and any future impacts on Aboriginal cultural heritage values with the objective that any such impacts do not breach the AH Act (WA). This may include obtaining all necessary Section 18 Notices. These measures will be undertaken with the objective of meeting the environmental protection objective for Aboriginal heritage.

10.4 Local Fishing and Pearling

The following sections present the assessment of impacts on local fishing and pearling associated with the Project, taking into account design modifications, mitigation methods and controls applied to reduce impacts.

10.4.1 Management Objectives

The EPA's objective is to ensure that existing and planned recreational uses of the environment are not compromised, and that the principles of ecologically sustainable development (as they relate to the integration of long-term and short-term economic, social and environmental considerations) are upheld.

10.4.2 Description of Factor

The baseline characteristics of the receiving social environment are described in Chapter 6*, Overview of Existing Environment*. Sources of data included a study undertaken to develop a sound understanding of recreational fishing activities within the Project area, confirm other relevant marine uses, document issues and concerns of commercial and recreational fishers, and assess the economic dependence on fishery and aquaculture resources.

The study included a literature review, individual and group interviews and data analysis. A total of 26 interviews were conducted with key stakeholders including the Western Australian Department of Fisheries, State commercial fishing industry bodies and commercial fishers. Recreational fishing industry organisations (for example, RecFishWest, charter boat operators, and tourist accommodation providers) were interviewed for their views on potential issues/impacts. Intercept surveys were also conducted with recreational fishers at popular fishing spots around Onslow.

Spatial analysis of fishing activity areas included in the State of the Fisheries report (Fletcher and Santoro 2008) and data collected from interviews with fishing industry stakeholders were used to determine which commercial fisheries should be screened for further examination. Those selected were:

- **Onslow Prawn Managed Fishery** – Production from the Onslow prawn fishery is small in comparison to other prawn grounds in WA and it is considered economically marginal. Landed catch is highly variable and some holders of licences have never fished the fishery. In response to difficult conditions, niche businesses have evolved and are, to a degree, dependent upon the fishery.
- **Pilbara Trap Fishery** – two trap fishery operators are permitted to work off Onslow but only one has operational associations with Onslow.
- **Pearl Oyster Managed Fishery** – Pearl shells are understood to be collected in the Onslow area. Wild shells are used as stock for pearl farming but the nearest pearl farming operations appear to be in the Exmouth Gulf, off Point Samson and in the Montebello Islands. As the Project will have negligible impact on pearling, this was not assessed further.
- **North Coast Blue Swimmer Crab Fishery** – Blue swimmer crabs are the subject of a small developmental fishery that covers an area between Onslow and Port Hedland with some fishing activity off Onslow.
- **Pilbara Line Fishery** – The Pilbara Line fishing boat licensees are permitted to operate anywhere within "Pilbara waters". They target a subset of the ten main Pilbara Trawl target species.
- **Mackerel Managed Fishery** – This fishery uses near surface trolling gear from small vessels in coastal areas around reefs, shoals and headlands to target mainly Spanish mackerel.
- **Specimen Shell Managed Fishery** – The Specimen Shell Managed Fishery is based on the collection of individual shells for the purposes of display, collection, cataloguing, classification and sale.
- **Marine Aquarium Fish Managed Fishery** – The Marine Aquarium Fish Managed Fishery targets more than 250 species of fish under the management plan. It is primarily a dive based fishery that uses hand held nets to capture the desired target species from boats up to 8 m in length (Fletcher & Santoro 2009).

Recreational fishing is an important part of recreational life in Onslow and the nearshore areas (including nearshore islands) provide recreation opportunities for locals and visitors from communities as far inland as Tom Price and Newman. Relatively little recreational fishing takes the form of charter boat hires. Onslow attracts long-staying tourists during the mild winter months and many enjoy fishing daily.

10.4.3 Assessment Framework

Relevant assessment framework for local fishing and pearling exists at Commonwealth and State levels. Specific policy and framework documents relating to local fishing and pearling are identified in Table 10.6.

The commercial fisheries of interest have management plans to ensure ecologically sustainable commercial fishing practices (for example, the Onslow Prawn Fishery Management Plan, 1991, Government of Western Australia);

Table 10.6: Legislation and Guidelines Specific to Local Fishing and Pearling

Legislation or Guideline	Intent
EPA Guidance Statement No 33: *Environmental Guidance for Planning and Development* (EPA 2008) – Chapter 4D	This guidance statement aims to ensure that existing and planned recreational uses of the environment are not compromised. The focus of the EPA's guidance is on the protection of recreational opportunities of high importance to the community that derive from the natural environment (for example, the coast) where these are consistent with maintaining key conservation values. The guidelines identify a requirement to consult with community, stakeholders and relevant agencies as appropriate.
EPBC Act (Cth)	This Commonwealth Act provides a legal framework to protect the environment, especially those aspects of the environment that are matters of NES. The Act includes describing the impacts on other users of the area and specifies that the Minister must consider economic and social matters in the decision making process.
Interim Guide for Community Involvement (DoE 2003)	This guideline is to assist Western Australian business with the community involvement process by outlining the tools that can be applied.
Shire of Ashburton Town Planning Scheme (DPI 2005)	This planning scheme provides guidance that all planning approvals should consider: • Impact of the development on the amenity of the locality • Any social issues that have an effect on the amenity of the locality.
Fish Resources Management Act (1994) (DoF 1994)	This State Act provides a legal framework to conserve, develop and share the fish resources of the State for the benefit of present and future generations. In particular the objectives are to: • Conserve fish and to protect their environment • Ensure that the exploitation of fish resources is carried out in a sustainable manner • Enable the management of fishing, aquaculture and associated industries, aquatic eco-tourism and other tourism reliant on fishing • Foster the development of commercial and recreational fishing and aquaculture including the establishment and management of aquaculture facilities for community or commercial purposes • Achieve the optimum economic, social and other benefits from the use of fish resources • Enable the allocation of fish resources between users of those resources • Provide for the control of foreign interests in fishing, aquaculture and associated industries • Enable the management of fish habitat protection areas and the Abrolhos Islands reserve. (Cont'd)

Legislation or Guideline	Intent
Shire of Ashburton Local Planning Policy 20 – Social Impact Assessment (Shire of Ashburton 2009)	This policy seeks to provide: • A framework for the identification of issues arising from development proposals that may impact on the social structure of the Shire • A consistent and thorough approach to the assessment of issues associated with proposals • A description of issues and means to address those issues for the consideration of the community and the Shire • Information and support for community input into the decision making process • Minimisation of negative impacts and maximisation of positive outcomes • Integration of expertise in the decision making process • The consideration of a wide range of issues that have social implications, including: infrastructure, resource issues, heritage impacts, landform impacts, economic and fiscal impacts, community impacts, cultural impacts, indigenous rights impacts, demographic impacts, transport impacts and other relevant considerations.

however, there is no specific EPA guidance statement for managing impacts on commercial fishing operations. The EPA provides guidance for assessing impacts on recreational assets and how to consult communities as part of such assessments.

10.4.4 Consequence Definitions

To enable assessment of risks associated with the Project, specific consequence definitions were developed. Table 10.7 provides the consequence definitions that have been used in the risk assessment of local fishing and pearling.

10.4.5 Impact Assessment and Management

Impacts to local fishing and pearling will occur to some extent as a result of Project activities. The following sections summarise the aspects and activities that may directly and indirectly affect local fishing and pearling in, and surrounding, the Project area. Chapter 7, *Impact Assessment Methodology* contains the risk matrix used to assess the likelihood and consequence of impacts occurring. The potential impacts and the management measures to be implemented are discussed in detail. Table 10.10 in Section 10.4.9 provides a summary of the potential impacts, management measures and residual risk as a result of Project activities.

10.4.5.1 Recreational Fishing

Residual risk to recreational fishing from clearing of critical habitats is	**Low**
Residual risk to recreational fishing from decreased fish stocks due to recreational fishing by Project workforce in local waters and nearshore islands is	**Medium**
Residual risk to recreational fishing from exclusion zones or reduced access is	**Medium**

Interviews with residents, tourists, recreational fishers, charter boat operators and beach users showed that perceived impacts on recreation were primarily connected with fishing and reduced access to creeks near Ashburton North SIA. Key concerns included:

- The direct effects the Project may have on the marine environment and fish populations
- Access to fishing areas being restricted, with specific concern being the exclusion of access to Hooley Creek via land and uncertainty about the extent of a safety exclusion area
- The effect of a large construction workforce on existing activity and fish stocks in the local area, including impacts on the near-shore islands.

Table 10.7: Consequence Definitions for Local Fishing and Pearling

Social						
	1	2	3	4	5	6
Factor	**Catastrophic**	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Local Fishing and Pearling Industry	• Commercial fishing or pearling is no longer viable in the designated local fishing areas • Extinction of target species in designated local fishing areas • Permanent loss of access to all designated local fishing areas	• Significant threat to viability of commercial fishing or pearling in the designated local fishing areas • All target species in designated local fishing areas are endangered • Permanent loss of access to more than 20 per cent of designated local fishing areas	• Commercial loss due to long term (three seasons or more) reduction in abundance of target species in designated local fishing areas • Commercial loss due to permanent loss of access to 10 to 20 per cent of designated local fishing areas	• Commercial loss due to localised medium term (two seasons) reduction in abundance of target species in designated local fishing areas • Commercial loss due to permanent loss of access to less than 10 per cent of designated local fishing areas	• Commercial loss due to localised short term (one season) reduction in abundance of target species in designated local fishing areas • Commercial loss due to temporary loss of access to any part of designated local fishing areas	• No measurable impacts on commercial fishing or pearling
Local Recreational Fishing	• Permanent loss of access to all recreational fishing grounds in the local area	• Permanent loss of access to more than 20 per cent of recreational fishing grounds in the local area • Permanent reduction (10+ years) in quality of fishing experience (catch to effort ratio)	• Permanent loss of access to less than 20 per cent of recreational fishing grounds in the local area • Temporary reduction (6-10 years) in quality of fishing experience (catch to effort ratio)	• Temporary loss of access to more than 20 per cent of recreational fishing grounds in the local area • Temporary reduction (2-5 years) in quality of fishing experience (catch to effort ratio)	• Temporary loss of access to less than 20 per cent of recreational fishing grounds in the local area • Temporary reduction (1 year) in quality of fishing experience (catch to effort ratio)	• No measurable impacts on recreational fishing

Figure 10.5 shows the areas the community values and uses for recreational fishing.

Changes to fish availability (either as a temporary impact during construction activities such as dredging or more enduring changes to the ecology) is not being assessed directly, however the impacts on benthic habitats and local water quality are assessed in Chapter 8*, Marine Risk Assessment and Management*. Predictions have been made about changes in fish populations as a result of benthic habitat loss which suggest there will be a low impact.

Many of the most popular recreational fishing spots in and around Onslow such as Beadon Creek, The Groyne, Thevenard Island, Sunrise Beach (also known locally as Front Beach) and Sunset Beach (also locally known as Back Beach) are somewhat removed from the Ashburton North SIA location. Other fishing locations such as Four Mile Creek, Middle Creek, False Entrance and Coobra Point share similar characteristics to the habitat area likely to become an exclusion area. The assessment found a relatively low risk of recreational opportunity being significantly affected by changed fish availability as the fish species that may be affected are well represented in the region.

The assessment found there is likely to be an impact on recreational values as a result of changed access arrangements. In particular, land access to Hooley Creek may no longer be possible or may be restricted.

Charter boat operators depend on maintained environmental values for their commercial viability. Consultations revealed an optimism that the Project would result in additional customers for charter fishing services but some concern that excessive fishing by Fly-In Fly-Out (FIFO) workers may impact on local fish stocks and the ecology of nearshore islands.

The following management measures will be implemented to reduce the impact of Project activities on recreational fishing:

- Boats and recreational vehicles will not be permitted within the workforce accommodation village or the access road from the Onslow Road.

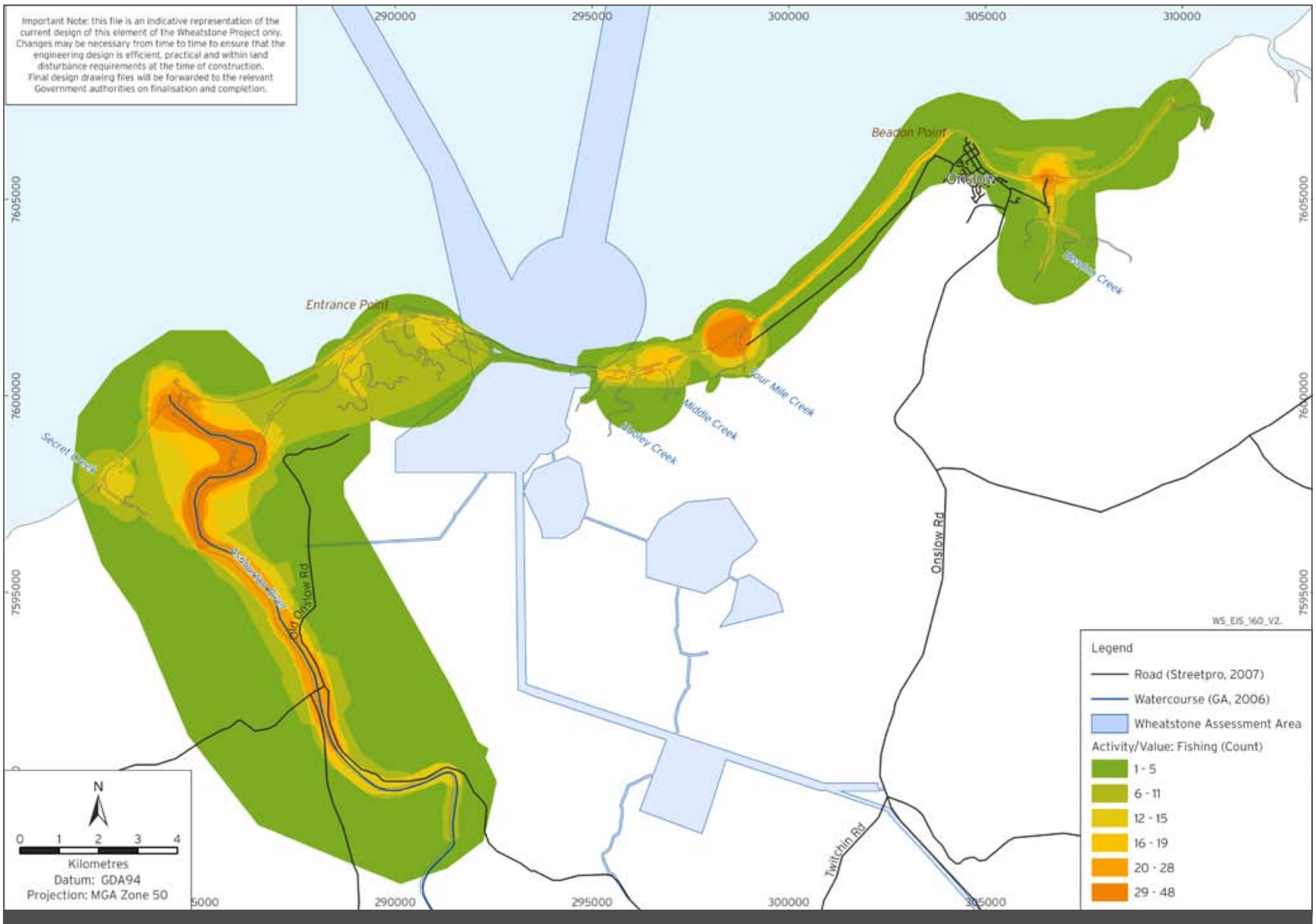

Figure 10.5: Area of Recreational Fishing Value and Use

- Behaviour standards to be expected from all construction workers will be clearly articulated in a Recreation Code of Conduct. Construction workers will be asked to sign the Code of Conduct.
- A community feedback procedure will be established whereby any complaints from the community about unacceptable behaviour from construction workers will be investigated and where necessary appropriate action taken.
- Chevron will work with the WA Department of Fisheries to reduce potential risks to the existing recreational fishery.
- Chevron will work with the WA Department of Environment and Conservation to reduce potential risks from excessive recreational use of the islands within a 25km radius of Onslow.
- For safety reasons, recreational activities such as fishing will not be permitted within the nearshore exclusion zones (for example, MOF and PLF).

It is not possible to estimate the natural population growth that may occur in Onslow as an indirect consequence of the Project, and therefore it is not possible to accurately assess the additional potential for over-fishing by the general population. However, Chevron will take into consideration the Project's residual or ongoing impacts on existing and planned recreational uses and evaluate the suitability of investment in recreation activities and facilities for the general community during development of its future social investment strategy.

Summary

Following the implementation of appropriate management measures presented in Table 10.8 it is possible that dredging and construction activities, the physical presence of marine infrastructure and vessel movements will result in impacts to recreational fishing as a result of decreased fish stocks or clearing of critical habitats. However, the residual environmental risk for this potential impact was assessed as being "Low" of "Minor" consequence and "Possible" likelihood.

Following the implementation of appropriate management measures presented in Table 10.8 it is possible that fishing by the Project workforce will result in impacts to recreational fishing as a result of decreased fish stocks. The residual environmental risk for this potential impact was assessed as being "Medium" of "Major" consequence and "Possible" likelihood.

Following the implementation of appropriate management measures presented in Table 10.8 it is possible that exclusion zones or reduced access due to the presence of infrastructure will result in impacts to recreational fishing. The residual environmental risk for this potential impact was assessed as being "Medium" of "Major" consequence and "Possible" likelihood due to the Project's potential impact on Hooley Creek. Although Hooley Creek is a small area geographically, the area is highly valued by the Onslow community and tourists. However, should impacts to Hooley Creek be reduced, the residual environmental risk for this potential impact would be assessed as being "Low" of "Moderate" consequence and "Possible" likelihood.

10.4.6 Implications for Matters of National Environmental Significance

There are no matters of NES directly attributable to recreational fishing.

10.4.7 Residual Risk Summary

Table 10.8 provides a summary of the aspects, activities and potential impacts to recreational fishing as a result of Project activities. Indicative management controls and mitigating factors are also listed, along with the residual risk following implementation of the management controls.

10.4.7.1 Commercial Fishing

Residual risk to commercial fishing from clearing of critical habitats or other ecological change is	**Medium**
Residual risk to commercial fishing from exclusion zones or reduced access is	**Medium**
Residual risk to commercial fishing from decreased fish stocks due to recreational fishing by the Project workforce is	**Low**

As part of stakeholder consultation undertaken for the EIS/ERMP, interviews were conducted with industry participants that revealed concerns which included:

- Prawn fishing may temporarily cease to be viable when access to productive fishing grounds is limited due to port infrastructure being placed in areas of heaviest fishing activity and other restrictions that may be placed on operations.
- The ecology of the prawn and crab fisheries may be adversely affected by construction activity, with uncertainty about the duration of these temporary impacts.

Table 10.8: Summary of Management Controls and Residual Risk for Recreational Fishing

Aspect, Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Dredging							
Construction (capital) dredging – channel, pipeline, berthing area	Reduced recreational fishing opportunity due to decreased fish stocks as a consequence of clearing critical habitats	• Dredging impacts will be managed through a DSDMP • Chevron will evaluate the suitability of investment in recreation activities and facilities for the general community as part of its future social investment strategy	5	3	**Low**	**Reasonable level** Modelling conducted and survey data available	No
Maintenance dredging	Reduced recreational fishing opportunity due to decreased fish stocks as a consequence of clearing critical habitats	• Dredging impacts will be managed through a DSDMP • Chevron will evaluate the suitability of investment in recreation activities and facilities for the general community as part of its future social investment strategy	5	3		**Reasonable level** Modelling conducted and survey data available	No
Physical Presence of Infrastructure							
Operation of Nearshore Production Facilities and Onshore Plant which requires exclusion zones and other restricted access to recreational fishing areas	Reduced recreational fishing opportunity as a result of restricted access	• For safety reasons, recreational activities such as fishing will not be permitted within the nearshore exclusion zones (for example, MOF and PLF) • Chevron will evaluate the suitability of investment in recreation activities and facilities for the general community as part of its future social investment strategy	3	3	**Medium**	**Reasonable level** Available information is adequate **Uncertainties:** Extent of access restrictions	No

Construction Activities and Operational Activities							
Recreational fishing by Project workforce	Reduced catch due to recreational fishing by Project workforce in local waters and nearshore islands	• Boats and recreational vehicles will not be permitted within the workforce accommodation village or the access road from the Onslow Road • Behaviour standards to be expected from all construction workers will be clearly articulated in a Recreation Code of Conduct. Construction workers will be asked to sign the Code of Conduct • A community feedback procedure will be established whereby any complaints from the community about unacceptable behaviour from construction workers will be investigated and where necessary appropriate action taken • Chevron will work with the WA Department of Fisheries to reduce potential risks to the existing recreational fishery • Chevron will work with the WA Department of Environment and Conservation to reduce potential risks from excessive recreational use of the islands within a 25 km radius of Onslow • For safety reasons, recreational activities such as fishing will not be permitted within the nearshore exclusion zones (for example, MOF and PLF)	3	3	**Medium**	**Reasonable level** Available information is adequate	No

Aspect, Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Additive Effects							
Construction and operational activities that impact on recreational fishing	Reduced catch due to Project-related ecological changes, exclusion zones, restricted access, vessel movements or recreational fishing by Project workforce	• Boats and recreational vehicles will not be permitted within the workforce accommodation village or the access road from the Onslow Road • Behaviour standards to be expected from all construction workers will be clearly articulated in a Recreation Code of Conduct. Construction workers will be asked to sign the Code of Conduct • A community feedback procedure will be established whereby any complaints from the community about unacceptable behaviour from construction workers will be investigated and where necessary appropriate action taken • Chevron will work with the WA Department of Fisheries to reduce potential risks to the existing recreational fishery • Chevron will work with the WA Department of Environment and Conservation to reduce potential risks from excessive recreational use of the islands within a 25km radius of Onslow • For safety reasons, recreational activities such as fishing will not be permitted within the nearshore exclusion zones (for example, MOF and PLF) • Chevron will evaluate the suitability of investment in recreation activities and facilities for the general community as part of its future social investment strategy • Dredging impacts will be managed through a DSDMP	3	3	**Medium**	**Reasonable level** Available information is adequate	No

- The ecology of the prawn and crab fisheries may be adversely affected by ongoing operations, in particular, the effect of changed hydrology and nutrient flows and the subsequent impact on prawn nursery areas.
- The uncertainty about whether the Project will go ahead is currently affecting investment planning by potentially affected businesses.
- The impact assessment found the Project will directly affect the Onslow Prawn Managed Fishery. Key potential impacts on the prawn fishery were grouped as:
  - Lost commercial value through restricted access
  - Reduced commercial catch due to temporarily changed ecology
  - Reduced commercial catch due to permanent modification to habitat affecting fish stocks.

Chapter 8, *Marine Risk Assessment and Management* provides discussion and impact assessment of Project activities on fish in the Onslow and the Ashburton North SIA areas. Table 10.9 lists the fisheries operating in the general area and identifies whether the Project footprint intersects the fishing license area. In cases where the Project footprint intersects a fishery, advice was sought from fishing industry stakeholders and the Department of Fisheries (DoF) to determine which fisheries should be further assessed.

Pearl farming operations are considered too far removed from the Ashburton North SIA to be affected. Wild oyster collection is also unlikely to be affected. In addition, the Project occupies a small fraction of the collection area for these inputs into pearl farming.

Similarly, blue swimmer crab fishing is unlikely to be affected as 'the area the Project may impact is a very small fraction of the total area of the crab fishery. Areas of trap fishing are distant from the Ashburton North SIA.

The Project intersects the Pilbara Line Fishery, however this small fishery can work around Project operations without significant impact. It is possible the dredging program may have a minor impact on the Mackerel Managed Fishery. The fishery is active around the offshore islands, however the target species are considered mobile and commercial activity will be temporarily displaced within the fishery rather than prevented.

It is possible the Project may have some impact on the Specimen Shell Managed Fishery and the Marine Aquarium Managed Fishery. Both these fisheries are active in the shallow waters off Onslow and therefore may be affected by dredging activities.

For the Onslow Prawn Managed Fishery, the proposed Project footprint including exclusion areas would occupy less than one per cent of the area trawled between 2004 and 2006. However, the jetty and shipping lanes may on occasion affect a trawler's ability to operate in the most productive part of a mobile prawn fishery.

Analysis by URS Pty Ltd. (2009m) suggests disturbed areas of the prawn fishery will be recolonised as sediment settles and that Area 2 of the fishery is unlikely to experience significant habitat change. In the least productive years of this fishery, the season has been abandoned. However, there are commercial implications for the fishing operators if Project activities result in long periods when they are unable to fish.

Although there is some uncertainty about the prediction of the permanent impacts to prawn availability due to biological and physical changes, the Project footprint is a very small area of the fishery and a small portion of the smaller, most productive (Area 1) part of the fishery.

Correspondence from, and subsequent discussions with DoF raised concerns on potential interaction with other fisheries and charter boat operations. As a result, discussions were held with the:

- Charter Boat Owners & Operators Association (CBOOA)
- Professional Specimen Shell Fishermen's Association of WA (Inc) (PSSFA)
- Aquarium Specimen Collectors Association of WA (Inc) (ASCA)
- Western Australian Fishing Industry Council (WAFIC) (for the Mackerel Managed Fishery).

The CBOOA could not identify regular charter fishing activity in the areas around the Ashburton North SIA closer than Thevenard Island. Many charters tended to go to the Montebello and other islands off the Pilbara coast.

PSSFA believes very little specimen shell collection takes place closer to the Ashburton North SIA than Peak Island off Exmouth's North West Cape. Of the 32 licenses that exist for the fishery, there are perhaps eight to ten active fishers. Advice from the DoF suggests that as little as 2.5 per cent of fishing effort occurs in the area around the Ashburton North SIA.

DoF data on the precise level of aquarium specimen collection activity off the Ashburton North SIA through fishers' GIS log returns is not available to Chevron. DoF advises that nine of the 12 licences have been fished in recent years.

Table 10.9: Interaction of Commercial Fishing Areas with Project Footprint

Fishery	Interaction of Activity Area with Project Area	Assessment Completed
Onslow Prawn Managed Fishery	There is some overlap in permitted fishing areas and the Project footprint.	Yes
Nickol Bay Prawn Managed Fishery	The Project footprint does not intersect the fishery.	No
Broome Prawn Managed Fishery	The Project footprint does not intersect the fishery.	No
Kimberley Prawn Managed Fishery	The Project footprint does not intersect the fishery.	No
Kimberley Gillnet & Barramundi Managed Fishery	The Project footprint does not intersect the fishery.	No
Pilbara Fish Trawl (Interim) Managed Fishery	The Project footprint intersects the fishery. The fishery consists of two zones, and Zone 1 in the south west of Fishery has had zero effort allocated for more than 10 years. The Project pipeline intersects Zone 2 of the fishery but no impacts are expected on trawling operations.	No
Pilbara Trap Managed Fishery	Two licenses allow for operation off Onslow but only one within the Project footprint.	Yes
Pilbara Line Fishery	The Project footprint intersects the fishery but operators in this small fishery can work around Project operations limiting potential impacts.	Yes
Mackerel Managed Fishery	The Project footprint intersects the fishery. The three to four year dredging program may overlap active fishing areas around the offshore islands. These species are considered mobile and commercial activity may be temporarily displaced rather than prevented.	Yes
Northern Shark Fishery	Fishery is effectively closed.	No
Pearl Oyster Managed Fishery	The Project footprint intersects the fishery. Pearl shells are understood to occasionally be collected in the Onslow area of Pearl Oyster Zone 1 but actual pearl farming areas are Exmouth Gulf, off Point Samson and in the Montebello Islands.	Yes
Beche-de-mer Fishery	The Project footprint intersects the fishery, however practically all collection activities in this small fishery take place much further north.	No
Pilbara Developing Crab Fishery	The Project footprint does not intersect the fishery.	No
Specimen Shell Managed Fishery	The Project footprint intersects the fishery.	Yes
Marine Aquarium Fish Managed Fishery	The Project footprint intersects the fishery.	Yes

It appears numerically few operators work off the Ashburton North SIA but the area could represent a significant portion of those operators' income. Activity tends to cluster around Broome and Karratha where airports make live exports viable.

Dredging can affect collection activity (of fish and corals) through reduced visibility and habitat modification. The area available for collection may be reduced through port safety exclusion zones although ASCA acknowledged that this is likely to be a relatively minor impact. ASCA expressed concerns about the continued viability of the industry as a result of cumulative area closures/restrictions on activity. The assessment of the potential impact of closures over a wide area is beyond the scope of this EIS/ERMP.

Chevron is seeking further discussions with WAFIC to identify impacts on the Mackerel Managed Fishery.

In regard to the impact of recreational fishing by the Project workforce on commercial fisheries, it is possible there may be some impact on the Pilbara Trap Fishery, the Pilbara Line Fishery and the Mackerel Managed Fishery. However, there will be management measures as outlined in Table 10.10 to reduce potential impacts. Recreational fishing by the Project workforce is not expected to impact prawns, oysters, crabs, specimen shells or aquarium fish.

To manage potential impacts on commercial fishing in the local area, Chevron will appoint a staff member whose role includes liaising between Chevron and holders of commercial fishing licenses. The liaison will provide information on key Project activities such as dredging, pipelaying and vessel traffic.

Summary

Following the implementation of appropriate management measures presented in Table 10.10 it is possible that dredging and construction activities, the physical presence of marine infrastructure and vessel movements will result in impacts to commercial fishing as a result of decreased fish stocks or clearing of critical habitats. The residual environmental risk for this potential impact was assessed as being "Medium" of "Major" consequence and "Possible" likelihood.

Following the implementation of appropriate management measures presented in Table 10.10 it is possible that exclusion zones or reduced access due to the presence of infrastructure will result in impacts to commercial fishing. The residual environmental risk for this potential impact was assessed as being "Low" of "Minor" consequence and "Likely" likelihood.

Following the implementation of appropriate management measures presented in Table 10.10 it is possible that fishing by the Project workforce will result in impacts to commercial fishing. The residual environmental risk for this potential impact was assessed as being "Low" of "Moderate" consequence and "Possible" likelihood.

10.4.8 Implications for Matters of National Environmental Significance

There are no matters of NES directly attributable to commercial fishing or pearling.

10.4.9 Residual Risk Summary

Table 10.10 provides a summary of the aspects, activities and potential impacts to commercial fishing and pearling as a result of Project activities. Indicative management controls and mitigating factors are also listed, along with the residual risk following implementation of the management controls.

10.4.10 Predicted Environmental Outcome

The aspects described above have the potential to impact local fishing and pearling in an additive manner. The combined consequence of dredging, construction activities, operational activities, and physical presence of infrastructure on local fishing and pearling has been determined to be of "Major" consequence. The likelihood of this consequence occurring is "Possible". The additive risk from the Project on local fishing and pearling is "Medium".

It has been assumed that the Project will affect only a small proportion of the available commercial and recreational fishing areas in the region. Target fish species are well-represented in the region and permanent changes as a result of the Project should have negligible effect on fish abundance. Some impacts, such as those resulting from dredging or temporary exclusion zones, will only occur for a relatively short period of time. Other impacts, such as permanent exclusion zones around the LNG Plant, Multi User Facilities and Common User Infrastructure, will have an ongoing effect in the area, however, the effect should be localised.

The main drivers for assessing the additive effects as "Medium" relates to the potential for recreational fishing by the Project workforce and permanent loss of access to Hooley Creek. In regard to recreational fishing by the Project workforce it is difficult for the Project to restrict a person's activities on their allocated time off. Hooley Creek is a valued recreational fishing area, and even though it is a small area and there are numerous alternatives, it is culturally important to the Onslow community and tourists.

Overall, there is likely to be some disturbance to recreational use of the marine environment and there is likely to be some reduced access to valued recreational fishing areas. However, similar and superior recreational fishing locations exist in the area and pursuit of the sport remains viable.

It is possible there will be some impacts on commercial fishing, however Chevron will liaise with holders of commercial fishing licenses to manage any impacts identified. The EPA management objective for local fishing and pearling is expected to be achieved.

10.5 Disturbance to Other Recreational Use

The following sections present the assessment of impacts on local recreational use associated with the Project, taking into account design modifications, mitigation methods and controls applied to reduce impacts.

10.5.1 Management Objectives

The EPA objective for this assessment is to ensure that existing and planned recreational uses are not compromised.

10.5.2 Description of Factor

The baseline characteristics of the receiving social environment are described in Chapter 6, *Overview of Existing Environment*. Sources of data included:

- A Values and Land Use Assessment which included interviews with community members and visitors to Onslow
- A community photographic project
- A review of relevant literature and ABS statistics
- Interviews with government and private sector stakeholders.

10.5.2.1 Natural Environment – Values and Uses

A Values and Land Use Assessment for the Project has established that the area surrounding the Project footprint has outdoor recreational value for both tourists and locals. Figure 10.6 highlights the areas that community members and visitors identified as being of high community value and/or use. The areas of highest value and/or use are highlighted in red or orange and include the Ashburton River, Four Mile Creek, Hooley Creek, Sunset Beach, Sunrise Beach and Beadon Creek.

Figure 10.6 shows the types of recreational activities conducted in the local area.

Community stakeholders identified the protection of fish, marine fauna and their physical habitats as very important, both along the Onslow coastline and nearshore islands. This concern was connected with general environmental conservation values and the importance of marine fauna to local recreational activities.

Onslow's proximity to the ocean and the Ashburton River attracts many visitors each year in pursuit of recreational coastal activities. Intercept surveys undertaken with visitors to the area highlighted visitors that were predominantly from WA (77 per cent). More than a quarter stayed in the area for longer than three months, and 70 per cent of visitors engaged in recreational fishing.

Walking, and specifically dog walking, was identified as a popular recreational activity, especially along Sunset Beach as well as other nearby beaches and creek areas. Stakeholders often spoke about being able to walk along the beaches in town and be totally alone, enjoying the serenity and tranquillity. There is concern that population change associated with the Project and other developments in the area will reduce this important aspect of community amenity.

The Ashburton River is a very popular camping location, particularly at Three Mile Pool located close to the river's causeway. This camping area is more commonly used for long-term camping trips in the winter months by "Grey Nomads" who often make annual trips to the location. Residents in the Onslow area also indicated they use the Ashburton River as a camping ground.

Recreational four wheel driving mostly takes place on Sunset Beach and Sunrise Beach. 4WDs are also used to access more remote recreational areas such as Hooley Creek.

For members of the Aboriginal community, hunting and gathering remains an important recreational and cultural activity. Although some hunting and gathering takes place across the proposed Project area, it mostly occurs along the Ashburton River and to the east of the river.

10.5.2.2 Physical (Urban) Environment

Onslow has numerous elements in the physical environment that are used for recreation, including a sporting oval, community garden, Shire Hall, basketball courts, Beadon Creek wharf and a heritage trail walk around the Old Onslow Townsite heritage area. There are two motels and two caravan parks that provide tourist accommodation.

The town does not have many commercial buildings that are primarily used for recreational purposes. For example,

Table 10.10: Summary of Management Controls and Residual Risk for Commercial Fishing and Pearling

Aspect, Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Dredging							
Construction (capital) dredging – channel, pipeline, berthing area	Reduced commercial catch due to decreased fish stocks as a consequence of clearing critical habitats, increased turbidity, sedimentation and light attenuation or other ecological changes that result from dredging	• Dredging impacts will be managed through a DSDMP • There will be a role within Chevron who will liaise with commercial fishers on dredging and other marine construction activities	3	3	**Medium**	**Reasonable level** Modelling conducted and survey data available	No
	Reduced commercial catch due to temporary exclusion zones during dredging or increased vessel movements	• Dredging impacts will be managed through a DSDMP • There will be a role within Chevron who will liaise with commercial fishers on dredging and other marine construction activities	3	3		**Reasonable level** Available information is adequate	No
Maintenance dredging	Reduced commercial catch due to decreased fish stocks as a consequence of clearing critical habitats	• Dredging impacts will be managed through a DSDMP • There will be a role within Chevron who will liaise with commercial fishers on dredging and other marine construction activities	5	3	**Low**	**Reasonable level** Modelling conducted and survey data available	No
Physical Presence of Infrastructure							
Operation of Nearshore Production Facilities and Onshore Plant which requires exclusion zones and other restricted access to commercial fishing areas	Reduced commercial catch as a result of restricted access	There will be a role within Chevron who will liaise with commercial fishers on exclusion zones, restricted access and vessel traffic	4	4	**Low**	**Reasonable level** Available information is adequate **Uncertainties:** Importance of nurseries within exclusion zones, related changes to productivity of fisheries and full footprint of development	No

Aspect, Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Operation of Offshore Production Facilities and Onshore Plant which results in permanent reduction in marine ecosystem productivity	Reduced commercial catch due to permanent damage to critical habitats affecting stocks of available for fishers	Chevron will create a commercial fishing industry liaison role to liaise between Chevron and commercial fishers	4	4	**Low**	**Reasonable level** Modelling conducted and survey data available **Uncertainties:** Importance/ presence of nurseries, related changes to productivity of fisheries and full footprint of development	No
Construction Activities							
Construction of Nearshore Production Facilities and Onshore Plant	Reduced catch due to restricted access (exclusion zones)	• There will be a role within Chevron who will liaise with commercial fishers on exclusion zones, restricted access and vessel traffic • For safety reasons, recreational activities such as fishing will not be permitted within the nearshore exclusion zones (for example, MOF and PLF)	4	4	**Low**	**Reasonable level** Available information is adequate **Uncertainties:** Importance/ presence of nurseries, related changes to productivity of fisheries and full footprint of development	No
Fishing by Project construction workforce	Reduced catch due to fishing by construction workers in local waters and nearshore islands	• Chevron will work with the WA Department of Fisheries to reduce potential risks to the existing recreational fishery • Chevron will work with the WA Department of Environment and Conservation to reduce potential risks from excessive recreational use of the islands within a 25 km radius of Onslow	4	3		Reasonable level Available information is adequate	No

Operational Activities							
Fishing by Project operational workforce	Reduced catch due to fishing by operational workers in local waters and nearshore islands	• Chevron will work with the WA Department of Fisheries to reduce potential risks to the existing recreational fishery • Chevron will work with the WA Department of Environment and Conservation to reduce potential risks from excessive recreational use of the islands within a 25 km radius of Onslow	4	3	**Low**	**Reasonable level** Available information is adequate	No
Changes to commercial fishing industry in Onslow	Changed community identity if commercial fishing industry declines in Onslow	Chevron will create a commercial fishing industry liaison role to liaise between Chevron and commercial fishers Note: this has not been risk-ranked as the impact of a change to community identity is subjective and values-based. Therefore risk ranking is not appropriate				**Low level** Available information is inadequate	No
Additive Effects							
Construction and operational activities that impact on commercial fishing	Reduced catch due to Project-related ecological changes, exclusion zones, restricted access, vessel movements or fishing by Project workforce	• Chevron will create a commercial fishing industry liaison role to liaise between Chevron and commercial fishers • Dredging impacts will be managed through a DSDMP • For safety reasons, recreational activities such as fishing will not be permitted within the nearshore exclusion zones (for example, MOF and PLF) • Chevron will work with the WA Department of Fisheries to reduce potential risks to the existing recreational fishery • Chevron will work with the WA Department of Environment and Conservation to reduce potential risks from excessive recreational use of the islands within a 25km radius of Onslow	3	3	**Medium**	**Reasonable level** Available information is adequate	No

Figure 10.6: Onslow Community Recreational Values and Uses

buildings that formerly housed a café and video shop are no longer in use. Stakeholders interviewed suggested population growth associated with the Project and other developments may bring new businesses and enhanced recreational facilities to the town. In particular, many people expressed the desire for a community swimming pool, an indoor recreation facility and more recreational activities for young people. It should be noted that some of these recreational needs will be addressed as the Shire of Ashburton recently received AU$7 million from the state government to develop a sporting and multi-purpose precinct.

10.5.3 Assessment Framework

Relevant assessment framework for recreation use exists at Commonwealth and State levels. Specific policy and framework documents relating to recreation use are identified in Table 10.11.

10.5.4 Consequence Definitions

To enable assessment of risks associated with the Project, specific consequence definitions were developed. Table 10.12 provides the consequence definitions that have been used in the risk assessment of disturbances to other recreational use.

10.5.5 Impact Assessment and Management

Impacts to recreation use will occur to some extent as a result of Project activities. The following sections summarise the aspects and activities that may directly and indirectly affect recreation use in, and surrounding, the Project area. Chapter 7, *Impact Assessment Methodology* contains the risk matrix used to assess the likelihood and consequence of impacts occurring. The potential impacts and the management measures to be implemented are discussed in detail. Table 10.13 in Section 10.5.7 provides a summary of the potential impacts, management measures and residual risk as a result of Project activities.

Residual risk for impacts on recreational activities as a result of exclusion zones or reduced access is	**Medium**
Residual risk for impacts on availability of tourist accommodation as a result of Project workforce activities is	**Low**
Residual risk for impacts on availability of tourist accommodation as a result of population growth induced by the Project is	**Medium**
Residual risk for impacts on availability of tourist accommodation as a result of general infrastructure and/or construction activities induced by the Project is	**Low**

A Values and Land Use Assessment assisted in defining and understanding the recreational values associated with the Project area and the areas surrounding Onslow. The assessment involved structured interviews and a values mapping exercise with over 75 members of the Onslow community and visitors to Onslow. Participants identified locations of importance using aerial photography and data were collected about specific values, uses and pastimes.

Table 10.11: Legislation and Guidelines Specific to Recreation Use

Legislation or Guideline	Intent
EPA Guidance Statement No. 3: *Separation Distances between Industrial and Sensitive Land Uses 2005* (EPA 2005a)	This guidance statement aims to address generic separation distances between industrial and sensitive land uses to avoid conflicts between these land uses.
EPA Guidance Statement No. 33: *Environmental Guidance for Planning and Development 2008* (EPA 2008)	This guidance statement aims to ensure that existing and planned recreational uses are not compromised.
The Pilbara Coastal Water Quality Consultation Outcomes: *Environmental Values and Environmental Quality Objectives* (DoE 2006a)	These objectives provide an interim framework to guide environmental impact assessment, waste discharge regulation and natural resource management in Pilbara coastal waters.
EPBC Act (Cth)	This Commonwealth Act provides a legal framework for the protection of the environment, especially those aspects of the environment that are matters of NES. The Act includes describing the impacts on other users of the area.

(Cont'd)

Legislation or Guideline	Intent
Conservation and Land Management Act 1984 (WA)	This State Act provides a legal framework for making better provision for the use, protection and management of certain public lands and waters and the flora and fauna. The most relevant aspects of the Act are that aquaculture, commercial fishing, recreational fishing and pearling activity not permitted in a marine park area classified as a sanctuary area, recreation area, a special purpose area, or an area where the activities would be incompatible with a conservation purpose.
State Planning Policy 2.6 – State Coastal Planning Policy (WAPC 2003)	This State Act provides a legal framework to: • Protect, conserve and enhance coastal values, particularly in areas of landscape, nature conservation, Indigenous and cultural significance • Provide for public foreshore areas and access to these on the coast • Ensure the identification of appropriate areas for the sustainable use of the coast for housing, tourism, recreation, ocean access, maritime industry, commercial and other activities • Ensure that the location of coastal facilities and development takes into account coastal processes including erosion, accretion, storm surge, tides, wave conditions, sea level change and biophysical criteria.
Shire of Ashburton Town Planning Scheme No 7 (DPI 2005)	This planning scheme provides guidance that all planning approvals should consider: • Impact of the development on the amenity of the locality • Any social issues that have an effect on the amenity of the locality • Specifically, Council will assess any social issues which that have an effect on the amenity of the locality • The capacity of the site and surrounding locality to support the development (including access, traffic generated, need for public transport services, services infrastructure and community services, amenity impacts on the locality) • Compatibility of the proposed use within its setting • Potential loss of community benefit or service resulting from the planning approval.
Shire of Ashburton Local Planning Policy 20 – Social Impact Assessment (Shire of Ashburton 2009)	This policy seeks to provide: • A framework for the identification of issues arising from development proposals that may impact on the social structure of the Shire • A consistent and thorough approach to the assessment of issues associated with proposals • A description of issues and means to address those issues for the consideration of the community and the Shire • Information and support for community input into the decision making process • Minimisation of negative impacts and maximisation of positive outcomes • Integration of expertise in the decision making process • The consideration of a wide range of issues that have social implications, including: infrastructure, resource issues, heritage impacts, landform impacts, economic and fiscal impacts, community impacts, cultural impacts, indigenous rights impacts, demographic impacts, transport impacts and other relevant considerations.

Table 10.12: Consequence Definitions for Recreational Use

Social						
	1	2	3	4	5	6
Factor	**Catastrophic**	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Disturbance to Other Recreational Use	• Permanent loss of ability to use all recreational areas within a region • Permanent loss of ability to use all tourist accommodation within a region	• Permanent loss of ability to use 20 per cent or more of recreational areas within a region • Permanent loss of ability to use 50 per cent or more of tourist accommodation within a region	• Permanent loss of ability to use all local recreational areas • Permanent loss of ability to use all tourist accommodation within the local area	• Permanent loss of ability to use 20 per cent or more of local recreational areas • Permanent loss of ability to use 50 per cent of tourist accommodation within the local area	• Temporary loss of ability to use less than 20 per cent of local recreational areas • Permanent loss of ability to use less than 20 per cent of local recreational areas • Temporary loss of ability to use less that 50 per cent of tourist accommodation within the local area	• No measurable impacts on recreational use • No measurable impacts on tourist accommodation

A community photographic project (The Onslow Oracle) used a methodology known as Photovoice and formed an important part of this assessment. Participants took photographs of locations of importance to them, shared a short explanation of the area's use and importance, and then participated in community workshops to develop robust themes. The 33 participants included primary school children, high school children, Aboriginal and non-Aboriginal people, and members of the community reference group.

Information gathered through the Values and Land Use Assessment and The Onslow Oracle project was used in conjunction with information about the physical locations the Project will affect to assess the level of disturbance to recreational use. The risk assessment found the Project may have the following impacts:

- Reduced access to recreational areas within Ashburton North SIA
- Restricted or eliminated access to Hooley Creek
- Reduced sense of serenity as a result of population growth, including the temporary population growth associated with the construction workforce
- Reduced availability of tourism accommodation through use of accommodation by Project-related workforce, as a result of population growth induced by the Project, or as a result of workforces associated with other infrastructure or construction projects.

Summary

Following the implementation of appropriate management measures presented in Table 10.13, it is possible that dredging, construction activities, operational activities and the physical presence of infrastructure will result in impacts to recreation use as a result of exclusion zones or reduced access. However, the residual environmental risk for this potential impact was assessed as being "Medium" of "Minor" consequence and "Almost Certain" likelihood.

Following the implementation of appropriate management measures presented in Table 10.13, it is possible that construction activities and operational activities will result in impacts to recreation use as a result of tourists not being able to access temporary tourist accommodation due to Project workforce activities. However, the residual environmental risk for this potential impact was assessed as being "Low" of "Minor" consequence and "Unlikely" likelihood. This is because Chevron will be providing accommodation for both the construction and operational workforce, however, there may be temporary impacts during the construction phase.

It is possible that impacts on recreational activities as a result of tourists not being able to access temporary tourist accommodation due to population growth will result in impacts to recreation use. Experience in other Pilbara towns has shown that major capital projects can stimulate population influx, and in locations that have limited housing options (such as Onslow) this can place strain on the availability of existing tourist accommodation and sometimes lead to permanent loss of ability to use most or all tourist accommodation within the local area. However, Chevron is not responsible for developing management measures for the general population. The residual environmental risk for this potential impact was assessed as being "Medium" of "Major" consequence and "Possible" likelihood.

It is possible there will be impacts on recreational activities as a result of tourists not being able to access temporary tourist accommodation as a result of general infrastructure or construction activities induced by the Project. It is acknowledged that infrastructure such as new roads and houses are likely to be required; however, Chevron is not aware of how the companies and/or government departments responsible for that construction intend to house their workforce. The residual environmental risk for this potential impact was assessed as being "Low" of "Minor" consequence and "Possible" likelihood.

It is assumed for impacts on tourist accommodation that new tourist accommodation will be built by the private sector should the demand exist, and that additional housing will be constructed within the town. If this is the case the risk in the above three scenarios will be reduced.

10.5.6 Implications for Matters of National Environmental Significance

There are no matters of NES directly attributable to recreational use.

10.5.7 Residual Risk Summary

Table 10.13 provides a summary of the aspects, activities and potential impacts to recreation use as a result of Project activities. Indicative management controls and mitigating factors are also listed, along with the residual risk following implementation of the management controls.

10.5.8 Predicted Environmental Outcome

The aspects described above have the potential to impact recreation use in an additive manner. The combined consequence of dredging, construction activities, operational activities and the physical presence of infrastructure on recreation use has been determined to be of "Major" consequence. This is because although the direct impact of the Project on recreational use through exclusion zones and changed access is expected to be "Minor" (and there is potential for future benefits for recreation use if the provision of financial support for recreation initiatives through social investment funding is determined to be suitable) the *indirect* impacts of the Project on tourist accommodation in Onslow may create long-term pressures on tourism if the private sector and relevant government agencies do not respond to market demand. The likelihood of this consequence occurring is "Possible". Therefore, a highly conservative assessment of the additive risk from the Project on recreation use is "Medium".

Overall, there will be some disturbance to recreational activities as a result of restricted access or exclusion zones near the Project. However, similar recreational locations exist in the area and all current recreational activities can continue to be enjoyed. There may also be some additional recreation opportunities created through social investment funding.

It is possible that the Project will induce impacts on tourist accommodation and hence affect the ability of tourists to enjoy the area for recreation. However, if this occurs it will be an indirect impact beyond the scope of Chevron's responsibility. The Project itself will have a limited direct and permanent impact on tourist accommodation and the EPA management objective for existing and planned recreational uses is expected to be achieved.

10.6 Public Amenity

The following sections present the assessment of impacts on public amenity associated with the Project, taking into account design modifications, mitigation methods and controls applied to reduce impacts.

10.6.1 Management Objectives

The EPA objective for this assessment is to ensure developments do not adversely affect the amenity of people and land users. The following specific management objectives apply:

- Air quality: To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards
- Noise: To protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring the noise levels meet statutory requirements and acceptable standards
- Light: To avoid or manage potential impacts from light overspill and comply with acceptable standards
- Visual amenity: To ensure that aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable.

10.6.2 Description of Factor

The baseline characteristics of the receiving social environment are described in Chapter 6, *Overview of the Existing Environment.* Sources of data included:

- Baseline noise assessment study (Appendix E)
- Acoustic modelling (Appendix E)
- Air modelling (Appendix C)
- Visual impact modelling (URS 2009n)
- Light impact modelling (Appendix D).

Public amenity refers to how noise emissions, air emissions and visual impacts (including light emissions) impact on the amenity of a local area and affect the sense of well-being and quality of life of the community (EPA 2008). For the purposes of this assessment, 'public' and 'community' includes Onslow residents, campers, tourists, other recreational users and nearby commercial land users.

10.6.3 Assessment Framework

The assessment frameworks for public amenity related to noise emissions, air emissions and visual amenity are contained within the following discussions of these aspects. The predicted environmental outcome due to additive impacts on public amenity are be presented in Section 10.6.8.10.

10.6.4 Consequence Definitions

To enable assessment of risks associated with the Project, specific consequence definitions were developed. Table 10.14 provides the consequence definitions that have been used in the risk assessment of impacts on public amenity.

Table 10.13: Summary of Management Controls and Residual Risk for Recreation Use

Aspect, Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Dredging							
Construction (capital) dredging – channel, pipeline, berthing area	Reduced marine recreational activity due to exclusion zones or reduced visibility as a result of increased silt in creeks, waterways and sea	Chevron will evaluate the suitability of investment in recreation activities and facilities for the general community as part of its future social investment strategy	5	1	**Medium**	**Reasonable level** Modelling conducted Uncertainties: Extent of exclusion zones	
Maintenance dredging	Temporary reduction of marine recreational activities due to temporary exclusion zones or reduced visibility as a result of increased silt in creeks, waterways and sea during maintenance dredging	Chevron will evaluate the suitability of investment in recreation activities and facilities for the general community as part of its future social investment strategy	5	2	**Low**	**Reasonable level** Modelling conducted Uncertainties: Extent of exclusion zones	
Physical Presence of Infrastructure							
Location of LNG plant near / on recreation areas	Reduced access to recreation areas due to exclusion zones, leading to loss of recreational value	Chevron will evaluate the suitability of investment in recreation activities and facilities for the general community as part of its future social investment strategy	5	1	**Medium**	**Reasonable level** Available information is adequate **Uncertainties**: Extent of exclusion zones	
Construction activities							
Housing of construction workers	Reduced access to temporary tourism accommodation due to use of accommodation by construction workforce	Project impacts on tourism accommodation will be reduced through provision of accommodation for all construction workers associated with the Project	5	2	**Low**	**Reasonable level** Available information is adequate	
Operational activities							
Housing of operational workers	Reduced access to temporary tourism accommodation due to use of accommodation by operational workforce	Project impacts on tourism accommodation will be reduced through provision of accommodation for all operational workers associated with the Project	5	4	**Very Low**	**Reasonable level** Available information is adequate	

Construction activities/ Operational activities							
Housing of new residents who relocate as a result of economic opportunities associated with the Project	Reduced access to temporary tourism accommodation due to population growth induced by the Project	Management of population growth is beyond Chevron's control and therefore is not within Chevron's scope of responsibility	3	3	**Medium**	**Low level** No modelling conducted and available information is inadequate **Uncertainties:** Extent of population growth	
Housing of workers for infrastructure and/or construction projects induced by the Project	Reduced access to temporary tourism accommodation due to use of accommodation by workforce of infrastructure and/or construction projects induced by the Project	Management of other projects' workforces is not within Chevron's control or scope of responsibility	5	3	**Low**	**Low level** No modelling conducted and available information is inadequate **Uncertainties:** Workforce numbers and accommodation plans for non-Chevron projects	

Aspect, Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Additive Effects							
Construction and operational activities that impact on recreation use	Reduced access to recreation areas due to temporary or permanent exclusion zones, leading to loss of recreational value Reduced access to temporary tourism accommodation due to use of accommodation by Project construction or operational workforce; population growth induced by the Project; or use of accommodation by workforce of infrastructure and/or construction projects induced by the Project	• Chevron will evaluate the suitability of investment in recreation activities and facilities for the general community as part of its future social investment strategy • Project impacts on tourism accommodation will be reduced through provision of accommodation for all workers associated with the Project • Management of population growth is beyond Chevron's control and therefore is not within Chevron's scope of responsibility • Management of other projects' workforces is not within Chevron's control or scope of responsibility	3	3	**Medium**	**Low level** No modelling conducted and available information is inadequate **Uncertainties:** Extent of exclusion zones Extent of population growth Workforce numbers and accommodation plans for non-Chevron projects	

Table 10.14: Consequence Definitions for Public Amenity

Social						
	1	2	3	4	5	6
Factor	**Catastrophic**	**Massive**	**Major**	**Moderate**	**Minor**	**Negligible**
Public Amenity	• Permanent and significant reduction in public amenity in a region as a result of dust and acoustic emissions, air quality and visual impacts	• Temporary but significant reduction to public amenity in a region as a result of dust and acoustic emissions, air quality and visual impacts	• Permanent and significant reduction in public amenity in a local area as a result of dust and acoustic emissions, air quality and visual impacts	• Temporary but significant reduction in public amenity in a local area as a result of dust and acoustic emissions, air quality and visual impacts • Permanent but insignificant reduction in public amenity in a local area as a result of dust and acoustic emissions, air quality and visual impacts	• Temporary but insignificant reduction in public amenity in a local area as a result of dust and acoustic emissions, air quality and visual impacts	• No measurable impacts on public amenity

Table 10.15: Legislation and Guidelines Specific to Public Amenity – Noise

Legislation or Guideline	Intent
EPA Draft Guidance Statement No 8, 2007 (EPA 2007)	This guidance statement aims to enhance the environmental approvals process whilst ensuring that an appropriate standard of technical and public information relating to noise impacts is presented in assessment reports. The guidance material falls into two main parts: • EPA policy covering a range of types of proposals that may emit noise • EPA guidance on the assessment of noise and presentation of information to the EPA.
Environmental Protection (Noise) Regulations 1997	These regulations set out allowable noise emissions including assigned levels for various types of land use and specific exemptions; specifies how noise is to be measured.
Australian Standard AS 2436-1981: *Guide to Noise Control on Construction, Maintenance and Demolition Sites 1981* (Standards Australia 1981)	These standards provide a standard management approach to addressing noise created through non-routine operations such as construction of an industrial facility.
EPA Guidance Statement No. 14: *Road and Rail Transportation Noise (Preliminary Draft - Version 3) 2000* (EPA 2000)	This guidance statement advises that noise from vehicles on roads or aircraft is excluded under Regulation 3 of the Environmental Protection (Noise) Regulations 1987 (WA).
Shire of Ashburton Local Planning Policy 20 – Social Impact Assessment (Shire of Ashburton 2009)	This policy seeks to provide: • A framework for the identification of issues arising from development proposals that may impact on the social structure of the Shire • A consistent and thorough approach to the assessment of issues associated with proposals • A description of issues and means to address those issues for the consideration of the community and the Shire • Information and support for community input into the decision making process • Minimisation of negative impacts and maximisation of positive outcomes • Integration of expertise in the decision making process • The consideration of a wide range of issues that have social implications, including: infrastructure, resource issues, heritage impacts, landform impacts, economic and fiscal impacts, community impacts, cultural impacts, indigenous rights impacts, demographic impacts, transport impacts and other relevant considerations.

10.6.5 Implications for Matters of National Environmental Significance

There are no matters of NES directly attributable to public amenity.

10.6.6 Public Amenity - Noise

10.6.6.1 Management Objectives

The EPA objective for this assessment is that noise emissions do not adversely affect environmental values or the health, welfare and amenity of people and land users. This section specifically addresses the objective as it applies to the amenity of people and land users.

10.6.6.2 Description of Factor

The baseline characteristics of the receiving social environment are described in Chapter 6, *Overview of Existing Environment*. Sources of data for noise impacts included:

- A baseline noise assessment study
- Acoustic modelling.

The town of Onslow and the recreational areas around it are valued by locals and tourists for their relative isolation and peacefulness. A baseline noise assessment was undertaken to determine the current noise levels in the area. This assessment was undertaken in 2009 at locations determined through public consultation. These locations included Onslow town site, Four Mile Creek (a popular recreation area), Five Mile Pool (an informal camping and recreation area along the Ashburton River), the Old Onslow Townsite heritage area, and Ten Mile Dam (the proposed location of the Project's workforce accommodation village). The results from this assessment are described in Chapter 4, *Emissions, Discharges and Wastes* and in Appendix E1.

In addition to this baseline monitoring, acoustic modelling was undertaken. This modelling was based on potential construction, operational and emergency scenarios (see Appendix E1).

10.6.6.3 Assessment Framework

Relevant assessment framework for noise impacts on public amenity exists at a State level. Specific policy and framework documents relating to noise are identified in Table 10.15.

10.6.6.4 Impact Assessment and Management

Impacts to public amenity from noise will occur to some extent as a result of Project activities. The following sections summarise the aspects and activities that may directly and indirectly affect public amenity in, and surrounding, the Project area. Chapter 7, *Impact Assessment Methodology* contains the risk matrix used to assess the likelihood and consequence of impacts occurring. The potential impacts and the management measures to be implemented are discussed in detail. Table 10.16 in Section 10.6.6.5 provides a summary of the potential impacts, management measures and residual risk as a result of Project activities.

Construction Activities

Residual risk to Onslow community from construction noise is	Low

Noise from construction activities, including noise from activities such as earth moving and vehicle movements, is predicted to fall below assigned values. Therefore, noise from construction should not diminish the public's quality of life and sense of serenity. The exception to this is noise associated with pile driving during the construction phase. It is possible that noise from pile driving could exceed assigned levels at Onslow because its hammering sound is more intrusive than other noises. Should this occur, there could be stress-related impacts on community well-being. However, exceeding assigned levels at Onslow would require:

- All pile drivers to be operating at night
- Noise from all pile drivers to arrive simultaneously at Onslow
- Weather conditions that make sound travel further than normal ("weather conditions which are conducive to the propagation of sound")
- Very low background noise at Onslow.

It is highly unlikely that all of the above conditions will occur at the same time.

To comply with Environmental Protection (Noise) Regulations 1997 and environmental objectives for noise emissions during construction activities, noise will be managed as part of the CEMP. The current Project design and implementation of industry standard management measures enable noise levels to comply with government regulations. Therefore, it is unlikely noise levels will be exceeded at Onslow during the construction phase.

Operational Activities

Residual risk to Onslow community from operational noise is	Low

The Environmental Protection (Noise) Regulations 1997 specify the noise levels that are acceptable at residential premises during night time periods and at industrial areas. The noise assessment study confirmed that noise levels for normal plant operation will comply with the night-time regulatory noise levels for Onslow.

The proposed location for the workforce accommodation village is far enough away from the plant site to ensure noise levels will be significantly below assigned levels (Appendix E). Predicted noise levels at the public access areas of Four Mile Creek, Five Mile Pool and Old Onslow Townsite heritage area are higher than underlying background noise. It is, therefore, possible that plant noise may be heard at these locations when weather conditions are conducive to the propagation of sound.

Predicted noise levels from emergency flaring comply with the assigned levels. Noise from flaring during non-routine operations may be noticeable at the Old Onslow Townsite heritage area and Four Mile Creek during weather conditions that are conducive to the propagation of sound; however these sites are not residential areas. On the occasions when flaring does take place, tourists and local residents using the Old Onslow Townsite heritage area or Four Mile Creek may experience temporary noise impacts.

After the implementation of management measures, noise is only likely to be heard on a very localised and short-term scale. The processing facility is unlikely to be heard above background noise at the Onslow town site even under weather conditions that are conducive to the propagation of sound.

The current Project design and implementation of industry standard management measures will ensure noise levels comply with government regulations. Therefore, it is unlikely noise levels will be exceeded at Onslow during the operational phase, and noise from operational activities should not diminish the public's quality of life and sense of serenity.

Summary

Following the implementation of appropriate management measures presented in Table 10.16 it is possible that acoustic emissions during operations and construction will result in impacts to public amenity. However, the residual environmental risk for this potential impact was assessed as being "Low". For construction activities the risk is of "Minor" consequence and "Possible" likelihood, and for operational activities the risk is of "Moderate" consequence and "Unlikely" likelihood.

10.6.6.5 Residual Risk Summary

Table 10.16 provides a summary of the aspects, activities and potential impacts to public amenity from noise as a result of Project activities. Indicative management controls and mitigating factors are also listed, along with the residual risk following implementation of the management controls.

10.6.6.6 Predicted Environmental Outcome

The Project is considered to have a "Low" residual risk of noise affecting Onslow residents and Project staff living in the workforce accommodation village. There may be noise impacts at recreational areas close to the Project site; however these will be temporary and likely to only occur under weather conditions that are conducive to the propagation of sound. The EPA management objective for noise impacts is expected to be achieved.

10.6.7 Public amenity - Air Emissions

10.6.7.1 Management Objectives

The EPA objective for this assessment is to ensure that air emissions do not adversely affect environment values or the health, welfare and amenity of people and land users by meeting statutory requirements and acceptable standards (EPA 2004b). Chapter 4, *Emissions, Discharges and Wastes* and Chapter 9, *Terrestrial Risk Assessment and Management* contain a detailed description of the Project's air emissions and their potential impacts.

10.6.7.2 Description of Factor

The baseline characteristics of the social environment were described in Chapter 6, *Overview of Existing Environment*. Sources of data included an air modelling study.

The Project will increase atmospheric emissions compared to existing concentrations. Each of the phases of construction, commissioning, and operation will contribute differently to the local and regional airshed. This section describes the potential impact on public amenity.

10.6.7.3 Assessment Framework

Relevant assessment framework for public amenity from air emissions exists at Commonwealth and State levels. Specific policy and framework documents relating to public amenity are identified in Table 10.17.

10.6.7.4 Impact Assessment and Management

Impacts to public amenity from air emissions will occur to some extent as a result of Project activities. The following sections summarise the aspects and activities that may directly and indirectly affect public amenity in, and surrounding, the Project area. Chapter 7, *Impact Assessment Methodology,* contains the risk matrix used to assess the likelihood and consequence of impacts occurring. The potential impacts and the management measures to be implemented are discussed in detail. Table 10.18 in Section 10.6.7.5 provides a summary of the potential impacts, management measures and residual risk as a result of Project activities.

Construction Activities

Residual risk to Onslow community from dust and air emissions during construction is	Low

Emissions from construction activities are discussed in detail in Chapter 4, *Emissions Discharges and Wastes*. These emissions will generally consist of dust from vehicle movements and ground clearance, and emissions from construction equipment.

The main impact of dust on public amenity is likely to be from reduced visibility due to airborne dust or dust settling on property (e.g. caravans, vehicles, buildings located nearby). This is generally referred to as Total Suspended Particulates (TSP). The potential likelihood and impact of TSP and PM_{10} (the potential respirable fraction) are discussed in Chapter 9, *Terrestrial Risk Assessment and Management*.

Dust will be managed as part of the CEMP, with the key objective of maintaining dust generation and dispersion in compliance with the EPA Guidance for the Assessment of Environmental Factors – prevention of air quality impacts from land development sites – No.18, 2000. Complying with this objective will ensure dust impacts on public amenity are also managed.

Air emissions during the construction phase will mostly come from the vehicles and equipment required to support construction activities. This includes the various ships, airplanes, trucks and cars that will transport workers, materials and equipment to site. The volume of air emissions generated during construction is not considered to be significant.

It is possible that odorous compounds may be emitted during the construction phase from the placement of nearshore dredge material and from operation of a sewage treatment facility (see Chapter 4, *Emissions, Discharges and Wastes*). Odours from the placement of nearshore dredge material are not anticipated to be experienced outside of the Project's buffer zone, and therefore should not affect public amenity. Operation of the sewerage treatment facility to Project control requirements is expected to manage odours from the facility so they are unlikely to reduce public amenity in the local area.

Operational Activities

Residual risk to Onslow community from dust and air emissions during operations is	Low

The main activities likely to generate air emissions during operations are the following:

- Combustion of fuel gas in the gas turbines
- Flaring during upset or emergency conditions
- Dust generated during routine maintenance.

The results of the air modelling study are discussed in Chapter 4, *Emissions, Discharges and Wastes* and Chapter 9, *Terrestrial Risk Assessment and Management*, and described in detail in Appendix C. The results of the modelling assessment show that even under worst-case conditions, air quality levels do not exceed guideline values.

For the operational phase dust will be managed as a part of the Operations Environment Management Plan (OEMP).

Summary

Following the implementation of appropriate management measures presented in Table 10.18 it is possible that air emissions during construction and operations will result in impacts to public amenity. However, the residual environmental risk for this potential impact was assessed as being "Low" of "Minor" consequence and "Possible" likelihood.

10.6.7.5 Residual Risk Summary

Table 10.18 provides a summary of the aspects, activities and potential impacts to public amenity from air emissions as a result of Project activities. Indicative management controls and mitigating factors are also listed, along with the residual risk following implementation of the management controls.

10.6.7.6 Predicted Environmental Outcome

The Project is considered to have a Low residual risk of air emissions impacting on the amenity of Onslow residents, campers, tourists, other recreational users and nearby commercial land users. The EPA management objective for air quality impacts is expected to be achieved.

Table 10.16: Summary of Management Controls and Residual Risk Analysis for Public Amenity – Noise

Aspect, Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Acoustic Emissions during Operations and Construction							
General construction activities that create acoustic emissions, including noise from increased road traffic and heavy vehicles	Diminished quality of life due to acoustic emissions that are audible from key receptor points	• Construction activities will comply with Environmental Protection (Noise) Regulations 1997 • Noise will be managed as part of the CEMP. The management plan will focus on noise to surrounding receptors beyond the site boundary	5	3	Low	**Reasonable level** Survey data available from one expert – complies with EPA guidance	
General construction activities that create acoustic emissions, including noise from piling	Diminished quality of life due to acoustic emissions that are audible from key receptor points Stress-related impacts on community well-being as a result of hammering noise	• Construction activities will comply with Environmental Protection (Noise) Regulations 1997 • Noise will be managed as part of the CEMP. The management plan will focus on noise to surrounding receptors beyond the site boundary	4	4		**Reasonable level** Survey data available from one expert – complies with EPA guidance **Uncertainties**: Pile driving program of works	
General construction activities that create acoustic emissions, including flare noise	Diminished quality of life due to acoustic emissions that are audible from key receptor points and diminish quality of life / sense of serenity	• Construction activities will comply with Environmental Protection (Noise) Regulations 1997 • Noise will be managed as part of the CEMP. The management plan will focus on noise to surrounding receptors beyond the site boundary	4	4		**Reasonable level** Survey data available from one expert – complies with EPA guidance	

General operational activities that create acoustic emissions, including flare noise	Diminished quality of life due to acoustic emissions that are audible from key receptor points and diminish quality of life / sense of serenity	• Operational activities will comply with Environmental Protection (Noise) Regulations 1997 • Noise will be managed as part of the OEMP. The management plan will focus on noise to surrounding receptors beyond the site boundary	4	4	**Low**	**Reasonable level** Survey data available from one expert – complies with EPA guidance	
Additive Effects							
Additive effects of construction and operational activities	Diminished quality of life due to acoustic emissions that are audible from key receptor points Stress-related impacts on community well-being as a result of acoustic emissions	• Construction and operational activities will comply with Environmental Protection (Noise) Regulations 1997 • Noise will be managed as part of the CEMP and OEMP. The management plan will focus on noise to surrounding receptors beyond the site boundary	4	4	**Low**	**Reasonable level** Survey data available from one expert – complies with EPA guidance	

Table 10.17: Legislation and Guidelines Specific to Public Amenity – Air Emissions

Legislation or Guideline	Intent
NEPC 2003 (as amended), *National environment protection (ambient air quality) measure (NEPM)*, National Environment Protection Council, Canberra, Australia.	These measures set standards that consist of quantifiable characteristics of the air against which ambient air quality can be assessed.
Air quality modelling guidance notes, Department of Environment, Perth. (DoE 2006)	This guidance aims to provide a clear understanding of the DoE's (now DEC) expectations with respect to air quality modelling and associated meteorological monitoring and/or modelling.
State Environmental (Ambient Air) Policy 2009, Draft Policy for Public and Stakeholder Comment. (EPA 2009e)	The purpose of the policy is to: • Establish the basis on which ambient air quality is to be protected • Abate pollutants and restrict activities that diminish the environmental value of ambient air • Establish a framework and program to protect and enhance • Environmental quality to support the environmental value of ambient air.
Guidance for the Assessment of Environmental Factors: *Prevention of Air Quality Impacts from Land Development Sites*. Report No. 18. (EPA 2000a)	This guidance statement aims to address the prevention of impacts on air quality from dust and smoke generated on land development sites.
Guidance for the Assessment of Environmental Factors: *Emissions of Oxides of Nitrogen from Gas Turbines*. Report No. 15. (EPA 2000b)	This guidance aims to provide advice on emissions of oxides of nitrogen from gas turbines. The Guidance provides information which the EPA will consider when assessing proposals where NOx emissions from gas turbines, as an environmental pressure on air quality in the Perth metropolitan area and regional areas of Western Australia, are relevant environmental factors in an assessment.
Air quality guidelines, 2nd edition, World Health Organisation Regional Office for Europe, Copenhagen, Denmark, 2000. (WHO 2000)	These guidelines provide a basis for protecting public health from adverse effects of air pollution and for eliminating, or reducing to a minimum, those contaminants of air that are known or likely to be hazardous to human health and wellbeing.
Shire of Ashburton Local Planning Policy 20 – Social Impact Assessment (Shire of Ashburton 2009)	This policy seeks to provide: • A framework for the identification of issues arising from development proposals that may impact on the social structure of the Shire • A consistent and thorough approach to the assessment of issues associated with proposals • A description of issues and means to address those issues for the consideration of the community and the Shire • Information and support for community input into the decision making process • Minimisation of negative impacts and maximisation of positive outcomes • Integration of expertise in the decision making process • The consideration of a wide range of issues that have social implications, including: infrastructure, resource issues, heritage impacts, landform impacts, economic and fiscal impacts, community impacts, cultural impacts, indigenous rights impacts, demographic impacts, transport impacts and other relevant considerations.

Table 10.18: Summary of Management Controls and Residual Risk for Public Amenity - Air

Aspect, Activity	Potential Impacts	Management Controls and Mitigation Measures	Residual Risk			Confidence Level	Matters of NES
			C	L	RR		
Air Emissions							
General construction activities, including dust from increased road traffic and heavy vehicles	Increased respiratory disease due to increased emissions Decreased public amenity due to increased air emissions	• Dust will be managed as part of the CEMP, including mitigation measures as detailed in Chapter 9, *Terrestrial Risk Assessment and Management* • Industry standard traffic management controls will be in place	5	3	Low	**Reasonable level** Survey data available from one expert - complies with EPA guidance **Uncertainties:** Number, volume and type of road traffic and heavy vehicles not yet known	
Vehicle movement / Heavy loads	Decreased public amenity due to increased air emissions	• Dust will be managed as part of the CEMP • Industry standard traffic management controls will be in place	5	3		**Reasonable level** Survey data available from one expert - complies with EPA guidance **Uncertainties:** Number, volume and type of road traffic and heavy vehicles not yet known	
General operational activities that create air emissions	Decreased public amenity due to increased air emissions	Dust will be managed as a part of the OEMP	5	3		**Reasonable level** Survey data available from one expert - complies with EPA guidance **Uncertainties:** Final LNG Plant layout yet to be determined although typical emissions from an LNG plant are known	
Additive Effects							
Operations and construction activities that create air emissions	Decreased public amenity due to increased air emissions	• Dust will be managed as part of the CEMP • Dust will be managed as a part of the OEMP • Industry standard traffic management controls will be in place	5	3	Low	**Reasonable level** Survey data available from one expert - complies with EPA guidance **Uncertainties:** Final LNG Plant layout yet to be determined although typical emissions from an LNG plant are known	

Table 10.19: Legislation and Guidelines Specific to Public Amenity – Visual Impact

Legislation or Guideline	Intent
EPA Guidance Statement No 33: *Environmental Guidance for Planning and Development* (EPA 2008) – Chapter 4D	This guidance statement aims to ensure that aesthetic values are considered and that measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable.
Australian Standard AS4282:*1997 Control of the Obtrusive Effects of Outdoor Lighting (1997)* (Standards Australia 1997)	This standard specifically refers to the potentially adverse effects of outdoor lighting on nearby residents (e.g. of dwellings such as houses, hotels, hospitals), users of adjacent roads (e.g. vehicle drivers, pedestrians, cyclists) and transport signalling systems (e.g. air, marine, rail), and on astronomical observations.
Visual Landscape Planning in Western Australia - a manual for evaluation, assessment, siting and design (DPI 2007).	This document is intended to: • Provide advice for local communities, local and state agencies on technique to protect valued visual landscape characteristics, including individual features and views • Assist development proponents to produce proposals that are compatible with visual landscape character • Assist those planners and decision makes who are responsible for assessing the potential impacts of development proposals • Provide a starting point for local authorities in establishing localised guidelines and policies • Help communities to address issues that impact on landscape values.
Shire of Ashburton Town Planning Scheme No 7 (DPI 2005)	This planning scheme provides guidance that all planning approvals should consider: • Impact of the development on the amenity of the locality • Any social issues that have an effect on the amenity of the locality • Specifically, Council will assess any social issues which that have an effect on the amenity of the locality • The capacity of the site and surrounding locality to support the development (including access, traffic generated, need for public transport services, services infrastructure and community services, amenity impacts on the locality) • Compatibility of the proposed use within its setting • Potential loss of community benefit or service resulting from the planning approval.
State Industrial Buffer Statement of Planning Policy 4.1	This policy aims to protect important industrial and infrastructure sites in Western Australia whilst providing safety and amenity for surrounding land uses.
EPA Guidance Statement No. 3: *Separation Distances between Industrial and Sensitive Land Uses 2005* (EPA 2005)	This guidance statement aims to address generic separation distances between industrial and sensitive land uses to avoid conflicts between these land uses.

Legislation or Guideline	Intent
State Planning Policy 2.6 – State Coastal Planning Policy	This policy aims to: • Protect, conserve and enhance coastal values, particularly in areas of landscape, nature conservation, indigenous and cultural significance • Provide for public foreshore areas and access to these on the coast • Ensure the identification of appropriate areas for the sustainable use of the coast for housing, tourism, recreation, ocean access, maritime industry, commercial and other activities • Ensure that the location of coastal facilities and development takes into account coastal processes including erosion, accretion, storm surge, tides, wave conditions, sea level change and biophysical criteria.
Shire of Ashburton Local Planning Policy 20 – Social Impact Assessment (Shire of Ashburton 2009)	This policy seeks to provide: • A framework for the identification of issues arising from development proposals that may impact on the social structure of the Shire • A consistent and thorough approach to the assessment of issues associated with proposals • A description of issues and means to address those issues for the consideration of the community and the Shire • Information and support for community input into the decision making process • Minimisation of negative impacts and maximisation of positive outcomes • Integration of expertise in the decision making process • The consideration of a wide range of issues that have social implications, including: infrastructure, resource issues, heritage impacts, landform impacts, economic and fiscal impacts, community impacts, cultural impacts, indigenous rights impacts, demographic impacts, transport impacts and other relevant considerations.

10.6.8 Public amenity – Visual Impacts

10.6.8.1 Management Objectives

The EPA objective is to ensure that aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable (EPA 2004b). Chapter 4, *Emissions, Discharges and Wastes* and Appendix D contain detailed descriptions of the Project's light emissions and its potential impacts.

10.6.8.2 Description of Factor

The baseline characteristics of the receiving social environment are described in *Chapter 6, Overview of the Existing Environment*. Sources of data included visual impact modelling.

The visual character of an area, on a local or a landscape scale, can influence the ways in which people use and value that area. Visual character can include daytime views as well as night-time views influenced by artificial lighting. Visual amenity is derived when visual character is valued by the community, and contributes to a sense of well-being and quality of life (EPA 2008).

The attractiveness of a view is highly subjective as it depends on an individual's perception. Therefore, although it is possible to document the potential scale of change that may occur, it is difficult to assign a meaningful risk ranking to visual amenity. For this reason, impacts to visual amenity have not been assigned a risk category and the impact is discussed in terms of the degree of change to the current visual landscape.

10.6.8.3 Assessment Framework

Relevant assessment framework for visual amenity exists at a State level. Specific policy and framework documents relating to visual amenity are identified in Table 10.19.

10.6.8.4 Impact Assessment

Impacts to the visual amenity will occur to some extent as a result of Project activities. The following sections summarise the aspects and activities that may directly and indirectly affect visual amenity in, and surrounding, the Project area. As mentioned in Section 10.6.8.2, visual amenity was not risk ranked.

10.6.8.5 Offshore Visual and Lighting Impacts

The offshore facilities associated with the Project will be located approximately 60 km north-north-west of the Montebello Islands and 145 km from mainland WA. Offshore illumination will include flares and artificial lighting on the central processing platform complex.

The offshore area the Project will affect is very distant from any human settlements, and the gas-production facility would only be visible to passing ships. The level of change to the visual amenity and the impact of lighting of the offshore area is therefore considered negligible.

10.6.8.6 Onshore and Nearshore – Visual Impacts

The onshore and nearshore Project area consists of undeveloped, low-lying plains and sand dunes, and a coastline of sandy beaches and rocky headlands between mangrove-lined river mouths. The Project area is relatively remote from human settlements, with the township of Onslow 12 km away and no other population centres for hundreds of kilometres. The evaporation dams of Onslow Salt are located approximately 5 km from the site, and along with various sealed and unsealed roads represent the largest existing man made feature in the landscape.

Development of the Project will result in a significant change to the landscape in the onshore and nearshore area. There are no other major industrial facilities in the vicinity, and large-scale earthworks and construction will be required to install the gas-processing and export infrastructure. Therefore, the scale of change to the visual character of the area will be relatively large.

The consequence of this relatively large change is mitigated by the remoteness of the site and the distance from areas of public amenity. Through community consultation (public meeting, Onslow, March 2009), a number of areas of public amenity were identified that could become "viewpoints" from which the Project infrastructure would be seen. Selected viewpoints (shown in Figure 10.7) include camping

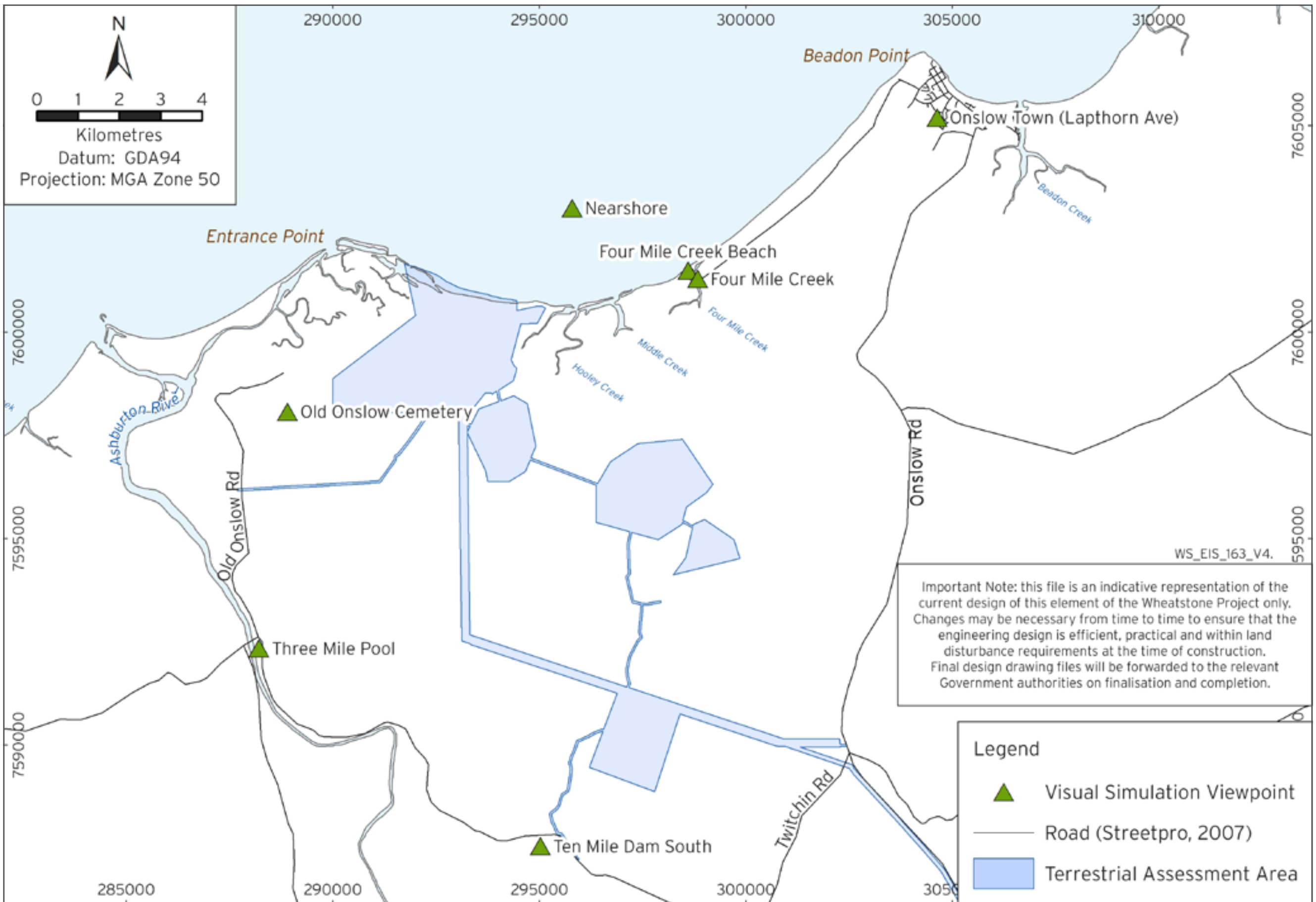

Figure 10.7: Viewpoints of Interest

and recreation areas at Four Mile Creek and the Ashburton River, as well as a nearshore area used for recreational fishing. Other viewpoints include the Old Onslow Cemetery, a site in Onslow town, and Ten Mile Dam South where the accommodation village is proposed to be located.

10.6.8.7 Visual Simulations

In order to characterise the potential views from each viewpoint, computer-simulated photomontages of the Project infrastructure were developed for each viewpoint. From most of the viewpoints, the long distances between the observer and the Project area result in minor or negligible changes to the overall view, with the facilities barely visible on the horizon. The three most affected viewpoints, at distances of 3 to 4.5 km, are:

- The nearshore recreational fishing area
- Four Mile Creek beach
- The Old Onslow Cemetery.

Photograph 10.1, Photograph 10.2, and Photograph 10.3 show the visual impact from these areas.

10.6.8.8 Onshore and Nearshore – Lighting Impacts

Light emissions will be generated by:

- Construction activities
- The operational processing facility
- Flaring that is required during, commissioning, start-up or operation
- The accommodation village, which will be visible at night from moderate distances.

Construction activity is expected to be carried out 24 hours per day and lighting will therefore be required to provide safe working conditions. Initially, lighting is likely to be provided by mobile lighting towers, which are relatively close to the ground and unlikely to be visible over any great distance. As construction of the facility progresses, lighting will be installed on the structure and is likely to become visible over a greater distance. Light emissions as construction progresses are expected to be similar to the light emissions during operation.

The completed processing facility is also anticipated to operate 24 hours per day and lighting will therefore be required. Light emissions will be generated by the processing facility, the MOF, PLF flaring, the accommodation village and the access road. Light emissions from the accommodation village are considered to be minor compared to the processing facility because it will have lighting similar to that of a residential area

Photograph 10.1: Visual Simulation of the Project from a Nearshore Recreational Fishing Area

Photograph 10.2: Visual Simulation of the Project from Four Mile Creek Beach

Photograph 10.3: Visual Simulation of the Project from Old Onslow Cemetery

containing single storey structures. As there are no known community or optical observatories in proximity to the production plant, there is no regulatory requirement to control sky glow.

The lighting impact assessment is based on assumed light sources during the period of dusk until dawn. It has been based on conditions which are conducive to the propagation of light and the impacts may be less than indicated. The following assumptions were used:

- Lamp posts for perimeter lighting, jetty and roadway assumed to be 30 m apart
- 250 and 400 W high pressure sodium (HPS) globes were assumed to be used throughout the facility
- Air mass ratio of 1.0 – clear air
- Flare temperature to be 1000 °C.

AS 4282:1997 notes that with any outdoor lighting it will rarely be possible to contain all light within the boundaries of the property on which the lighting system is installed. Some light will inevitably be spilled outside the property boundaries, either directly or by reflection.

Table 10.20 shows the estimated lighting levels for areas around the facility.

URS (2009n) estimated the impacts of light spill at six viewpoints of interest to give a visual representation of light emissions from the processing facility. This estimate accounts for the heights of major infrastructure within the onshore development area (e.g. buildings, tanks, flares, etc.) as well as the topography within the catchments of each viewpoint. Allowances were not made for average natural vegetation heights in areas of uncleared bushland.

Table 10.21 indicates the light spill at Old Onslow, Four Mile Creek beach, Ashburton River camp site, Ashburton Island and the offshore location will be brighter than full moon conditions. However, this will only occur during intermittent flaring.

The visual impacts of light dissipate both laterally (over distance) and longitudinally (increasing height), depending on the viewing location. Figure 10.8 compares the impact of various locations, equipment and overall light spill from the processing facility. It compares the ambient light spill to the light levels from the average family living room, full moon on a clear night and moonless clear night. The graph shows that the impact of light spill is greatest closest to the plant (due to proximity to light source). It then falls off rapidly as the distance increases from 400 m to 12.5 km.

Chapter 4, *Emissions, Discharges and Wastes* provides further detail on the methods used to estimate the light emissions from the Project.

Table 10.20: Estimated Lighting Levels in the Project Area

Area	Lux (lx)(lumens/m²)
Roadway, Jetty, Pathway, Perimeter Fence	24
Security lighting for Administration Buildings	16168
LNG Trains, Domgas trains	395
Condensate and other tanks	235

Table 10.21: Estimated Lighting Levels at Sensitive Receptors

Area	Lux at location from LNG trains	Lux at location from Marine PLF	Lux at location from wet/dry flare
Onslow	6.77E-10	3.90E-07	1.58E-06
Ten Mile Dam	2.14E-09	8.34E-07	4.65E-04
Old Onslow	1.14E-08	5.62E-06	7.53E-02
Four Mile Creek Beach	2.32E-08	1.56E-05	4.23E-02
Ashburton River Camp Site	3.37E-09	1.59E-02	2.31E-04
Ashburton Island	4.33E-05	2.52E-02	2.24E-02
Offshore	1.73E-04	1.08E-01	7.22E-02

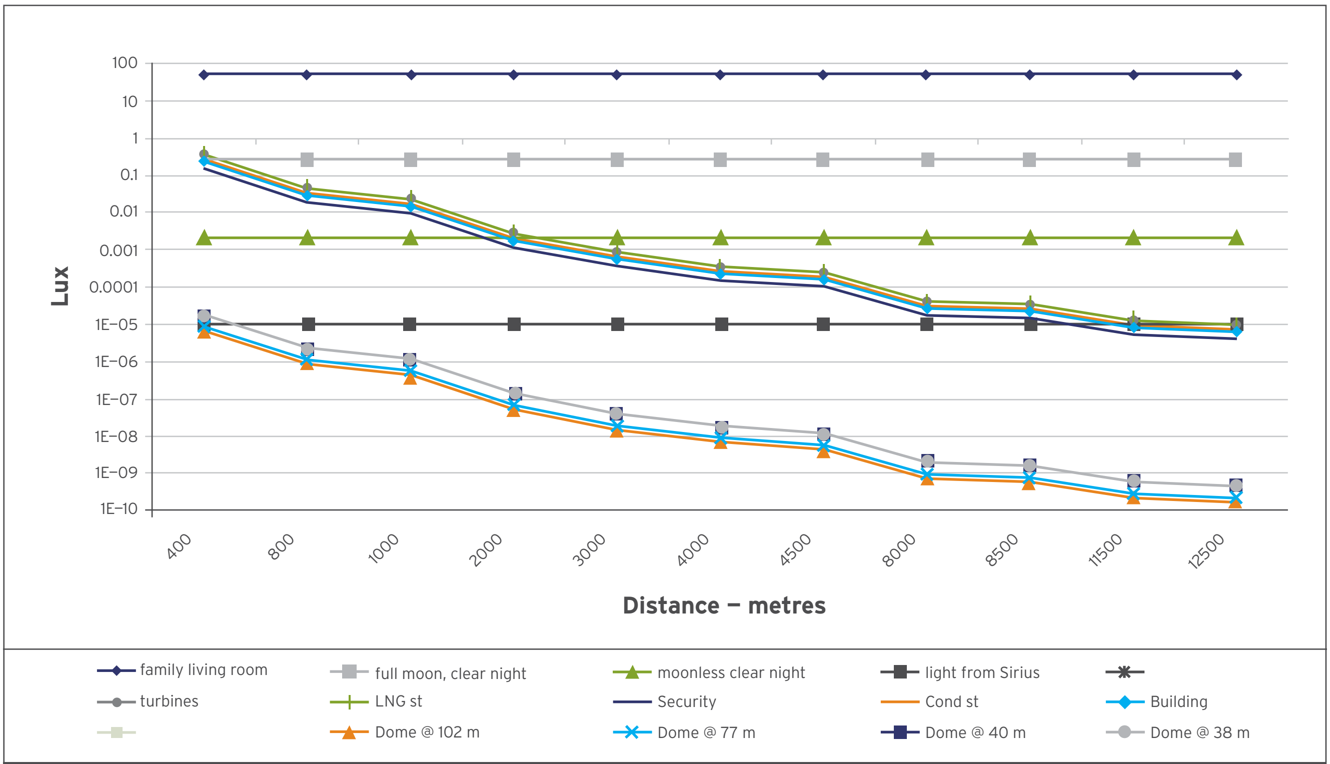

Figure 10.8: Estimated Light Spill from the Project

10.6.8.9 Predicted Environmental Outcome

The likelihood of changes to the visual character of the Project area is almost certain due to the size of the facility. Table 10.22 lists the scale of the change at each viewpoint; however, as mentioned above, a residual risk rating has not been assigned due to the subjective nature of values associated with visual amenity.

10.6.8.10 Predicted Environmental Outcome - Public Amenity Overall

The aspects described above have the potential to impact public amenity in an additive manner. The combined consequence of air emissions, acoustic emissions and visual impacts on public amenity has been determined to be "Major", which is a permanent and significant reduction in public amenity in the local area, however the likelihood of this consequence occurring is "Unlikely". The additive risk from the Project on public amenity is "Low". The EPA management objective for public amenity is expected to be achieved.

10.7 Health and Well-being

The following sections present the assessment of impacts on health and well-being associated with the Project.

10.7.1 Management Objectives

The EPA does not have a management objective in regard to a project's impact on a community's general health and well-being. Chevron's management objective is to reduce as far as practicable the risk posed by the Project on the health and well-being of the local Onslow community and key users in the Project area. In regard to public risk, the EPA's objective is to reduce the risk (individual, societal and environmental) associated with hazardous industrial plants.

10.7.2 Description of Factor

Chevron believes the health of its employees and the community where it operates is critical to achieving business results. Health is "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (WHO 2003). The World Health Organisation describes the three determinants of health and well-being as follows (WHO 2009):

- Social and economic environment
- Physical environment
- Individual characteristics and behaviours.

For the purposes of this assessment, health and well-being refers to the health and well-being of Onslow residents, tourists and short-term visitors, and key users in the Project area. Background information on these receptors is included in Chapter 6, *Overview of Existing Environment*. The health and well-being of the Project construction and operations workforce is covered under occupational health and safety legislation and therefore is not assessed in the EIS/ERMP.

Risk Based Approach to Assessing Impacts on Health and Well-being

The environmental impact assessment process in Australia has historically focused on a project's impacts on the natural environment and the statutory management of emissions. According to the EPA:

> *Recent interpretation of the EP Act is that the environmental impact assessment process is not an appropriate process for the consideration of public safety. The only aspect of risk that the EPA is likely to continue to assess during environmental impact assessment is significant risk to the physical or biological environment. This is known as environmental risk and relates to the likelihood of damage to the physical or biological environment arising from a hazardous event associated with hazardous industrial plant (EPA 2008).*

Therefore, this section only contains a brief discussion of health issues that were identified in the Project's Environmental Scoping Document and are within the requirements of this EIS/ERMP, namely mosquito-borne disease, public risk from motor vehicle accidents and public risk from upset conditions.

10.7.3 Assessment Framework

Table 10.23 summarises the legislation and guidelines relevant to health and well-being.

10.7.4 Impact Assessment and Management

Consultation with community and health stakeholders revealed the areas of greatest concern in regard to the health and wellbeing of community members were:

- Increase in consumption of alcohol and illicit drugs
- Increase in communicable disease, including sexually transmitted infections
- Increase in mosquito-borne disease
- Increase in diabetes
- Increase in pressure on health and emergency services
- Increase in motor vehicle accidents
- Public risk from upset conditions during operation of the facilities.

Only three of these issues fall under the scope of an EIS/ERMP: Mosquito-borne disease, public risk from motor vehicle accidents and public risk from upset conditions. The remaining issues will be assessed in consultation with the Western Australian Department of Health (DoH), and Chevron will develop appropriate management measures.

10.7.4.1 Increase in Mosquito-borne Disease

Consultation with key health stakeholders revealed a concern that the Project may result in an increased prevalence and incidence of mosquito-borne diseases. This is due to the accommodation village being located near potential mosquito activity areas; the potential for new species to be introduced via transport of materials and equipment required for the Project; and the potential for changes in surface water flows as a result of the Project to increase the amount of mosquito breeding grounds.

Onslow is situated in an environment that includes tidal salt marshes and mudflats, rivers and seasonally flooded plains and salt pans. These landscapes are very important habitat for mosquitoes, biting midge (also known as sandflies) and march flies (or horseflies). Each group has over 200 species in Australia; however a much smaller proportion of species have implications on human health and comfort. A number of species of mosquitoes in Australia are known vectors (carriers) of viruses that affect humans, such as Ross River Virus (RRV), Barmah Forest Virus (BFV) and Murray Valley Encephalitis (MVE). Although biting midges and march flies are not known to transmit disease to humans they are well known to cause a severe allergic reaction in some people from their bites. In each group it is the females who bite humans, in search of a blood meal needed for egg development.

In the Onslow area several species of mosquito are likely to occur in plague numbers following infrequent heavy rainfall and a further two species are significant pests as a result of tidal flooding of salt marshes. A major nuisance species is the summer salt marsh mosquito (*Aedes vigilax*) which is the most important pest and vector species for coastal communities. It is most prevalent following summer rainfall that causes flooding of salt marsh over wide areas and is an important vector of RRV and BFV.

Biting midges are common near sandy estuarine and foreshore areas and mangroves swamps on the coasts of Western Australia. The mangrove biting midge, *Culicoides ornatus*, associated with estuarine creeks, is a major pest species to humans. Numbers of this species varies greatly

Table 10.22: Scale of Change to Visual Amenity

Viewpoint	Scale of Change
Ten Mile Dam South accommodation Village area	Negligible
Ashburton River campsite	Minor
Old Onslow Cemetery	Moderate
Four Mile Creek beach	Moderate
Four Mile Creek river mouth	Minor
Nearshore recreational fishing area	Moderate
Onslow town; Simpson Street	Negligible

Table 10.23: Legislation and Guidelines Relevant to Health & Well-being

Legislation or Guideline	Intent
EPA Guidance Statement No. 2: *Guidance for Risk Assessment and Management: Offsite individual risk from Hazardous Industrial Plant* (EPA 2000c)	This guidance statement aims to ensure that risk from a proposal is as low as reasonably achievable and complies with acceptable standards and EPA criteria.
EPA Guidance Statement No. 3: *Separation Distances between Industrial and Sensitive Land Uses 2005* (EPA 2005)	This guidance statement aims to ensure that risk from a proposal is as low as reasonably achievable and complies with acceptable standards and EPA criteria.
EPA Guidance Statement No. 33: *Environmental Guidance for Planning and Development 2008* (EPA 2008)	This guidance statement provides advice on the EPA's advice on protecting aspects of the biophysical environment of cultural and social significance to the community (social surroundings factors), and the EPA's position on risk.
EPA Guidance Statement No. 40: *Guidance Statement for Management of Mosquitoes by Land Developers* (EPA 2000d)	This guidance statement provides information which the EPA will consider when assessing proposals where mosquito management is a relevant environmental factor in an assessment. It takes into account: • The factor of mosquitoes, where mosquitoes present a health risk or severe nuisance to residents; and • Protection of the environment as defined by the Environmental Protection Act 1986 (WA) with a focus on minimising environmental impacts associated with methods for mosquito management.
Guidance for the Assessment of Environmental Factors – Assessment of Odour Impacts from New Proposals. No. 47. March 2002. Environmental Protection Authority, Western Australia. (EPA 2002b)	This interim guidance provides direction if generic buffer distances of EPA Guidance Statement No. 3 cannot be met.
Shire of Ashburton Town Planning Scheme No 7 (DPI 2005)	This planning scheme provides guidance that all planning approvals should consider: • Impact of the development on the amenity of the locality • Any social issues that have an effect on the amenity of the locality. (Cont'd)

Legislation or Guideline	Intent
Health Act 1911, WA	This State Act provides a legal framework for the regulation of activities and the provision of services relating to public health. It provides for the development of codes of practice. The relevant sections of this extensive Act include regulations relating to: • Design and connection of sewerage and drainage schemes • Offensive trades • Notification of disease • Pesticides • Infectious diseases • Venereal diseases • Child health and preventative services.
State Industrial Buffer Statement of Planning Policy 4.1	This policy aims to protect important industrial and infrastructure sites in Western Australia whilst providing safety and amenity for surrounding land uses.
Main Roads Act (WA) 1930	This State Act provides a legal framework for the construction, maintenance, supervision and management of highways, main roads and secondary roads.
Guide to Traffic Engineering Practice Part 2 – Roadway Capacity, Austroads (Austroads 1999)	This guide provides advice on assessment techniques and acceptable performance indicators for specific standards of roads within a network.
A Guide to the Geometric Design of Rural Roads – Rural Road Design, Austroads (Austroads 2003)	This guide provides advice on specific design standards depending upon the purpose and use of proposed routes.
Dangerous Goods Safety Act 2004 (WA)	This State Act provides a legal framework for the regulation of the manufacture, importation and use of explosives, and the classification, marking, storage, carriage, and sale of explosives and dangerous goods.
Shire of Ashburton Local Planning Policy 20 – Social Impact Assessment (Shire of Ashburton 2009)	This policy seeks to provide: • A framework for the identification of issues arising from development proposals that may impact on the social structure of the Shire • A consistent and thorough approach to the assessment of issues associated with proposals • A description of issues and means to address those issues for the consideration of the community and the Shire • Information and support for community input into the decision making process • Minimisation of negative impacts and maximisation of positive outcomes • Integration of expertise in the decision making process • The consideration of a wide range of issues that have social implications, including: infrastructure, resource issues, heritage impacts, landform impacts, economic and fiscal impacts, community impacts, cultural impacts, indigenous rights impacts, demographic impacts, transport impacts and other relevant considerations.

during the month, with plague numbers occurring around the time of the full moon and to a lesser extent around the new moon. Bites from midges are usually painful and itchy and can persist for days or weeks, sometimes resulting in secondary infection due to scratching of the bites.

March flies are large stout-bodied flies that breed in a number of habitats including freshwater creeks, estuaries and mangroves and can be a serious pest to humans, livestock, domestic animals and wildlife. Adults are most active during daylight hours during the warmer months and inflict a painful bite which can result in severe allergic reactions to the fly's saliva in some people. As with midges, bites are painful and itchy and can persist for days or weeks, sometimes resulting in secondary infection due to scratching of the bites.

In order to manage mosquito-borne diseases in the Project area, Chevron will meet the requirements of DoH's Mosquito Management Manual (DoH 2006) and EPA Guidance Statement No. 40 (EPA 2000d). This includes already having completed a baseline mosquito survey that investigated the potential mosquito breeding habitats in and around the Project area, and the number and species of adult mosquitoes in the area. This survey was undertaken in April 2010 with results expected to be available in August 2010. Chevron will also establish a mosquito monitoring program for a minimum of one year to develop an understanding of the mosquito population and its associated health risk cycle at Ashburton North SIA.

Chevron also completed a baseline survey in April 2010 to investigate potential biting midge and march fly breeding habitats in and around the Project area, and the number and species of adult biting midges and march flies in the area. The results of this survey are due in August 2010. Should potential health risks be identified, Chevron will implement measures with the objective of managing those identified health risks.

10.7.4.2 Increase in Motor Vehicle Accidents

Community consultation and discussions with health service providers revealed a concern about the potential for an increase in the number of motor vehicle accidents as a result of Project-related activities.

North West Coastal Highway (NWCH) is the major regional road connecting Geraldton with Port Hedland. Onslow Road is the only link between the NWCH and the Onslow town site, while Beadon Creek Road forms a link between Onslow Road and Onslow Port (Beadon Creek Maritime Facility). NWCH is a permitted road for operation of certain long vehicles and road trains.

A transport assessment was made of the adequacy of the existing road network (namely NWCH, Onslow Road, Airport Access Road and the respective intersections) to support the transport activities associated with the Project's construction and operation phases. The assessment was based on traffic-related information provided by Shire of Ashburton, Main Roads WA, Department of Planning, and Department of Transport. It also included a site visit during July 2009 to observe and assess existing road network conditions.

Based on currently available information, it was established that the current available capacities of NWCH and Onslow Road are sufficient to accommodate additional traffic associated with the construction phase of the Project without compromising the operating conditions. If new information becomes available that materially changes the assumptions used to assess the Project's impact on traffic, additional traffic modelling will be completed.

It should be noted that most heavy vehicle traffic will bypass the town of Onslow. It is likely that there will be an increase in the amount of heavy traffic along Onslow Road. If this occurs an upgrade of Onslow Road (including widening and sealing of shoulders) may be necessary to meet the requirements of Austroads' "Rural Road Design" document. Twitchin Road (Old Onslow Road) is not suitable for extensive and regular vehicle use and is often closed during periods of heavy rain and therefore an access road to the site will be constructed.

In order to reduce the risk to the public of an increase in motor vehicle accidents, traffic management measures will be developed in consultation with Main Roads WA and the Shire of Ashburton that are consistent with standard AS 1742.3-2009 to cover the construction and operational phases of the Project. Key objectives for the management of traffic are:

- To provide safe and efficient access along key transport networks
- To reduce adverse impacts on surrounding transport networks and the users of those networks
- To reduce impacts on the community, surrounding land uses and sensitive habitats.

10.7.4.3 Public Risk from Upset Conditions

Community consultation and discussions with health service providers revealed a concern about the potential for risk to the public from upset conditions during facility operations, in particular from explosions.

Chevron will conduct a quantitative risk assessment of potential health and safety impacts to the public that could be posed by the Project. The Project will meet all legislative requirements and EPA guidelines relating to management of safety risks. This assessment will be completed prior to commencement of works.

10.7.5 Predicted Environmental Outcome

There is no statutory requirement to assess environmental outcomes on health and well-being in an EIS/ERMP. However, the Project's potential impacts on the health and well-being of the community will be assessed separately and will be evaluated by the DoH and relevant experts facilitated through the DoH.

Chevron will comply with acceptable standards and EPA criteria with the aim of reducing public risk from upset conditions at the Project to levels that are as low as reasonably practicable. The EPA management objective for public risk is expected to be achieved.

10.8 Conclusion

The social impacts associated with European cultural heritage, Aboriginal cultural heritage, fishing and pearling, recreation, public amenity, health and wellbeing, and public risk can be managed for the Project provided that appropriate mitigation strategies are put in place. The cumulative impacts for social factors are assessed in Chapter 11, *Cumulative Impacts*.

11.0

Cumulative Impacts

11.0 Cumulative Impacts

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11.0 Cumulative Impacts

11.1 Introduction

Cumulative impacts may result when the potential impacts from the proposed Wheatstone Project (Project) are added to those of other past, present and reasonably foreseeable future actions. As such, the magnitude of the potential impacts assessed in Chapter 8, *Marine Risk Assessment and Management,* Chapter 9, *Terrestrial Risk Assessment and Management*, and Chapter 10, *Social Risk Assessment and Management* may increase when in combination with the effects of aspects associated with other actions. Therefore, in assessing the overall acceptability of the Project, it is important that the potential cumulative impacts are considered.

The Western Australian Environmental Protection Authority's (EPA) draft guidelines *Paper 10 Application of risk in EIA* instructs proponents to determine cumulative risk levels for each key environmental factor. The Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) requires consideration of cumulative impacts in strategic assessments of major projects (DEWHA 2008). This is further defined as a project's incremental effects that can cause change to the environment when added to "any other actions (of which the proponent should reasonably be aware) that have been, or are being, taken or that have been approved in the region affected by the action" (DEWHA 2008). In addition, the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requires cumulative impacts on matters of National Environmental Significance (NES) to be addressed, taking into consideration such issues as threatened species and bioregional planning (DEWHA 2008a).

It should be noted that the development of the Project as a 25 MTPA multi-train LNG facility reduces the potential for future expansion of Chevron's gas-processing facilities in the Ashburton SIA. The development of the Project as an LNG hub is also likely to lessen the need for future LNG related developments in the Pilbara. However, due to insufficient detail, the related reductions of potential cumulative impacts are not considered in this assessment.

11.2 Cumulative Impacts Assessment Methodology

The approach undertaken for the assessment of cumulative impacts is briefly outlined in Section 7.3.9 of this EIS/ERMP and in Section 5.5 of the approved Environmental Scoping Document (Scoping Document). Candidate actions for inclusion into the cumulative assessment were considered by applying the following criteria:

- It must be pre-existing, under construction or proceeding in the reasonably foreseeable future
- It must have aspects that may cause impacts on the same factor to those of the Project
- It must have sufficient information available to undertake a qualitative assessment.

In order to assess cumulative impacts, considerations include analysis of the type of actions, their spatial scale and duration and potential to interact with the Project. The analysis needs to be cognisant that baseline conditions are not static and also take into account a current understanding of what is reasonably foreseeable.

Cumulative impacts were assessed for each factor identified in the impact assessment of the Project. The additive effects from the Project on individual factors were assessed in Chapter 8, *Marine Risk Assessment and Management*, Chapter 9 *Terrestrial Risk Assessment and Management* and Chapter 10, *Social Risk Assessment, and Management*. The additive effects were then examined in this chapter for their potential to interact with other actions.

Greenhouse gas emissions, discussed in Chapter 4, *Emissions, Discharges and Wastes,* are not assessed. Greenhouse gases do not have local impacts, although they may impact upon global climate systems. This is beyond the scope of this assessment – a lack of publically available data would make any assessment purely speculative – and therefore not discussed further in this chapter. However, further discussion can be found in Chapter 3, *Project Alternatives and Site Selection* and Chapter 4, *Emissions, Discharges and Wastes*.

This cumulative assessment has been undertaken using qualitative analysis and discussion. Quantification of air emissions and terrestrial footprint was included in the evaluation of cumulative impacts where known. Risk rankings were not undertaken as they would be speculative due to lack of data or specific information available on the other actions considered. Unless otherwise stated, definitions are consistent with those used in Chapter 8, *Marine Risk Assessment and Management,* Chapter 9, *Terrestrial Risk Assessment and Management*, and Chapter 10, *Social Risk Assessment and Management*.

11.3 Considered Actions

A number of actions were considered for this cumulative impacts assessment. Guidance was drawn from the EPA, whose comments on the Scoping Document stated "As the Ashburton North area has been designated as a Strategic Industrial Area (SIA), the proponent will need to ensure potential environmental impacts are not addressed in isolation. Cumulative impacts must be addressed due to other users operating in the proposed area into the future and the close proximity to the town of Onslow".

Future actions within the local area were considered and include the BHP Billiton / Apache Macedon Gas Development (Macedon) and the Exxon Mobil / BHP Billiton Scarborough (North West Shelf) Pilbara Liquefied Natural Gas (LNG) Processing Plant (Scarborough) within the Ashburton North SIA. For this assessment, it is assumed that the proposed gas industry actions will be subject to the approvals process and appropriate mitigation measures incorporated.

A number of existing or pre-existing actions were also considered including the town of Onslow, Onslow Salt, pastoral leases, commercial and recreational fishing, as they were assessed as potentially contributing to cumulative impacts (Figure 11.1).

The criteria listed in Section 11.2 determined whether the considered actions were either accepted or discounted for inclusion in this cumulative impacts assessment. Actions are detailed in Figure 11.1 and Table 11.1 and further described in the following sections.

11.3.1 Actions Considered for Cumulative Assessment

11.3.1.1 Wheatstone Project

This cumulative assessment includes the Project, which incorporates the full multi-train development case for assessment, reducing the scope for further Chevron LNG processing developments in the region. The development of the Ashburton North SIA should furthermore reduce the need and therefore likelihood of additional LNG port developments in the Pilbara.

Also incorporated is associated development, including access roads and road upgrades, airport expansion, landfill, quarry and borrow pits used for sourcing fill material and associated traffic.

Refer to Chapter 2, *Project Description* for details.

11.3.1.2 BHP Billiton/Apache Macedon Gas Development

Macedon is a WA domestic gas (domgas) project designed to commercialise gas reserves in the Petroleum Title WA-12-R. The title is located offshore from the north-west coast of Western Australia (WA), approximately 100 km west of Onslow, 40 km north of Exmouth, and 16 km north-west of the Murion Islands.

The offshore components for Macedon will comprise four subsea production wells with potentially a further three infill wells or local tie-back wells drilled during operations and there will be no permanent sea surface infrastructure. The wells will be tied back to a subsea manifold and connected to the main wet gas pipeline. The subsea pipeline and umbilical will be approximately 80 km in length. Commissioning hydrotest liquid will be discharged at the gas field end of the pipeline at seabed level, where mixing and dilution with seawater will occur.

The onshore domgas plant is expected to be located 15 km south-west of Onslow to the south of the Project in the Ashburton North SIA. The gas plant is designed with a single train with a nominal capacity of 200 million standard cubic feet per day (MMscfd), or 5.7 million standard cubic metres per day. The likely area of impact / disturbance during operations will drop to approximately 150 ha; the significant decrease in area due to rapid rehabilitation of construction easements and corridors. The current proposal is for a domgas facility that would compress gas brought ashore and utilise/align as much as possible with existing corridors such as the Griffin Joint Venture LPG pipeline, the gas plant access infrastructure corridor and Onslow Road to connect to the Dampier to Bunbury Natural Gas Pipeline (DBNGP). The lack of liquefaction suggests that the plant itself will be relatively small compared to the Project having compressor sufficient only to achieve pipeline pressures. Macedon will have a maximum potential disturbance area of approximately 885 ha (onshore and offshore, WA State Waters).

Nitrogen dioxide (NO_2) will be emitted from the gas turbines, power generation plant and from construction vehicles. The burners will also produce low levels of sulphur dioxide (SO_2), carbon monoxide and particulates. Other emissions will include carbon dioxide, methane and other non-methane volatile organic compounds. Very low levels of air contaminants (relative to air quality standards such as National Environment Protection Measures - NEPM) at Onslow and other sensitive receptors are expected.

Commissioning of the onshore pipeline also involves hydrotesting prior to operation. Where practicable, the water will be re-used in each new section of the pipeline being tested (including the wet gas pipeline) and may ultimately be discharged to an evaporation pond or offshore in Commonwealth Waters. During operations, produced water and corrosion inhibitors will be fed to evaporation ponds.

An onshore construction workforce of up to 280 persons is predicted to be required over an anticipated 18 month

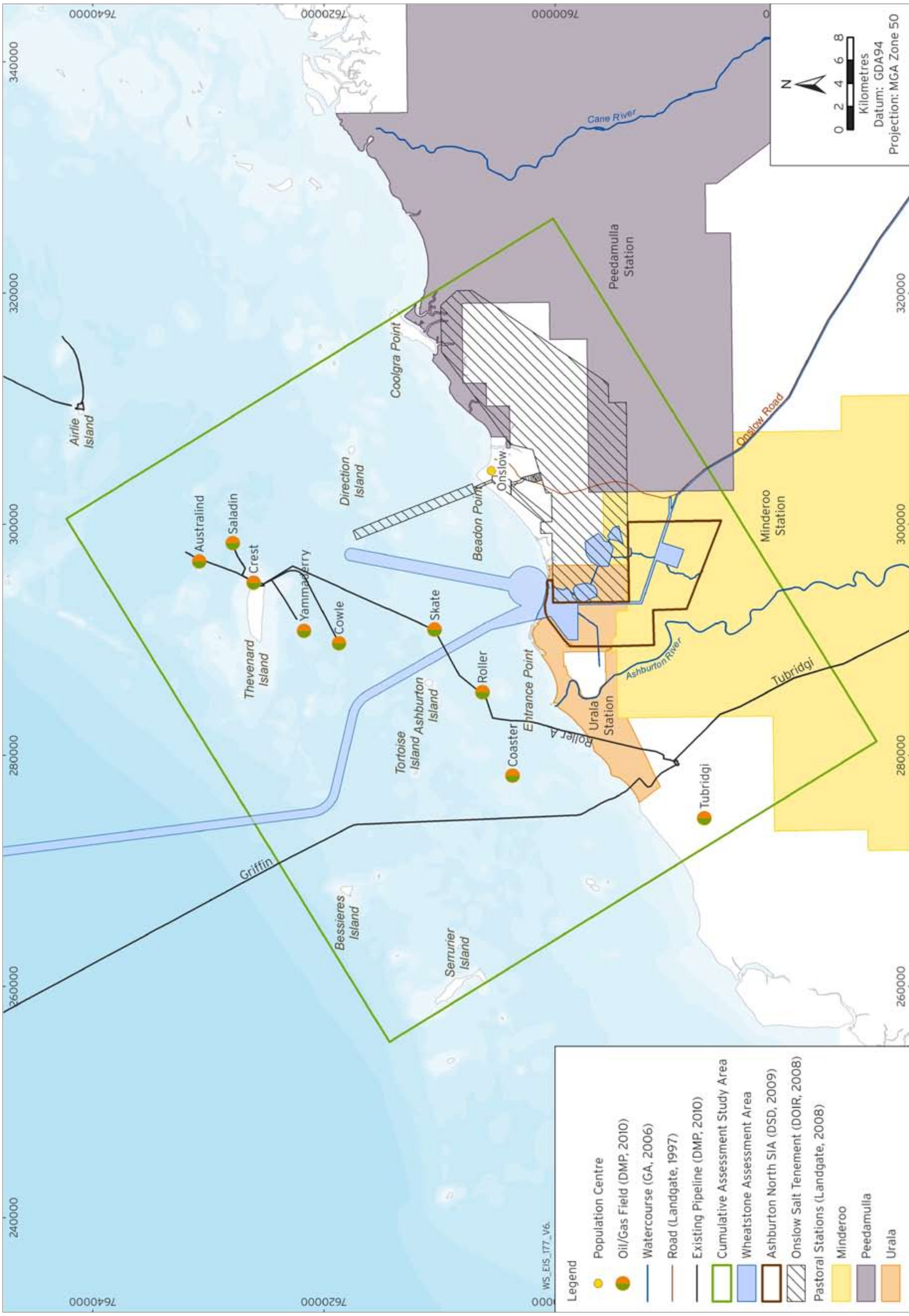

Figure 11.1: Cumulative Impacts Assessment Study Area

construction period for the Macedon construction village. Domestic wastewater is likely to be discharged to evaporation ponds after treatment.

11.3.1.3 Exxon Mobil/BHP Scarborough (North West Shelf) Pilbara LNG Processing Plant and Offshore Infrastructure

It is unclear whether or not this proposal will proceed; at time of writing the original referral was withdrawn. It is reasonable to assume that a referral resubmission is likely to occur in the near future and this action has therefore been included in this cumulative impacts assessment.

Scarborough's offshore components will be situated in Commonwealth waters within Petroleum Titles WA-1-R and WA-346-P. These are located in approximately 900 m water depth approximately 280 km north-west of Onslow, and 250 km north-west of Exmouth.

Based on the initial referral, the offshore components may comprise a series of subsea production wells connected by an infield flowline to gather the gas from the gas fields. A floating subsea support facility may be used to manage gas production from the wells with a subsea pipeline approximately 300 km long extending from the gas fields to the onshore plant in the Ashburton North SIA. The potential pipeline connecting the LNG plant to the existing Western Australian domestic gas pipeline network may follow or share existing pipeline easements and gas will also be transported to overseas markets by LNG tankers.

Table 11.1: Projects (Actions) Considered for Cumulative Assessment

Development	Description	Status	Included in the Cumulative Assessment
Project	25 million tonne per annum (MTPA) LNG plant, offshore infrastructure and associated development	Proposed	Yes
Macedon	200 million standard cubic feet per day (MMscfd) domestic gas (domgas) plant and offshore infrastructure	Proposed	Yes
Scarborough	6 MTPA LNG plant, possibly with additional trestle and LNG tanker berth, and offshore infrastructure	Proposed	Yes
Thevenard Island Facilities	Hydrocarbon production and storage facility	Existing	Yes
Tubridgi Gas Field and Griffin Gas Plant	Discontinued field 36 km^2 in area and two discontinued gas plants designated for removal	Existing	Yes
Onslow Salt	2.5 MTPA, currently operating and producing salt from 8000 ha of salt ponds	Existing	Yes
Pastoral Leases	Urala and Minderoo pastoral leases within the study area	Existing	Yes
Commercial Fisheries	Primarily restricted to the inshore prawn fishery off Onslow	Existing	Yes
Recreational Fisheries	Conducted by local residents and visitors in coastal and nearshore areas	Existing	Yes
Onslow Town	Community of 600 to 900 people located 12 km from the Project. This assessment includes potential population growth as a result of foreseeable future actions, but not additional population growth that may occur as a consequence of economic activity in the area. The physical presence of the town is also included	Existing and Future	Yes
Ashburton North SIA	Area designated for future development by the Department of State Development (DSD)	Unknown	No
Existing Offshore Discoveries	Timing and nature of any future production is not known	Unknown	No
Old Onslow Townsite	Past Action - identified as the primary receptor under the European Heritage factor	Existing	No

It can be expected that this proposal would include an LNG plant producing approximately six MTPA located at the Ashburton North SIA adjacent to the Project, an additional shore crossing for a pipeline and possibly another trestle and tanker berth to allow export of LNG. However, it would also be reasonable to assume that Scarborough would use Project shared infrastructure as far as possible (such as the existing MOF and shipping channel), limiting coastal development and footprint and the need for additional dredging.

11.3.1.4 Thevenard Island Facilities

Thevenard Island Nature Reserve is located approximately 25 km from the proposed onshore facilities. It is the hub for six adjacent oil and gas fields, four of which are currently in production. The first oil flowed in 1989, with subsequent fields brought into production in a staged development. Currently operated by Chevron, oil is produced from 21 wells from two offshore locations and nine unmanned offshore structures. The facilities are capable of processing 120 000 barrels of oil per day and 18 million cubic feet of gas per day. Oil is stored at a one million barrel storage facility on the island and exported via an offshore tanker mooring.

11.3.1.5 Tubridgi Gas Field and Griffin Gas Plant

The Tubridgi Gas Field was located under Urula Station pastoral lease, approximately 25 km south-west of Onslow and is now non-operational. This field was approximately 36 km^2 in area and supplied domgas over a period of around ten years. Gas was processed in a plant operated by Doral Resources NL, also located on Urula Station, and fed to the DBNGP through an export pipeline shared with the Griffin Gas Plant. The plant components are in the process of being removed. Four wells used to collect gas, and pipes connecting the wells to the plant are still present.

Adjacent to the Tubridgi Gas Plant is the Griffin Gas Plant, used to process gas from the Griffin Gas Field located 62 km offshore in the North West Shelf and also now non-operational. The Griffin oil and gas project was operated by BHP Billiton, and gas produced was fed to the DBNGP through the shared export pipeline. The trunkline used to transport gas from the offshore field to the plant is still present, as are sedimentation ponds located at the plant site onshore. The plant components are in the process of being removed.

11.3.1.6 Onslow Salt

The Onslow Solar Salt Project (OSSP) holds a lease covering a site immediately east and adjacent to the proposed Project site. In 1990, a proposal was submitted by Gulf Holdings Pty Ltd to develop a new salt field near Onslow to produce and ship salt from a new port facility to be built near Beadon Point. In 1995, Onslow Salt Pty Ltd replaced Gulf Holdings Pty Ltd as the proponent of the $80 million OSSP, with capacity to produce up to 2.5 million tonnes of sodium chloride per year from 8000 ha of salt ponds.

Onslow Salt has handling facilities to transport, process, store and load salt into ships for export via a 1.3 km steel-trestle jetty off Sunset Beach, together with a dredged navigation channel. The company loaded its first commercial shipment of salt in 2001.

11.3.1.7 Pastoral Leases

The proposed Project, including the construction village and infrastructure corridor spans Minderoo Station, one of the Pilbara's largest cattle stations, and the Urala pastoral station.

Minderoo is a 226 585 ha station with 10 000 cattle, which was founded as a station in the 1870s. The Urala pastoral lease was acquired by BHP Billiton in 2005 and covers the site of the Griffin onshore pipeline, the Griffin export facility, and the recently decommissioned Tubridgi gas plant. The pastoral lands that falls within the study area (Figure 11.1) were considered in this cumulative assessment.

11.3.1.8 Onslow Town

Onslow's population seasonally varies between 600 and 900 people. Local businesses in the town service the construction industry and the retail trade sector. A landfill is sited at the southern edge of town and power for the town is generated by a 1.5 million volt amps (MVA) gas fired plant with a standby 1 MVA diesel generator. Wastewater is treated to a secondary standard and consists of a series of primary and secondary treatment ponds.

Onslow has numerous elements in the physical environment that are used for recreation, including a sporting oval, community garden, Shire Hall, basketball courts and a heritage trail walk around the Old Onslow Townsite heritage area. A 50 m public jetty with fuel facilities is located at Beadon Creek. There are two motels, a hotel and two caravan parks that provide tourist accommodation.

Section 11.5.3 details estimates of cumulative population growth as a result of foreseeable future actions.

11.3.1.9 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 Western Australian Department of Fisheries and include:

- Onslow Prawn Managed Fishery
- Pilbara Managed Trap Fishery
- North Coast Blue Swimmer Fishery
- Pearl Oyster Managed Fishery.

Commercial fishery actions within the local marine area as defined in Chapter 6, *Overview of the Existing Environment* were considered in this cumulative assessment.

11.3.1.10 Recreational Fisheries

Fishing is one of the key recreational activities in Onslow, drawing tourists and contributing to Onslow's identity as a small fishing town. A local charter vessel services the Mackerel Islands Resort on Thevenard and Direction islands offering diving, whale watching and recreational fishing. Charter and tourist boats, usually from Exmouth and Dampier, offer fishing trips and visits to offshore islands including the Montebello Islands.

Beadon Creek has a small boat ramp which services local residents and recreational fishers. Larger vessels can travel to waters around Thevenard, Direction, The Twin, and Ashburton islands. Most recreational fishers target fish for consumption, such as trevally, red emperor and coral trout. Those with smaller boats often travel north and south of Beadon Creek, staying close to the coastline and accessing creek systems. Popular fishing creeks include Second Creek just north of Beadon Creek, Four Mile, Middle and Hooley Creeks, False Entrance and Secret Creek located to the west.

Recreational fishing activities in Onslow also occur from shore. Many locals and tourists fish off the wharf and groyne at Beadon Creek, and also at Four Mile Creek, located about eight km west of the townsite and accessible via a paved road. Further information can be found in Section 6.5.3.1.

11.3.2 Discounted Actions

11.3.2.1 Ashburton North SIA Future Development

The DSD has allocated an area in the Ashburton North SIA for future development. This could be an area where additional industries processing or using gas may be located. To date, none have been proposed therefore it is not possible to reasonably foresee development in this part of the Ashburton North SIA.

This cumulative impacts assessment will not address potential indirect growth in Onslow from economic development at the Ashburton North SIA. No actions have been referred and potential new business or industrial activity is highly speculative at this time.

11.3.2.2 Third Party Gas

At this stage, additional gas fields that may supply the Ashburton North SIA have not been referred to the State or Commonwealth and therefore the size and nature of development cannot reasonably be foreseen. These potential developments have been excluded from consideration and the offshore components of these projects will be subject to environmental assessment upon referral.

11.3.2.3 Existing Offshore Discoveries

A number of offshore discoveries exist off the Pilbara coast. To date, no referrals have been submitted for production. As a result, no information has entered the public realm and these discoveries were not included in this cumulative assessment.

11.4 Matters of National Environmental Significance

Careful consideration of species categorised as matters of NES, as defined in Section 6.4.10.1, is included in this cumulative assessment and discussed in Section 11.5.1.3 and Section 11.5.2.4.

11.5 Impact Assessment and Mitigation

The following environmental factors have been assessed for cumulative impacts as a result of the Project and other actions as described above.

11.5.1 Marine Factors

11.5.1.1 Marine Water and Sediment Quality

Potential risks to marine water and sediment quality from the Project are assessed in Section 8.2 and the residual additive risk for all aspects assessed as High. Potential cumulative impacts may result when aspects from other actions are added, including discharges from onshore operations, discharge and waste from offshore operations (including vessels) and downstream construction activities. At the time of preparation of this EIS/ERMP, no significant developments were planned along the coastline, making cumulative impacts from construction activities unlikely. For example, Scarborough is expected to use existing coastal infrastructure such as the Materials Offloading Facility (MOF). Other than the Project, no future actions are predicted to require dredging as the shipping channel is designated a common user facility (refer to Chapter 8, *Marine Risk Assessment and Management* for details).

Dredging activities have taken place previously through the development of Onslow Salt.

The proposed gas industry actions are anticipated to have marine discharges from their construction and commissioning that will be smaller than the Project. Any discharges from Scarborough are speculative at this time and are assumed to occur approximately 300 km offshore, although they may be received by the nearshore environment. Commissioning water from Macedon may be disposed into the offshore marine environment. Macedon is estimated to add an additional two per cent increase in marine outfall and an additional 13 per cent increase in sanitary outfall above Project levels. The discharges are spatially and/or temporally separated from the Project and will have a limited duration.

The existing Onslow waste water treatment plant (WWTP) has a capacity for 1000 people, which is adequate for the current population with a typical requirement of 200 litres pp/day. A large increase in population would necessitate an expansion of the existing plant or construction of a new plant. In this instance, treated wastewater may be discharged into the marine environment, although no details are available and this is not the current discharge point. Routine discharges may occur from proposed actions in the Ashburton North SIA, including reverse osmosis brine and treated wastewater. The extent of future wastewater discharges from Scarborough is largely unknown, although waste water may be discharged into the marine environment. Discharges of bitterns occur from Onslow Salt and are managed to reduce potential environmental impacts to the marine environment.

Storm water from the Ashburton North SIA and its surrounds may also be discharged into the marine environment, which may result in increased turbidity from sediment discharge, including from increased surface water run-off. It is expected that future proposals would utilise common user facilities, which reduces surface area where run-off may take place. There is potential for leaks and spills occurring during storage and handling of hydrocarbons, wastes and other hazardous materials during construction, operations and decommissioning of the Project and future actions. They may occur in nearshore and offshore marine environments. Chapter 8, *Marine Risk Assessment and Management* outlines the likelihood and consequence of potential impacts from leaks and spills from the Project, including controlling processes and contingency measures that will be in place to reduce potential impacts to the marine environment in the event of a large or small spill. It is expected that future actions would adopt a similar approach and would be required to demonstrate their environmental and safety systems and practices to prevent and mitigate any leak and spill incident.

There is also the potential for leaks and spills from increased ship movements. There will be additional shipping movements associated with Scarborough and, to a far lesser extent, the construction phase of Macedon. Most movements will be restricted to normal shipping pathways (i.e. the shipping channel) and ballast discharges will also be subject to Australian Quarantine and Inspection Service regulation. Other existing and potentially new traffic in the area would include recreational and commercial vessels including fishing boats. It is not possible to quantify how much additional recreational boat traffic would occur as a result of an influx of workers associated with future developments at the Ashburton North SIA. However, any leaks or spills from these vessels would be limited in extent as recreational vessels are small and only carry limited quantities of fuel. In addition, potential small spills would be short lived and would not likely be entrained in sediment.

Significant cumulative impacts to marine water and sediment quality are not predicted. This is largely due to the nature of discharges as described above and the incorporation of mitigation measures through the approvals process. With appropriate controls in place, the impacts to the receiving environment can be managed.

11.5.1.2 Benthic Primary Producer Habitat

Potential risks to benthic primary producer habitat (BPPH) from the Project are assessed in Section 8.3 and the residual additive risk for all aspects assessed as High. Potential cumulative impacts may result when aspects from other actions are added, including dredging, discharges from onshore operations, discharge and waste from offshore operations, and onshore and offshore construction activities.

Offshore cumulative impacts are primarily related to changes in benthic habitat due to offshore production facilities and well head installation layouts, release of drill cuttings, and discharges including drill mud, sludge and sand. Environmental impacts associated with the discharges are likely to include localised short term smothering of benthic communities and alteration of sediment particle size. However, this will occur in deep waters where BPPH is sparsely distributed. Given the location and localised zone of influence of discharges and wastes from offshore construction and operations, the expected cumulative impacts are likely to be insignificant.

As noted above, no known actions are planned along the coast that would require additional dredging and no future actions are proposed to be located along the coast. Domestic wastewater from Macedon is likely to be discharged to evaporation ponds, rather than the marine environment, after treatment and commissioning discharges will be in Commonwealth waters. The requirements for Scarborough are unknown. The impact of discharges from the Onslow township on BPPH are uncertain, although thought to be highly unlikely as sewage is currently treated to a secondary standard and evaporated via a WWTP and not discharged to the marine environment. There is a potential for leaks and spills to be discharged into the marine environment, as discussed above, and impact BPPH.

It is not anticipated that increased shipping or other marine traffic would contribute to BPPH cumulative impacts. However, pipelines from the resource fields to the Ashburton North SIA will be required and other pipelines exist in the study area. The Macedon subsea pipeline and umbilical will be approximately 80 km in length and the pipeline from the plant to the DBNGP is likely to be approximately 70 km. The subsea pipeline for Scarborough may be approximately 300 km long.

Significant cumulative impacts to BPPH resulting from the actions included in this assessment are not predicted. This is largely due to the nature of operations and discharges as described above and the incorporation of mitigation measures through the approvals process. The expectation of the EPA's Environmental Assessment Guideline 3 (Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment) is that "*Proponents will need to demonstrate 'best practicable' design, construction methods and environmental management aimed at minimising further damage/loss of BPPH through indirect impacts*". With appropriate controls in place, the impacts to the receiving environment can be managed.

11.5.1.3 Marine Fauna

Potential risks to marine fauna from the Project are assessed in Section 8.4 and the residual risk for additive effects assessed as Medium. Potential cumulative impacts may arise when aspects from other actions are added including physical interaction (vessel movements, recreational fishing, access to offshore islands), indirectly through loss of critical habitats, accidental or non-routine discharges (i.e. leaks and spills), noise and light emissions.

Marine noise generated by construction activities and vessel movements has the potential to disrupt the migratory behaviour of marine fauna, limited to localised displacement of a very small proportion of the migrating populations. This will occur mainly during the construction phases of the proposed actions. The Scarborough and Macedon onshore facilities are to be located away from the coastline at the Ashburton North SIA adjacent to the proposed Project facilities therefore reducing the requirement for further high decibel nearshore marine noise activities such as piling. However, this will not affect the success of the migrations and marine fauna temporarily displaced are predicted to resume normal behaviours during the operational phases when activity and noise emissions are lower.

Turtle nesting of a medium density occurs approximately 4 km from the Project site at Ashburton River Delta and further afield (refer to Figure 6.39). Light spill modelling has determined light emissions from the proposed Project facilities and flare present a Low risk of potential impact to nesting turtles and hatchlings (Section 8.4.5). The proposed Scarborough and Macedon facilities at the Ashburton North SIA will create light emissions that cumulatively could increase the risk of potential impact. However, the distance from the shoreline of these actions will greatly reduce this increase. Additionally, the dune system on the Ashburton River Delta beach reaches up to 10 m which will shield a large section of the nesting beach from illumination. It is thought that the light emissions from Onslow town have not greatly impacted marine fauna due to their limited nature, although no studies have been conducted to date to confirm this.

Non-routine discharges (i.e. leaks and spills) may result during construction, operations and decommissioning of the Project and other considered actions. Leaks and spills could potentially impact fauna through direct contact (smothering, oiling) and subsequent toxic effects, or indirectly through loss or damage to habitat. As discussed above, the Project and future actions are required to incorporate controlling processes and contingency measures to prevent and mitigate any leak and spill incident.

Indirect impacts to marine fauna through changes in habitat are unlikely in both the nearshore and offshore marine areas of the proposed actions. There are no critical habitats for marine fauna identified within the Project's proposed dredge or disposal areas and other actions considered are not likely to pose a potential risk to critical habitats from their activities.

Vessel traffic may cause physical impacts to protected marine megafauna through vessel strike. Marine megafauna recorded in the Project area include Humpback Whales, Dugongs and turtles, which are vulnerable to being struck by fast moving vessels when travelling or resting at or near the sea surface.

Aerial observations of the nearshore and offshore Project area have recorded southward migrating Humpback Whales (notably cow/calf pairs) occurring an average of approximately 35 km from the coastline. Based on the humpback whale surveys between May and December 2010, approximately five percent of animals come within 10.5 km from the coast (CWR 2010; Appendix O). Vessel activity, particularly relating to construction and recreational activities, will occur mainly in nearshore waters and therefore away from the majority of the humpback population. In addition, the lower speeds that larger vessels travel is not expected to cause significant risk.

Turtles and Dugongs inhabiting the area could be vulnerable to injuries or death from collisions with vessels. However, none of these fauna or their habitats have been found to be restricted to or concentrated within the areas of highest construction vessel activity. During operations of the proposed actions, the vessel departure routes do not intersect any known critical resting, feeding or breeding habitats of these species. Commercial fishing vessels are also not thought to pose a significant threat to turtles or Dugongs due to the low volume of vessels operating in the area where turtles and Dugongs may be concentrated.

Other than the Project, there are no known proposed actions planned in the vicinity of Ashburton North with major infrastructure positioned along the coast (discussed further in Section 11.5.1.4) or dredging activities. Therefore, cumulative impacts to fisheries resulting from changes in coastal processes are not expected.

Fishing has traditionally been part of Onslow's identity, with recreational beach and boat-based fishing undertaken by residents and tourists. Onslow is currently experiencing an increase in recreational fishing activities, particularly during the winter months (peak tourist period). Further increases from workforces of future actions, including the Project, are likely to significantly increase the volume of recreational fishing activities. It is unclear how many of these workforces will engage in these activities, although estimates of potential population growth are provided in Section 11.5.3.

Increased fishing pressure can lead to the depletion of local or regional fish stocks. Disturbance to nesting marine birds and turtles may also occur with increased visitation to offshore islands. This may include migratory birds species categorised as matters of NES. Use of small recreational vessels also poses a serious threat to marine megafauna through risk of vessel strike. A risk is posed to turtles and Dugongs, both of which are considered matters of NES, as these species are present closer to the coast where higher speed recreational vessels tend to operate.

Currently, the number of workers from the Project and other actions who will utilise the area for recreational fishing is unknown and therefore uncertainty exists on the level of potential impact. However, with appropriate controls in place, the impacts to the receiving environment can be managed.

11.5.1.4 Coastal Processes

Potential impacts to coastal processes from the Project are discussed in Section 8.5 and the residual additive risk for all aspects assessed as Medium. Potential cumulative impacts may result when aspects from other actions are added, in this case the presence of coastal and/or nearshore infrastructure.

Alteration of flood water flows has occurred across the saltflats resulting in diversion of the flood waters away from the eastern creeks (Appendix P1). This is potentially a result of modification of the coastal lagoon through the construction of Onslow Salt ponds. It is also possible that this is influenced by natural processes such as different coastal aspect, the underlying geologic framework, changes in entrance configuration or recent flood run-off patterns. In addition, Onslow Town Beach, between Beadon Point and Beadon Creek, has experienced significant change, including response to construction of a rock training wall with accumulation to the south and erosion to the north. A seawall has been constructed adjacent to the town site to limit the potential for storm erosion. This section of coast has been accreting as a whole, and Beadon Creek harbour requires maintenance dredging. The town of Onslow has no additional infrastructure or modifications planned that may influence coastal processes.

Other than the Project, there are no known proposed actions planned in the vicinity of Ashburton North with infrastructure positioned along the coast that may act as principal barriers to longshore sediment transport. For example, Macedon and Scarborough onshore locations are positioned away from the coastline in the Ashburton North SIA and it is unlikely that additional breakwaters or MOF and Product Loading Facility (PLF) access channels will be required. However, additional shore crossings for pipelay have the potential to cause limited impact to coastal processes, although this can be managed through design including subsurface placement. It is also likely that an additional trestle and tanker berth will be required. Whilst this structure may slow sediment transport in its immediate vicinity it will not act as a barrier.

Significant cumulative impacts to coastal processes are not predicted. This is largely due to the absence of proposed coastal infrastructure that may act as a principal barrier to longshore sediment transport other than that associated with the Project. With appropriate controls in place, the impacts to the receiving environment can be managed.

11.5.2 Terrestrial Factors

11.5.2.1 Soils and Landforms

Potential risks to soils and landforms from the Project are discussed in Section 9.2 and residual additive risk for all aspects was assessed as Low. Potential cumulative impacts may result when aspects from other actions are added, including clearing, earthworks, and leaks and spills

A total of 3100 ha may be filled and/or cleared for the Project, Macedon and Scarborough within the Ashburton North SIA. This may affect soil quality through the excavation of potential acid sulfate soils (PASS). The PASS risk map developed for the Project (Chapter 9, *Terrestrial Risk Assessment and Management*) shows that the risk of encountering PASS decreases further from the coast therefore reducing the potential for impacts from PASS. However, shore crossings such as trenching and the excavation of borrow areas could potentially disturb PASS and may be managed through incorporation of appropriate mitigation measures developed through the approvals process if necessary. No landforms of significance have been recognised in studies, which encompassed the Ashburton North SIA area.

It is not anticipated that additional dredging will be required and therefore no cumulative impacts are anticipated from the onshore placement of dredge material from other actions. As discussed above, there is potential for leaks and spills occurring during the storage and handling of hydrocarbons, wastes and other hazardous materials during the construction, operations and decommissioning of proposed actions, which are expected to be managed with appropriate mitigation measures and controls.

Therefore, significant cumulative impacts to soils and landforms are not predicted. With appropriate controls in place, the impacts to the receiving environment can be managed.

11.5.2.2 Groundwater

Potential risks to groundwater from the Project are discussed in Section 9.3 and the residual additive risk for all aspects was assessed as Medium. Potential cumulative impacts to the groundwater system may result when aspects from other proposals in the Ashburton North SIA proceed. These aspects include construction and earthworks, presence of infrastructure and spills of hydrocarbons and other hazardous materials.

Changes to landforms such as construction of an elevated pad for processing facilities may alter the local catchments, promote increased recharge and subsequently change the water table elevations. There is potential for such structures to promote mounding of the water table with consequent alteration of both groundwater flow directions and flow velocities. Construction of additional similar structures in the Ashburton North SIA may exacerbate groundwater mounding resulting in the impacts being apparent over a wider area. Details of future actions are not available at this stage however the impacts and management measures are expected to be similar to those described in Chapter 9, *Terrestrial Risk Assessment and Management*. Leaks and spills occurring during storage and handling of hydrocarbons and other chemicals have potential to impact the groundwater system, which can subsequently result in impacts to vegetation and fauna. As discussed above, the Project and future actions are required to incorporate controlling processes and contingency measures to prevent and mitigate any leak and spill incident. Significant cumulative impacts to groundwater are not predicted. Potential changes will be localised and not significant regionally. With appropriate controls in place, the impacts to the receiving environment can be managed.

11.5.2.3 Surface Water

Potential risks to surface water from the Project are assessed in Section 9.4 and the residual additive risk from all aspects was assessed as Medium. Potential cumulative impacts may result when aspects from other actions are added, including construction earthworks, presence of infrastructure and spills of hydrocarbons and other hazardous materials. Other than the Project, no actions are predicted to require dredging as the shipping channel is designated a shared facility. Therefore, no cumulative impacts are predicted from tailwater discharges from dredged material storage other than described in Chapter 9, *Terrestrial Risk Assessment and Management*.

Actions proposed to take place within the Ashburton North SIA will require earthworks during the preparation of sites for construction and installation of infrastructure. Earthworks may alter surface water flows through direct disturbance of natural drainage channels. Surface water quality may also be affected as a result of increased sediment concentrations and sediment loads in run-off entering local watercourses. The change in landform resulting from earthworks required for construction of the three proposed facilities at the Ashburton North SIA has the potential to result in both temporary (construction) and permanent (presence) impacts to surface water movement and quality, with subsequent secondary impacts to flora and fauna and the old Onslow Town Site and Cemetery (discussed below). These are expected to be managed through incorporation of appropriate mitigation measures developed through the approvals process.

Earthworks within the Ashburton North SIA has potential to expose PASS. Oxidation of PASS may result in acidification of soils and water and subsequent mobilisation of metals. The PASS risk map developed for the Project (Chapter 9, *Terrestrial Risk Assessment and Management*) shows that the risk of encountering PASS decreases further from the coast. The potential for PASS to be disturbed during construction of additional facilities is therefore reduced as they will be located inland from the Project facility. Cumulative impacts of acid sulfate soils on surface water are therefore considered unlikely.

Modelling of changes to surface water flows as a result of the presence of infrastructure has been conducted during the Project impact assessment. Chapter 9, *Terrestrial Risk Assessment and Management* provides results of the studies, which show that, provided appropriate surface water management strategies are implemented, significant changes in flood depths, flood elevations, stream flow period, peak flows and stream flow velocity are unlikely to occur. Impacts to the terrestrial and mangrove ecosystems adjacent to the Ashburton North SIA as a result of the presence of the Project infrastructure are therefore not expected.

The greater change in landform due to the development of the three proposed facilities at the Ashburton North SIA has the potential to have cumulative impacts to surface water movement and quality. The obstruction of natural drainage channels is expected to be the more significant potential cumulative impact. Surface water management strategies need to address the potential increase in significance of changes in drainage characteristics of the area. Provided these extended strategies are implemented the potential significance of these impacts can be managed.

Activity in the Ashburton North SIA will increase the potential for leaks and spills of hydrocarbons, wastes and other hazardous materials during storage, transport and transfer of products. Spills of these substances may enter surface water, with transport to local watercourses and marine receiving environments, such as mangrove habitats. As discussed above, the Project and future actions are required to incorporate controlling processes and contingency measures to prevent and mitigate any leak and spill incident.

Significant cumulative impacts to surface water are not predicted. This is largely due to the limited duration of construction phases and the incorporation of mitigation measures through the approvals process, which should include consideration of potential impacts resulting from the presence of infrastructure. With appropriate controls in place, impacts to the receiving environment will be on a local scale and can be managed.

11.5.2.4 Terrestrial Flora and Vegetation

Potential risks to terrestrial flora and vegetation from the Project are assessed in Section 9.5 and the residual additive risk for all aspects was assessed as Medium. Potential cumulative impacts may result when aspects from other actions are added, including vegetation clearing, alteration of surface water flow, dust deposition, noise and leaks and spills.

Flora and vegetation surveys have been conducted across an area which incorporates the Ashburton North SIA, as described in Chapter 6, *Overview of Existing Environment*. The studies showed that generally the vegetation is in good to excellent condition. However, there has been considerable disturbance in some areas as a result of extensive pastoral and recreational activity and introduced weeds are prevalent in some areas. Several species of flora considered to be threatened are found in the area. It was concluded that flora in the Ashburton North SIA are generally considered to be widespread and well represented in the local area, if not the region.

Approximately 3100 ha of native vegetation is proposed to be cleared in order to facilitate the construction of the onshore Project infrastructure, and approximately 150 ha and 730 ha respectively for Macedon and Scarborough (Biota 2006a). It is likely that management measures similar to those associated with clearing of land for the Project (discussed in Chapter 9, *Terrestrial Risk Assessment and Management*) will be implemented for all future proposals to manage potential impacts to conservation significant flora and vegetation.

Actions requiring Earthworks may have adverse impacts to adjacent flora and vegetation through:

- The introduction and/or spread of introduced flora
- Dust generation
- Changes to topography causing changes in tidal inundation and surface drainage patterns
- Exposure of PASS.

Localised impacts to flora and vegetation may occur from increased vehicle usage as a result of additional development within the Ashburton North SIA and the surrounding area. Existing vehicle usage from the Onslow town may also impact on the flora and vegetation, as off-road vehicle driving can cause erosion and unauthorised clearing of vegetation.

Dust deposition on vegetation is likely to be increased as a result of the combined activities in the Ashburton North SIA. It is anticipated that dust generation will be at its greatest during vegetation clearing and earthworks associated with the Project and future actions, but may also occur due to vehicle movements. It is expected that any impacts will mainly occur to vegetation adjacent to haul roads. Should construction periods occur concurrently then maximum dust levels will be elevated above the level of a single action alone. Subsequent construction periods will result in lesser maximum dust levels, although the period of potential impact will be extended.

Native vegetation can be adversely affected by exposure to oxides of nitrogen (NO_x – the collective term for nitric oxide [NO], NO_2 and nitrous oxide [N_2O]) and ozone (O_3), which can cause retarded growth rates and damage to leaf surfaces. It is anticipated that atmospheric pollutants from the Project are likely to come from the LNG and domgas plant and are expected to contribute to a relatively small increase in predicted ground-level concentrations of O_3, NO_2 and particulate matter. The air pollution cumulative impacts from the Project and future actions in the Ashburton North SIA can be mitigated by adopting the management controls and mitigation measures, such as those presented in Chapter 9, *Terrestrial Risk Assessment and Management*.

Diversion of natural surface water drainage lines will be required to develop the actions in the Ashburton North SIA and its surrounds to prevent impacts such as waterlogging. It is reasonable to assume that future proposals will mitigate the impacts associated with the alteration of surface water movement, using techniques such as utilising potential barriers such as roads and pipelines.

There is potential for leaks and spills occurring during storage and handling of hydrocarbons, wastes and other hazardous materials during construction, operations and decommissioning of the Project and future actions. Spills of these substances may impact flora and vegetation. As discussed above, the Project and future actions are required to incorporate controlling processes and contingency measures to prevent and mitigate any leak and spill incident.

Increased vehicle and machinery use, and activity of personnel in and around the Ashburton North SIA will increase the risk of fire. Conversely, there may be a reduction in the severity or duration of naturally occurring fires due to implementation of controls to manage potential fires adjacent to the Actions. This may potentially impact on the fuel load available and therefore future fire intensities and seed store/vegetation recovery adjacent to the various actions in the area. It is reasonable to assume that future actions will be required to adhere to management measures similar to those described for the Project to mitigate potential impacts from fire.

One threatened flora species—the Dwarf Desert Spike-rush (*Eleocharis papillosa*), listed as Vulnerable under the EPBC Act (Cth)—was recorded from a single location within a creek line habitat within the northern section of the domgas pipeline corridor during Project surveys. There is potential for the species to be present within the footprint of the proposed actions in the Ashburton North SIA, particularly within the creek line habitat. It is expected pre-clearance surveys would identify protected species if present and appropriate mitigation measures incorporated through the approvals process. Given the widespread distribution of *E. papillosa* (refer to Chapter 6, *Overview of Existing Environment*), it is considered highly unlikely that the Project and future actions will affect its conservation status.

Significant cumulative impacts to terrestrial flora and vegetation are not predicted. This is largely due to the incorporation of mitigation measures through the approvals process. With appropriate controls in place, the impacts to the receiving environment can be managed.

11.5.2.5 Terrestrial Fauna

Potential risks to terrestrial fauna from the Project are assessed in Section 9.6 and the residual additive risk for all aspects assessed as Low. Potential cumulative impacts may result when aspects from other actions are added, including vegetation clearing, earthworks, noise and light emissions.

Clearing of vegetation is likely to be the main impact on conservation-significant fauna and other local fauna species due to loss of habitat. The wider region contains suitable habitat for the conservation-significant fauna found in the study area (Biota 2009a) which will allow these species to relocate during the initial disturbance within the Ashburton North SIA.

Vehicle and machinery activity associated with existing and future actions has potential to impact terrestrial fauna through direct interaction with road traffic (road kills) and earthworks traffic and machinery. Indirect impacts may occur through introduction or spread of pest species. Increased vehicle, machinery and activity of personnel in and around the Ashburton North SIA area will increase the risk of fire during earthworks and construction, which could impact fauna directly though injury or death, or indirectly through loss of habitat. Conversely, a reduction in the severity or duration of naturally occurring fires is likely as fires may be prevented or rapidly extinguished.

Noise emissions from the construction and operation of facilities in the Ashburton North SIA will produce noise that may cause temporary, localised behavioural changes to terrestrial fauna. Fauna may move away initially but are then expected to come back to the area as they habituate, particularly during the operations phase when noise emissions are lower. Additionally, noise is expected to increase as a result of increased population and human activity in the area both from the industrial and urban areas. This is not expected to have a significant detrimental effect on fauna.

Leaks and spills occurring during storage and handling of hydrocarbons and other chemicals have potential to impact the groundwater system, which can subsequently result in impacts to vegetation and fauna. Leaks and spills could potentially impact fauna through direct contact and subsequent toxic effects, or indirectly impact fauna through loss or damage to fauna habitat. As discussed above, the Project and future actions are required to incorporate controlling processes and contingency measures to prevent and mitigate any leak and spill incident.

Light emissions from the Project, future actions and Onslow town may cause behavioural changes in localised terrestrial fauna populations. Management measures for the Project include reduction of lighting and light spill wherever practicable and safe to do so. It is considered likely that future actions in the Ashburton North SIA will adopt similar controls.

Waste materials including scrap metal, tyres, hydrocarbons, domestic wastes and processing wastes will be generated by proposed actions in the Ashburton SIA. Waste storage and disposal facilities have potential to impact on terrestrial fauna in several ways due to the attraction of fauna to these facilities and associated behavioural changes. Chapter 9 describes the waste management actions which will be implemented during the Project to reduce native and introduced fauna access to waste storage areas and thereby reduce impacts on native fauna. It is expected that future actions in the Ashburton North SIA will adopt similar measures.

Construction of the infrastructure associated with the future actions will involve changes to the ground levels and may impact and modify the surface water flow, quantity and quality of the catchments. These changes may subsequently impact on fauna and fauna habitat due to changes in vegetation community composition and the drying out or inundation of different areas. It is considered that the impacts to fauna for the Project can be appropriately managed through measures including designing the facility to retain natural drainage features where practicable and the use of shared access roads and infrastructure corridor, as detailed in Chapter 9, *Terrestrial Risk Assessment and Management*. Future actions in the area are expected to also implement appropriate measures.

Significant cumulative impacts to terrestrial fauna are not predicted. This is largely due to the incorporation of mitigation measures through the approvals process. With appropriate controls in place, the impacts to the receiving environment can be managed.

11.5.2.6 Subterranean Fauna

Potential risks to subterranean fauna from the Project are assessed in Section 9.7 and the residual additive risk for all aspects was assessed as Very Low. No troglobitic fauna were recovered from the Project area. Two stygofauna taxa were collected but both species were considered to be widespread. Potential cumulative impacts may result when aspects from other actions are added, including earthworks, leaks and spills and presence of infrastructure.

Studies have shown that it is unlikely that the diversity, geographic distribution and conservation status of stygofauna in and around the region will be significantly affected by the Project or any future actions in the Ashburton North SIA (Biota 2009b).

Assuming that the wider area is similar in nature to the study area, significant cumulative impacts to subterranean fauna should not occur for any actions undertaken by future proposals. Similarly, existing infrastructure and activities associated with the town of Onslow and Onslow Salt are unlikely to contribute significantly to cumulative impacts to subterranean fauna.

11.5.2.7 Air Quality

Potential risks to air quality from the Project are assessed in Section 9.8 and the residual additive risk for all aspects was assessed as Low. Potential cumulative impacts may result when aspects from other actions are added, including dust generation and atmospheric emissions.

Dust generation will be a significant impact during site clearing and construction of the Project and the proposed actions in the Ashburton North SIA. It is not expected that these activities will occur in parallel, although there may be some overlap between the construction phases of Macedon and the Project. Dust generation may occur during onshore placement of dredge material and the importation and placement of large quantities of fill. However, following construction significant dust generation is unlikely.

Significant airborne dust can be expected to arise at wind speeds above eight m/s. This happens when vegetation is removed from loose soil and stockpiles of dry material are established. Traffic movements over bare surfaces and the transport and deposition of dust generating material, including fill, can exacerbate this problem unless properly controlled. Cumulative impacts may occur sequentially as each site is constructed. Appropriate mitigation, as detailed in Chapter 9, *Terrestrial Risk Assessment and Management* can significantly reduce dust impacts.

Significant cumulative impacts to air quality are not predicted. SKM (2009b) conducted dispersion modelling to provide an indication of potential cumulative air quality impacts from the Ashburton North SIA, assuming an additional gas processing facility and a domgas plant located adjacent and to the south of the Project. (The potential emissions from the proposed Scarborough facility have been taken as similar to that of the fifth train; the potential emissions from the Macedon facility were assumed to be similar to that used in the air quality assessment of the proposed Apache Energy Domgas facility at Devil Creek - refer to Appendix C1 for further details). The atmospheric pollutants of most likely significance include oxides of nitrogen, ozone (as a secondary pollutant) and airborne particulate matter. The results indicate a slight increase in all modelled pollutants, although predicted concentrations of these pollutants are well within the applicable National Environment Protection Measure (NEPM) criteria. Section 9.8.8 and Appendix C1 contain further details.

It should be noted that particulate concentrations have the potential to exceed NEPM guideline values during periods of significant regional bushfires, followed by dust-storm events caused by erosion of the desiccated local soils. This scenario may arise independently of the Project's development in the area. Chevron is currently undertaking a monitoring study of baseline (existing) conditions for dust (Total Suspended Particulates and PM_{10}), NO_2, SO_2 and Volatile Organic Compounds (VOCs). Chevron has also installed a meteorological station at the plant site to obtain site-specific data. It is proposed that this monitoring is continued through to the commencement of plant operations, although the existing equipment and monitoring locations may alter due to technical and construction requirements.

11.5.3 Social Factors

Potential cumulative impacts on the social environment may result from future project activities or from population growth and its subsequent human activity in the local area. An estimate of cumulative population growth as a result of foreseeable future actions is presented in Table 11.2. The total peak workforce is an upper case scenario based on the projects being constructed concurrently. Sequential construction would reduce the peak numbers, but extend the presence of the workforce over a longer period of time. Table 11.2 also provides estimates of population change if future actions choose to have a proportion of their operations workforce based in Onslow. This highlights that there could be an additional 421 to 1684 people living in Onslow. However the most likely scenario will be at the lower end of the range. It should be noted that additional population growth may occur as a consequence of economic activity in the area.

11.5.3.1 European and Aboriginal Cultural Heritage

Potential risks to European cultural heritage from the Project are assessed in Section 10.2. However, as discussed in Chapter 10, *Social Risk Assessment and Management*, this factor has not been risked due to advice from the Heritage Council of Western Australia (HCWA). Potential cumulative impacts may result when aspects from other actions are added, namely construction earthworks for the preparation of sites for construction and installation of infrastructure. It is expected the Project will have the greatest impact on European cultural heritage due to the extensive site preparation works that will be required; Ashburton North SIA actions should have a lesser impact.

No future actions will undertake ground disturbance work in the Old Onslow Townsite or Old Onslow cemetery, which are the areas of most significant heritage value. However, the change in landform and physical presence of the three proposed facilities at Ashburton North SIA has the potential to increase the risk of flooding of part of the Old Onslow Townsite through obstruction of existing drainage channels and reduction of catchment storage in the catchment east of the Old Onslow road. This may increase the flood risk of the south-eastern part of the Old Onslow Townsite during extreme flood events, although it is not expected to impact the flood risk from the Ashburton River directly.
The Old Onslow Cemetery is located on an elevated dune area, reducing the flood risk of the cemetery to be less than that of the low lying areas of the Old Onslow Townsite. Impacts from all actions must be managed in accordance with guidance from the Heritage Council of Western Australia (HCWA) and the Office of Heritage. It is reasonable to assume that HCWA will consider cumulative

Table 11.2: Estimated Population Growth from Key Additional Actions

	Projected Approximate Cumulative Workforce Impacts			
	Wheatstone Project	Scarborough	Macedon	Total (Peak workforces coinciding)
Construction Workforce	3000 (expected) (maximum 5000)	2400	-	5400
Operations Workforce	300 (expected) (maximum 400)	125	10-15	440
Family level impacts (Assumes household size of 3.3 persons)				
100% Residential Operations Workforce	990	413	50	1453
75% Residential Operations Workforce	743	309	37	1089
50% Residential Operations Workforce	495	206	25	726
25% Residential Operations Workforce	248	103	12	363

impacts when assessing future proposals and provide appropriate direction to proponents on the management of those impacts.

Potential risks to Aboriginal cultural heritage from the Project are assessed in Section 10.3. However, as discussed in Chapter 10, *Social Risk Assessment and Management*, this factor has not been risked due to advice from key local Aboriginal stakeholders.

Some Aboriginal cultural heritage sites will be affected during the life of the Project. Potential cumulative impacts may result when aspects from other actions are added, namely construction earthworks for the preparation of sites for construction and installation of infrastructure and due to potential surface water impacts as detailed above. It is expected that future actions would encounter archaeological and ethnographic sites similar to those located in the Project area. This includes shell scatters, shell middens, evidence of grinding activities and artefacts. There is a low probability of encountering ethnographic sites. It is expected all potential impacts to Aboriginal cultural heritage will be managed in accordance with Section 18 notices of the *Aboriginal Heritage Act 1972* (AH Act [WA]). Chevron utilises a Cultural Heritage Management Plan to guide its management of impacts to Aboriginal cultural heritage, and it is likely that future proponents will develop similar plans. The most important historical Aboriginal habitation sites are located further to the south-west of the locations identified for the proposed actions on the opposite side of the Ashburton River. These sites for Aboriginal cultural heritage are located away from the Ashburton North SIA and are therefore unlikely to be impacted.

It is possible that an increased population as a result of future actions may impact on both European and Aboriginal cultural heritage sites outside of the Ashburton North SIA. For example, this could occur through human activities such as four wheel driving if heritage sites are not clearly demarcated, or through fossicking for artefacts. It is reasonable to assume that Chevron and future proponents will evaluate investment in the protection and enhancement of cultural heritage as part of their social investment strategies to mitigate potential cumulative impacts.

Significant cumulative impacts to European and Aboriginal Cultural Heritage are not predicted. This is largely due to the incorporation of mitigation measures through the approvals process and through guidance from relevant Government agencies such as the Office of Heritage, HCWA and the Department for Indigenous Affairs. It is expected that all future actions will utilise a CHMP to guide the management of impacts to Aboriginal heritage and will adhere to requirements under the AH Act (WA). Furthermore, management of impacts to European heritage should comply with relevant heritage legislation. It is likely future actions will proceed in a similar manner. With appropriate controls in place, the impacts to the receiving environment can be managed.

11.5.3.2 Local Fishing and Pearling

Potential risks to local fishing and pearling from the Project are assessed in Section 10.4 and the residual additive risk for all aspects was assessed as Medium. Potential cumulative impacts may result when aspects from other actions are added, including coastal development, increases in recreational fishing activities and the creation of exclusion zones around marine infrastructure.

As discussed in Section 11.5.1.4, no significant developments are planned along the coastline and hence there should be minimal cumulative impacts from coastal development other than of the Project. Exclusion from existing fishing grounds may occur where marine infrastructure from future actions, such as pipelines, is placed; this may result in the loss of a small proportion of the available commercial and recreational fishing areas in the region. The effect should be localised and it is expected that the proponent of future actions would liaise with owners of commercial fishing licenses to manage any impacts identified.

The main drivers for assessing the additive risk to local fishing and pearling as Medium relates to the potential for recreational fishing by the Project workforce and permanent loss of access to Hooley Creek. Population growth as a result of future actions will increase the level of recreational fishing in the area further. The magnitude of these potential cumulative impacts cannot be reliably predicted using information presently available.

11.5.3.3 Disturbance to Other Recreational Use

Potential disturbance to other recreational use from the Project is assessed in Section 10.5 and the residual additive risk for all aspects was assessed as Medium.

It is possible that an increased population as a result of future actions will result in an increased level of recreational use in the area, which in turn may affect the quality of recreation experience for existing and planned recreational uses. It is likely that Chevron and future proponents will evaluate investment in recreation activities and facilities for the general community as part of their social investment strategies to mitigate the cumulative impacts on recreational use. With appropriate controls in place, the impacts to the receiving environment can be managed.

11.5.3.4 Public Amenity

Potential risks to public amenity from the Project are assessed in Section 10.6 and the residual additive risk for all aspects was assessed as Low. Potential cumulative impacts may result when aspects from other actions are added, namely construction earthworks, dust generation, atmospheric emissions, light emissions, noise emissions and visual impacts.

It is expected there will be cumulative impacts on public amenity due to the scale of the North Ashburton SIA and the length of time during which activities will occur. Cumulative impacts may occur sequentially as each site is constructed, or in the case of visual impact, the cumulative impact will increase with the addition of each future project.

It is considered likely that future actions in the Ashburton North SIA will adopt similar management practices to meet EPA guidelines and legislative requirements for emissions, and manage potential cumulative impacts to public amenity. The most likely negative cumulative impact will be the potential for prolonged noise emissions, particularly if spread over an extended period of time. With appropriate controls in place, the impacts to the receiving environment can be managed.

11.5.3.5 Health and Well-Being

Potential risks from mosquito-borne disease, traffic and upset conditions associated with the Project are assessed in Section 10.7. However as discussed in Chapter 10, *Social Risk Assessment and Management* this factor has not been risked due to new risking guidance being developed by the Western Australian Department of Health (DoH).

Potential cumulative impacts for mosquito-borne disease may result when aspects from other actions are added, namely construction earthworks and the physical presence of infrastructure. It is possible that future actions may create additional mosquito breeding grounds. However the Ashburton North SIA is situated in an environment that is already seasonally flooded and is naturally a habitat that supports mosquitoes. It is possible that more people in the area could facilitate the spread of mosquito-borne disease. Chevron will comply with the requirements of DoH's Mosquito Management Manual and EPA Guidance Statement No. 40 (EPA 2000d), and it is expected future actions will also meet these standards to reduce the risk of mosquito-borne disease.

Potential cumulative impacts for public risk from traffic may result when aspects from other actions are added, namely construction activities and the physical presence of infrastructure. It is assumed there will be an increase in motor vehicle traffic in and around the Ashburton North SIA for each future project, and depending on whether these activities coincide with other actions there may be an increase in public risk from traffic. At this stage, there is not enough information available to evaluate the extent of that risk because transportation logistics have yet to be developed for any project. However, every future project is likely to have a traffic management plan which can be used to manage public risk.

The other potential cumulative impact is additional traffic as a consequence of population growth. It is possible that upgrades to some roads in the local area will be required to allow road standards to safely accommodate the additional traffic flow. It is likely that Chevron and future proponents will evaluate investment in traffic safety initiatives for the general community as part of their social investment strategies to mitigate potential public risk associated with traffic.

Based on currently available information (refer to Section 10.7.4.2), it was established that the current available capacities of NWCH and Onslow Road are sufficient to accommodate additional traffic associated with the construction phase of the Project without compromising the operating conditions, although if there is an increase in the amount of heavy traffic along Onslow Road then road alterations may be necessary. Potential cumulative impacts for public risk from upset conditions may result when aspects from other actions are added, namely the physical presence of infrastructure. It is assumed that all proponents will need to comply with relevant legislative requirements and EPA Guidance Statement No. 2 - Guidance for Risk Assessment and Management: Offsite Individual Risk from Hazardous Industrial Plant (EPA 2000c) and EPA Guidance Statement No. 3 – Separation Distances Between Industrial and Sensitive Land Uses (EPA 2005a). Therefore, the cumulative impact should be managed.

11.6 Conclusion

This evaluation of potential cumulative impacts has assessed potential impacts via a qualitative approach. It is not a rigorous scientific study due to a lack of publicly available information on proposed actions; it is a high level analysis of potential impacts using professional judgement, underpinned by baseline studies and a range of quantitative impact assessments related to individual aspects and factors related to the proposed Project.

The cumulative impacts arising from the Project and other actions included in this assessment are considered to be either not significant or manageable through the incorporation of appropriate mitigation measures. This includes environmental and social factors, which incorporate the Ashburton delta mangrove system, offshore island ecological communities, significant local coral reef assemblages and airshed quality.

As previously noted, the development of the Project as a 25 MTPA multi-train LNG facility reduces the potential requirement for future expansion of Chevron's gas-processing facilities in the Ashburton SIA. The development of the Project as an LNG hub will lessen the need for future LNG related port developments in the Pilbara. Therefore, the potential for future cumulative impacts not included in this assessment is reduced.

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12.0

Environmental Management Program

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12.1 Introduction

Protecting people and the environment is a core company value for Chevron Corporation. Chevron Corporation's commitment to this value is described in *The Chevron Way (Chevron 2009a)*, which is a publicly available document explaining: who Chevron Corporation is; what Chevron Corporation does; and, what Chevron Corporation plans to accomplish as a global energy company.

The Wheatstone Environmental Management Program has been developed in alignment with *The Chevron Way*, and a key purpose of the Environmental Management Program for the proposed Wheatstone Project (Project) is to identify the range of procedures required to effectively manage potential Project-attributable impacts that have been identified during the impact assessment process.

The Wheatstone Environmental Management Program has been developed to meet both the EPA and Commonwealth (Cth) Department of the Environment, Water, Heritage and the Arts (DEWHA) requirements. While the EIS/ERMP has adopted a risk-based assessment approach consistent with EPA expectations, it has also been developed to ensure alignment with the requirements of the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

This chapter details Chevron Pty Ltd's (Chevron) approach to environmental management including its proposed Outcome-based Conditions and associated proposed Environmental Management Plans (EMPs), which aim to address potential Project-attributable impacts predicted in this Draft Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP).

12.1.1 Wheatstone Approach

Key environmental factors and potential Project-attributable impacts were identified during scoping for the EIS/ERMP. Detailed studies were then undertaken to develop a baseline assessment of the receiving environment and to develop assessment criteria for at risk factors.

General mitigation and management measures were applied to the Project during Front End Engineering and Design (FEED), to ensure that the potential for common and well understood environmental impacts could be reduced or avoided altogether. Applicable regulatory requirements and guidelines were used in the development of these measures. Details of proposed measures are included in Chapter 8, *Marine Risk Assessment and Management*; Chapter 9, *Terrestrial Risk Assessment and Management* and Chapter 10, *Social Risk Assessment and Management*.

After general mitigation and management measures were applied, a risk assessment was completed to develop the EIS/ERMP. The approach used in this assessment was consistent with the Western Australian Environmental Protection Authority's (EPA) risk-based approach to Environmental Impact Assessment (EPA 2009b) and was designed to identify and prioritise Project environmental risks. The risk assessment process resulted in the categorisation of environmental factors into high, medium or low residual risk (i.e. the level of risk existing after general mitigation and management has been taken into consideration).

A set of Proposed Outcome-based Conditions (OBCs) have been developed in accordance with the *Draft EPA Assessment Guideline No. 4* (EPA 2009f), for those factors assessed as either having a high residual risk, or otherwise identified as being of ecological or social significance. The proposed OBCs, as detailed in Section 12.2.2.1, provide guidance and form part of the key objectives of the Environmental Management Program.

EMPs for key aspects of the Project (e.g. dredging) or specific receptors (e.g. marine fauna) have been, or will be, developed. These will detail the key mitigation and management strategies to be employed to address high and medium residual risks and to protect matters of National Environmental Significance (NES), as defined under the EPBC Act (Cth). These EMPs will be submitted along with the EIS/ERMP in support of the Project's Ministerial Approvals applications under the Western Australian *Environmental Protection (EP) Act* and EPBC Act and are herein referred to as Statutory EMPs.

Chevron will produce a number of additional plans in order to satisfy Chevron internal management purposes and/or the requirements of other legislative instruments, such as the Commonwealth *Offshore Petroleum (Greenhouse Gas Storage) Act 2006*. Such plans are included in the set referred to as Subsidiary Plans as they are not considered a requirement under either the Western Australian EP Act or Commonwealth EPBC Act.

Subsidiary Plans will manage environmental risks specifically related to the Project's various works programs. Subsidiary Plans may include detailed operating procedures which provide the workforce with clear guidance, reference material and performance expectations for relevant aspects of the work they undertake.

Subsidiary Plans are discussed further in Section 12.2.2.2.

Standard mitigation and management measures address low risk factors as described throughout the EIS/ERMP. Many of the general measures are likely to be included in the Subsidiary Plans to be developed in parallel to the Ministerial Approvals process.

A schematic of the above process is shown in Figure 12.1.

12.1.2 DEWHA Environmental Management Requirements

The key DEWHA requirement for the EIS/ERMP is that it must include information on specific and detailed mitigation measures, with a focus on matters of NES. The proposed measures must be substantiated, based on best available practices, and must include:

- A consolidated list of mitigation measures proposed to be undertaken to prevent, minimise or compensate for potential Project-attributable impacts on matters of NES (Refer to Chapter 8, *Marine Risk Assessment and Management*, Chapter 9, *Terrestrial Risk Assessment and Management* and Chapter 10, *Social Risk Assessment and Management)*
- An EMP that sets out the framework for management, mitigation and monitoring of relevant Project-attributable impacts. The EMP must address the construction phase of the Project and should include any provisions for independent environmental auditing (refer to Appendices O6, S1, T1, U1).

This chapter, along with the set of EMPs accompanying this EIS/ERMP (listed in Section 12.2.2.2), fulfils these DEWHA requirements.

12.1.3 EPA Environmental Management Requirements

The key EPA requirement for the EIS/ERMP is that Chevron has in place an Environmental Management Program appropriate to the scale and nature of potential Project-attributable impacts associated with the proposal, including provisions for performance review and a commitment to continuous improvement.

The program may be integrated with quality, health and safety systems and should include the following elements:

- Environmental policy and commitment
- Planning of environmental requirements
- Implementation of environmental requirements
- Measurement and evaluation of environmental performance
- Review and improvement of environmental outcomes.

The EPA notes that environmental management programs provide a framework for proposed environmental management measures and suggests these should be developed during the impact assessment to allow the EPA to develop confidence that proposed management measures will protect the environment.

In addition, the EPA supports the use of OBCs, rather than prescriptive conditions where the intended outcome can be clearly defined and measured.

Chevron's adoption of this approach, including the development of Outcome-based Conditions, is described in the following sections of this chapter.

12.1.4 Legislative and Regulatory Controls

Chevron will maintain a register of the principal regulatory requirements directly regulating environmental aspects of the Project. The current legislative summary is included as Appendix A1.

12.1.5 Environmental Objectives

The Project has been developed to align with the set of environmental objectives developed by the EPA. The EPA objectives will be used as a guide for the Project's Environmental Management Program and are described in Table 12.1.

12.2 Wheatstone Environmental Management Program

The Wheatstone Environmental Management Program has been developed on the basis of the above described elements to incorporate each component of the Project. It is structured into three tiers of management which reflects the cascading but interconnected nature of documentation required for Chevron to meet its environmental obligations.

Figure 12.2 illustrates the hierarchy of management in the Wheatstone Environmental Management Program.

Tier 1 of the program comprises Chevron Corporation's Operational Excellence Management System as well as Chevron's Australian Business Unit (ABU) Policy 530 which is central to the implementation of the OEMS in Australia. (Refer Section 12.2.1)

Tier 2 of the Environmental Management Program comprises a set of Outcome-based Conditions and associated Statutory Environmental Management Plans. The list of proposed Statutory EMPs is based on regulatory triggers from the West Australian *Environmental Protection Act 1986* (EP Act), EPBC Act (Cth) or the specific project guidelines that have been approved by the EPA and DEWHA for this Project. (Refer Section 12.2.2).

Tier 3 comprises a set of Subsidiary Plans which are defined as those environmental plans which are required by and/or impose relevant legal obligations on Chevron under

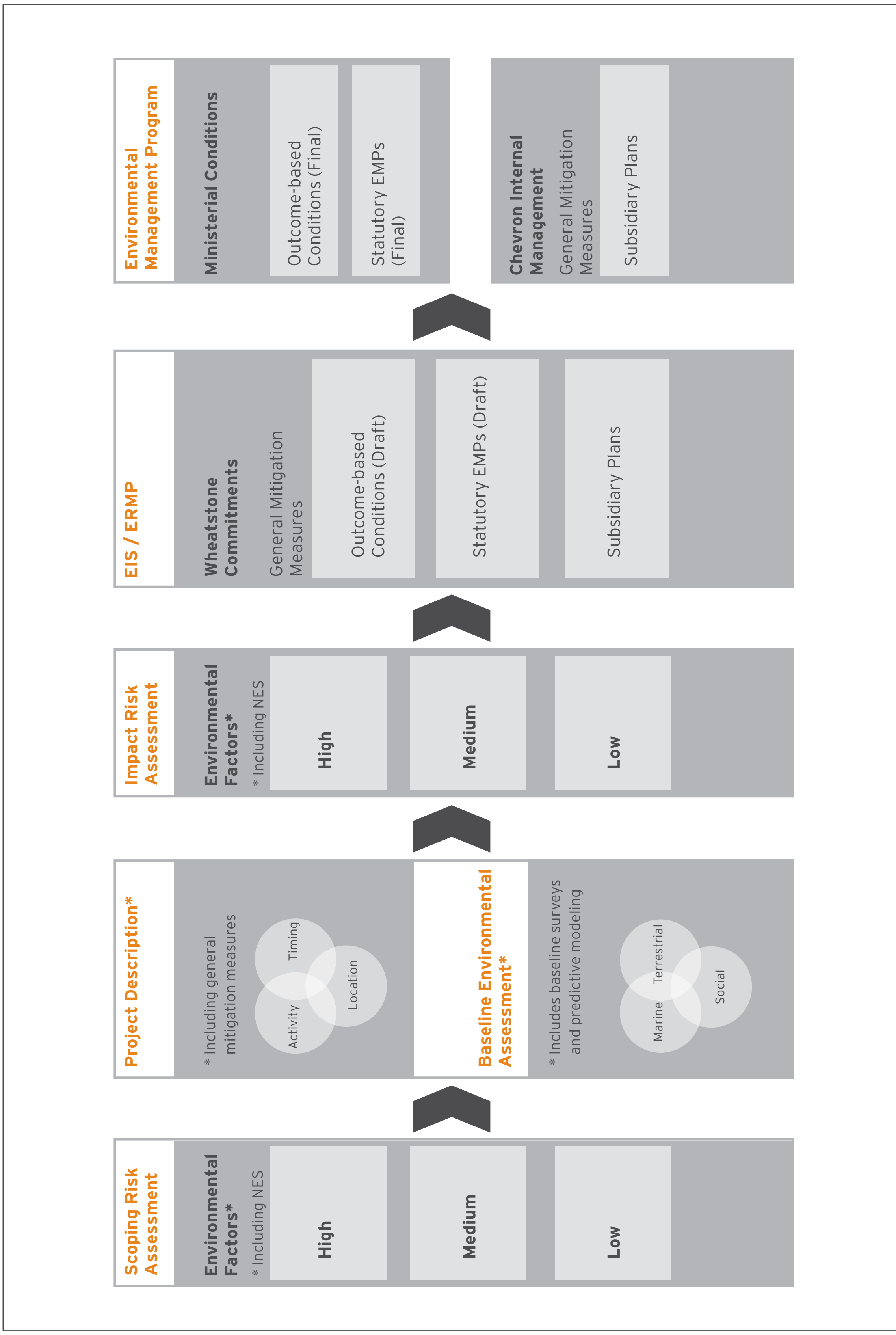

Figure 12.1: Environmental Assessment and Management Process

Table 12.1: EPA Environmental Objectives

Factor		Environmental Objective
Biophysical	Flora	To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.
	Fauna	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.
	Wetlands	To maintain the integrity, ecological functions and environmental values of wetlands.
	Surface and Ground Water (use)	To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected.
	Terrestrial Landforms	To maintain the integrity, ecological functions and environmental values of the soil and landform.
	Coastal Processes and Seabed	To maintain the integrity, ecological functions and environmental values of the seabed and coast.
	Conservation Areas	To protect the environmental values of areas identified as having significant environmental attributes.
Pollution Management	Air Quality	To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.
	Water Quality (surface, marine or ground)	To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.
	Noise	To protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring the noise levels meet statutory requirements and acceptable standards.
	Greenhouse gases	To minimise emissions to levels as low as practicable on an on-going basis and consider offsets to further reduce cumulative emissions.
	Soil Quality	To ensure that rehabilitation achieves an acceptable standard compatible with the intended land use, and consistent with appropriate criteria.
	Radiation	To ensure that radiological impacts to the public and the environment are kept as low as reasonably achievable and comply with acceptable standards.
	Light	To avoid or manage potential impacts from light overspill and comply with acceptable standards.
Social Surrounds	Heritage	To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.
	Risk	To ensure that risk from the proposal is as low as reasonably achievable and complies with acceptable standards and EPA criteria.
	Visual Amenity	To ensure that aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable.
	Recreation	To ensure that existing and planned recreational uses are not compromised.
Other	Decommissioning	To ensure, as far as practicable, that rehabilitation achieves a stable and functioning landform which is consistent with the surrounding landscape and other environmental values.

legislation, but are not legally binding under the Ministerial Approvals of this EIS/ERMP. Management plans which are required for Chevron internal purposes but which are not legally binding in their own right are also included in the list of Subsidiary Plans.

Subsidiary Plans will not be submitted for Ministerial Approval with this EIS/ERMP. (Refer Section 12.2.3).

Key Western Australian and Commonwealth legislation relating to onshore, nearshore (state waters) and offshore (Commonwealth waters) components of the Project have been considered in developing Tier 3 of the Environmental Management Program.

Figure 12.3 Illustrates the set of key environmental documentation which comprise the Wheatstone Environmental Management Program and which Chevron anticipates will be required in order for the Project to meet its principal environmental obligations.

12.2.1 Tier 1 – Chevron Operational Excellence Management System

Tier 1 of the Wheatstone EMS has been designed to facilitate the implementation of Chevron's Operational Excellence Management System (OEMS) and Australian Business Unit (ABU) Policy 530 – Operational Excellence (OE).

In 2008, Chevron received attestation from Lloyd's Register Quality Assurance that OEMS meets all requirements of the International Standards Organisation's Environmental Management Systems Series specification 14001 (ISO 14001).

In addition, the OEMS was confirmed as meeting the requirements of the Occupational Health and Safety Assessment Series management specification 18001 (OHSAS 18001) and as being fully implemented throughout the corporation. These standards are international benchmarks and demonstrate Chevron's commitment to world-class performance.

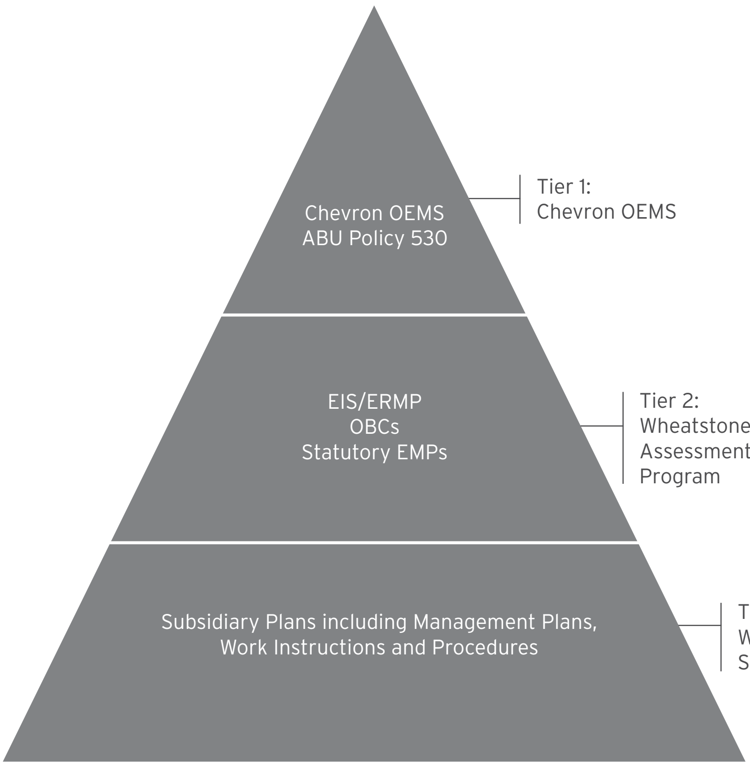

Figure 12.2: Wheatstone Environmental Management Program

Further information on this system is included in Chapter 1, *Introduction*.

12.2.2 Tier 2 - Environmental Management and Assessment Program

Tier 2 of the Environmental Management Program incorporates both the Environmental Impact Assessment (EIA) process for the Project as well as the proposed principal environmental management documents including conditions and environmental management plans.

The EIA component is required in order to meet both Chevron corporate governance and Australian Commonwealth and State Government regulatory requirements. The principal output of this review is the Wheatstone EIS/ERMP (this document).

The other key commitments within Tier 2 are a set of Outcome-based Conditions designed to align with the EPA's guidance statement- *Towards Outcome-based Conditions. Environmental Assessment Guideline No. 4 – Draft. December 2009* (EPA 2009f).

Additionally, a set of EMPs have been developed under this Tier of management which comprise part of the documentation submitted for Ministerial Approvals. Draft versions of these EMPs are included as Appendices to this EIS/ERMP.

12.2.2.1 Outcome-based Conditions

Introduction

In February 2008 the EPA initiated a review of Western Australia's EIA process with the general aim of enhancing the quality, timeliness and certainty of the EPA's advice to Government on development proposals. A key conclusion of the review was to recommend a move towards the use of outcome focused environmental conditions that are clear, relevant, reasonable and auditable (EPA 2009f).

The EPA then released Draft Guidelines in December 2009 to assist proponents in developing OBCs – *Towards Outcome-based Conditions. Environmental Assessment Guideline No. 4 – Draft. December 2009* (EPA 2009f).

	Onshore	Nearshore Western Australian Waters	Offshore Commonwealth Waters
Tier 1	Chevron Australia Operational Excellence Management System		
Tier 2	Outcome-based Conditions		
	Construction Environmental Management Plan	Marine Fauna Management Plan	
		Dredging and Spoil Disposal Management Plan	
		Coastal Process Management Plan	
	Operations Management		
	Decommissioning Management		
Tier 3	Old Onslow Townsite (3444) Development Impact Mitigation Plan	SAP Report & Sea Dumping Permits	Offshore Drilling EPs
	Aboriginal Cultural Heritage Management Plan	Shipping and Navigation	Offshore Installation & Commissioning / Operaions / Decomissioning EPs
	Mosquito Management Plan	Marine Pipeline Installation EMP	Marine Pipeline Installation EP
	Onshore Oil Spill Contingency Plan	Oil Spill Contingency Plans	
	Chevron Internal Management Plans		

Figure 12.3: Wheatstone Environmental Documentation

The EPA's support for the use of OBCs, rather than prescriptive conditions, is constrained to circumstances where the intended outcome can be clearly defined and measured. Prescriptive conditions are still recommended under circumstances where there is uncertainty or it is difficult to predict the environmental outcome.

OBCs are defined in the EPA Guidelines (EPA 2009f) as those conditions that are recommended in an EPA Report or set in a Ministerial Implementation Statement that may impose:

- A specific environmental outcome to be achieved (explicit condition) – for example, the avoidance of particularly significant vegetation or habitat, or the progressive rehabilitation of an area

  or

- An environmental performance standard that is to be met (performance-based condition) – such as standards that set out the limits or criteria (such as an emission limit) but do not describe how such limits or standards will be met.

Further, the EPA recommends conditions must be:

- Reasonably related to the proposal
- For the purposes of achieving the objective of the EP Act (WA) and relevant government policy
- Reasonable
- Final and certain
- Unambiguous and clear
- Placed only on the proponent.

It is important to note the EPA's recommendation that conditions should not be imposed where legislation exists to ensure an outcome, such as requiring approval for the removal of any flora or fauna protected under the *Wildlife Conservation Act 1955*.

The EPA recommended methodology for the development of OBCs follows a four-step process as shown in Figure 12.4.

The key benefit of this approach for external stakeholders is that it provides an upfront commitment by the Proponent with regard to maintaining the receiving environment in a condition that is at or above a predetermined level. It also provides certainty for the Proponent in that the parameters and approach to environmental monitoring programs can be directly linked to an achievable and measurable environmental outcome.

Predicted Environmental Outcomes for the Project are described in detail in Chapter 8, *Marine Risk Assessment and Management*, Chapter 9, *Terrestrial Risk Assessment and Management* and Chapter 10, *Social Risk Assessment and Management*.

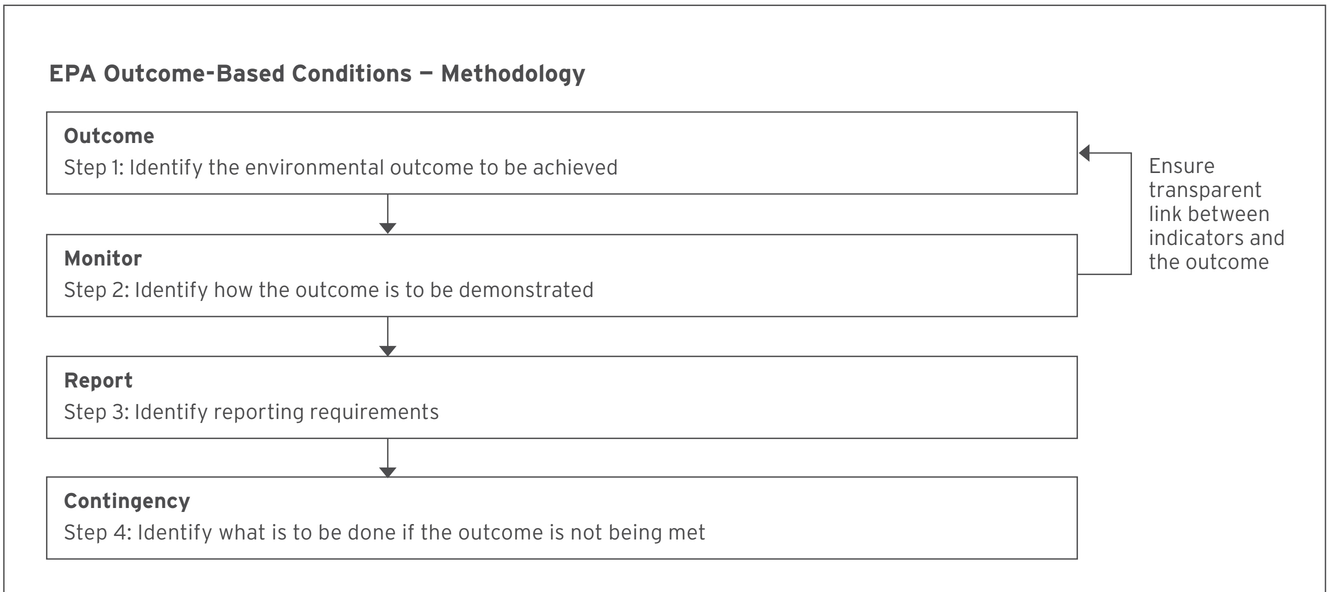

Figure 12.4: EPA Outcome-based Conditions Methodology

Chevron has adopted an approach for developing proposed Outcome-based Conditions for the Project that:

- Is consistent with EPA Guidelines released in December 2009
- Is consistent with the current risk-based assessment trial (and a natural progression from the risk-based assessment approach)
- Provides flexibility in the methodology for achieving the outcomes committed by Chevron (during the finalisation of Project design)
- Creates potential to streamline the approvals timeframe for the Project
- Continues the collaborative approach with State and Commonwealth Governments achieved to date
- Avoids duplication and reduces potential for inconsistencies across multiple documents.

Proposed Outcome-based Conditions

Proposed Outcome-based Conditions have been developed for those factors assessed as either having a high residual risk, or which otherwise have a high conservation value. Matters of NES, where different from WA-defined environmental factors, were also assessed using this approach. Details on the risk assessment methodology used can be found in Chapter 7, *Impact Assessment Methodology*.

To support the achievement of predicted environmental outcomes, each OBC, with the exception of OBC 7: Operational Marine Water and Sediment Quality Management, is linked to an associated Statutory EMP (Refer Section 12.2.2.2), which are proposed for EPA review. Table 12.2 lists the OBCs, and associated EMPs, that are proposed for the Project.

The proposed OBCs have been developed based on the current understanding of relevant environmental factors and proposed mitigation and management measures. As the Project continues to undergo FEED, the set of applicable mitigation and management measures is likely to expand and/or change. As such, it is Chevron's intent to further develop the proposed OBCs as FEED and the regulatory review process for the Project progress. However, Chevron acknowledges that final content for any OBC for the Project will be determined by the WA Minister for the Environment.

Table 12.2: Proposed Outcome-based Conditions

#	Proposed Outcome-based Condition	Proposed Statutory Plan
1	Coastal Processes Management	*Coastal Processes Management Plan*
2	Mangrove and Estuarine Habitat Management	*Construction Environmental Management Plan*
3	Benthic Primary Producer Habitat Management	*Dredge Spoil and Disposal Management Plan*
4	Marine Fauna Management	*Marine Fauna Management Plan & Dredge Spoil and Disposal Management Plan*
5	Terrestrial Flora and Vegetation Management	*Construction Environmental Management Plan*
6	Terrestrial Fauna Management	*Construction Environmental Management Plan*
7	Operational Marine Water and Sediment Quality Management	*N/A*

Table 12.3: Coastal Processes Management

1.	Proposed Outcome-based Condition 1: Coastal Processes Management
1.1	**Element I: Definition of Outcome and Associated Management Plans**
1.1.1	The Proponent will manage its construction and operation activities to reduce, as far as practicable, nearshore infrastructure-attributable impacts on the physical integrity of coastal processes and functionality between Beadon Creek and Entrance Point, as shown in Figure 12.5. This will be achieved by way of managing littoral transport to: • Ensure that the nearshore infrastructure does not result in an erosive shoreline trend under non-cyclonic conditions • Ensure that the nearshore infrastructure does not demonstrably impede post cyclonic shoreline recovery.
1.1.2	The Proponent will manage its construction and operation activities to reduce, as far as practicable, nearshore infrastructure-attributable impacts on the physical integrity and functionality of coastal processes at Hooley Creek, as shown in Figure 12.6. This will be achieved by way of managing littoral transport to: • Ensure that nearshore infrastructure-attributable impacts to tidal exchange in the Hooley Creek system do not cause an erosive or accretive trend, adversely affecting tidal system habitats.
1.1.3	The Proponent will manage its construction and operation activities to reduce, as far as practicable, nearshore infrastructure-attributable impacts on the physical integrity and functionality of coastal processes at the East Ashburton Delta, as shown in Figure 12.7. This will be achieved by way of managing littoral transport to: • Reduce the destabilisation of the chenier that impounds the coastal lagoon, east of Entrance Point.
1.2	**Element II: Monitoring Program**
1.2.1	The Proponent will monitor nearshore infrastructure-attributable changes to the integrity of coastal processes and functionality between Beadon Creek and Entrance Point, as shown in Figure 12.5 by monitoring the following: • Beach width using a combination of topographic surveys and aerial photography/satellite imagery. Beach width will be measured from the water line to the permanent vegetation line at spring high tide.
1.2.2	The Proponent will monitor Nearshore infrastructure-attributable changes to the integrity of coastal processes and functionality at Hooley Creek, as indicated in Figure 12.6 by monitoring the following: • Spit width during spring high tide through a combination of on-ground surveys and aerial photography/satellite imagery.
1.2.3	The Proponent will monitor nearshore infrastructure-attributable changes to the integrity of coastal processes and functionality at the East Ashburton Delta, as indicated in Figure 12.7 by monitoring the following: • Beach profile through the use of on-ground photo capture • Chenier width through the use of topographic survey methods. Chenier width will be measured from internal waterline to external waterline (or permanent vegetation line) at spring high tide.
1.2.4	The Proponent will establish management criteria for the purpose of Condition 1.4.1 prior to the commencement of the monitoring program. The Proponent's monitoring program as described elsewhere in this Condition 1.2 will assess whether those management criteria have been reached.
1.3	**Element III: Monitoring Program Reporting**
1.3.1	The Proponent shall report the results from the Monitoring Program required under Condition 1.2 on an annual basis. (Cont'd)

1.4	**Element IV: Contingency and Management Action**
1.4.1	If the monitoring program in 1.2 shows that the management criteria levels established in Condition 1.2.4 are reached, one or more of the following management responses may be applied: • Increase level of observation and review whether management measures are being implemented • Review effectiveness of management measures and determine alternative or additional practicable management measures • Implement practicable alternative and/or additional management measures.
1.4.2	In the event that the monitoring program in 1.2 shows that the predicted outcomes established in Condition 1.1 are not being achieved: • The Proponent shall report such findings to the Chief Executive Officer of the OEPA within 21 days of receipt of an internal monitoring report confirming such findings.

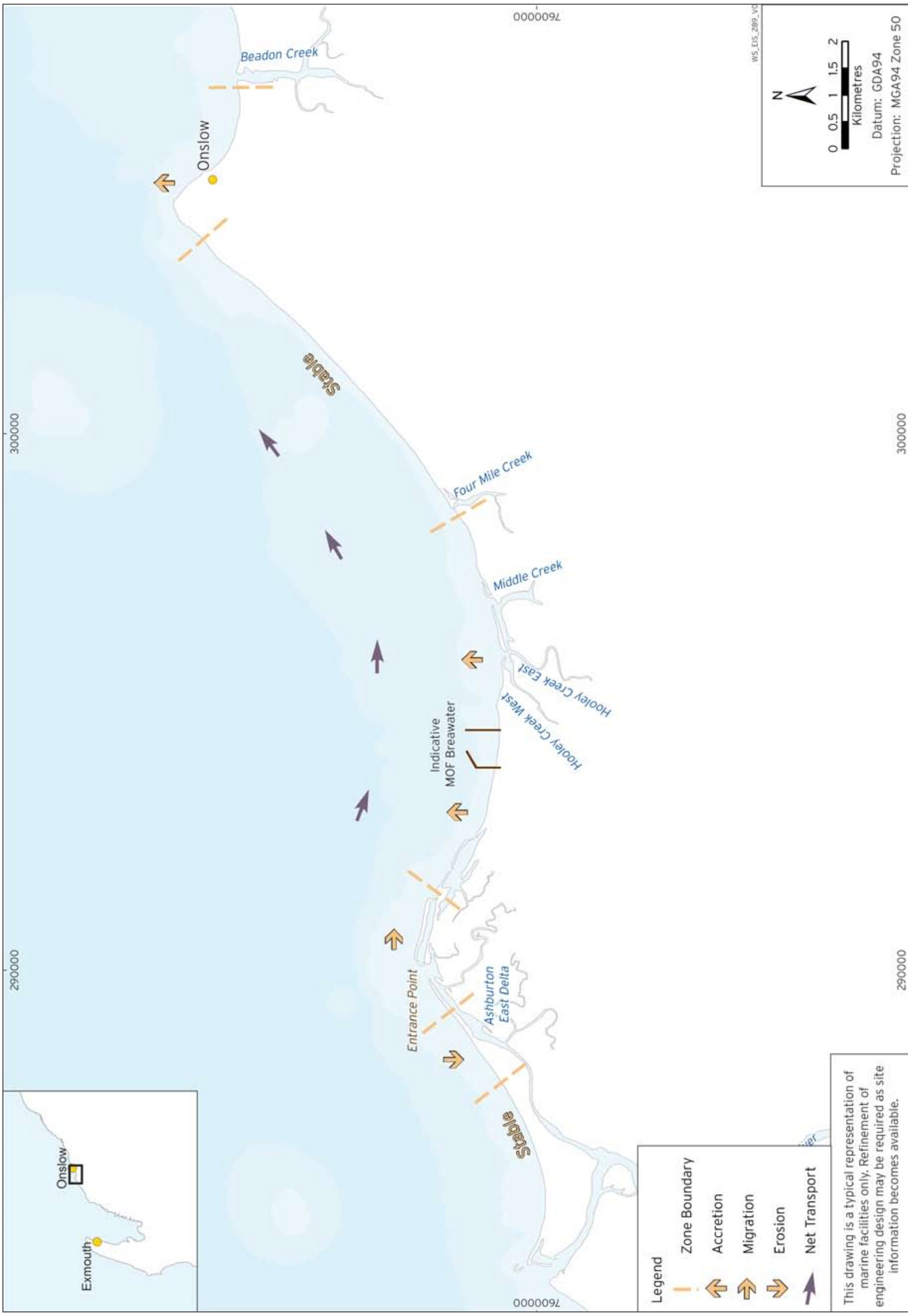

Figure 12.5: Coastal Processes: Beadon Creek to Entrance Point

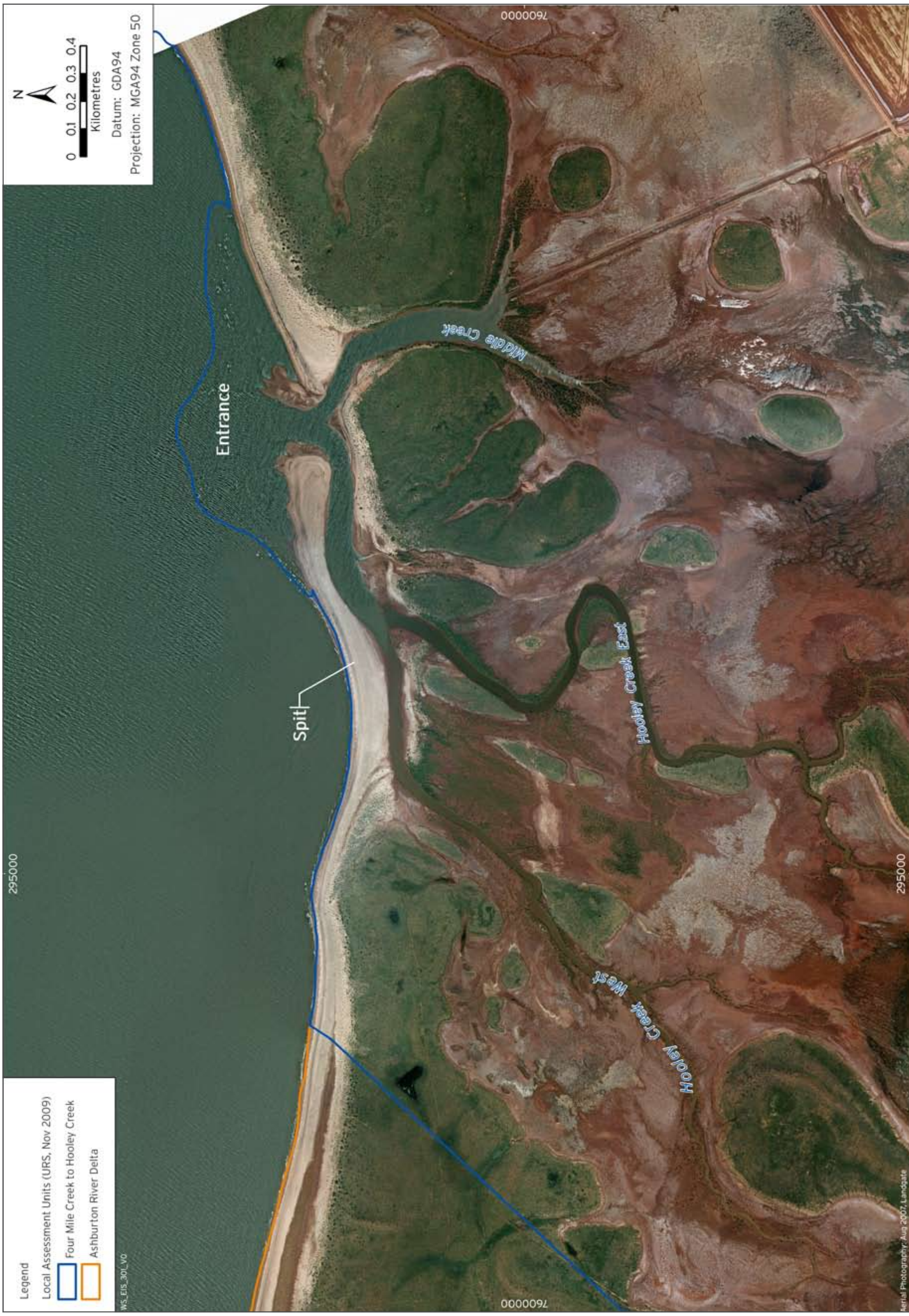

Figure 12.6: Coastal Processes: Hooley Creek

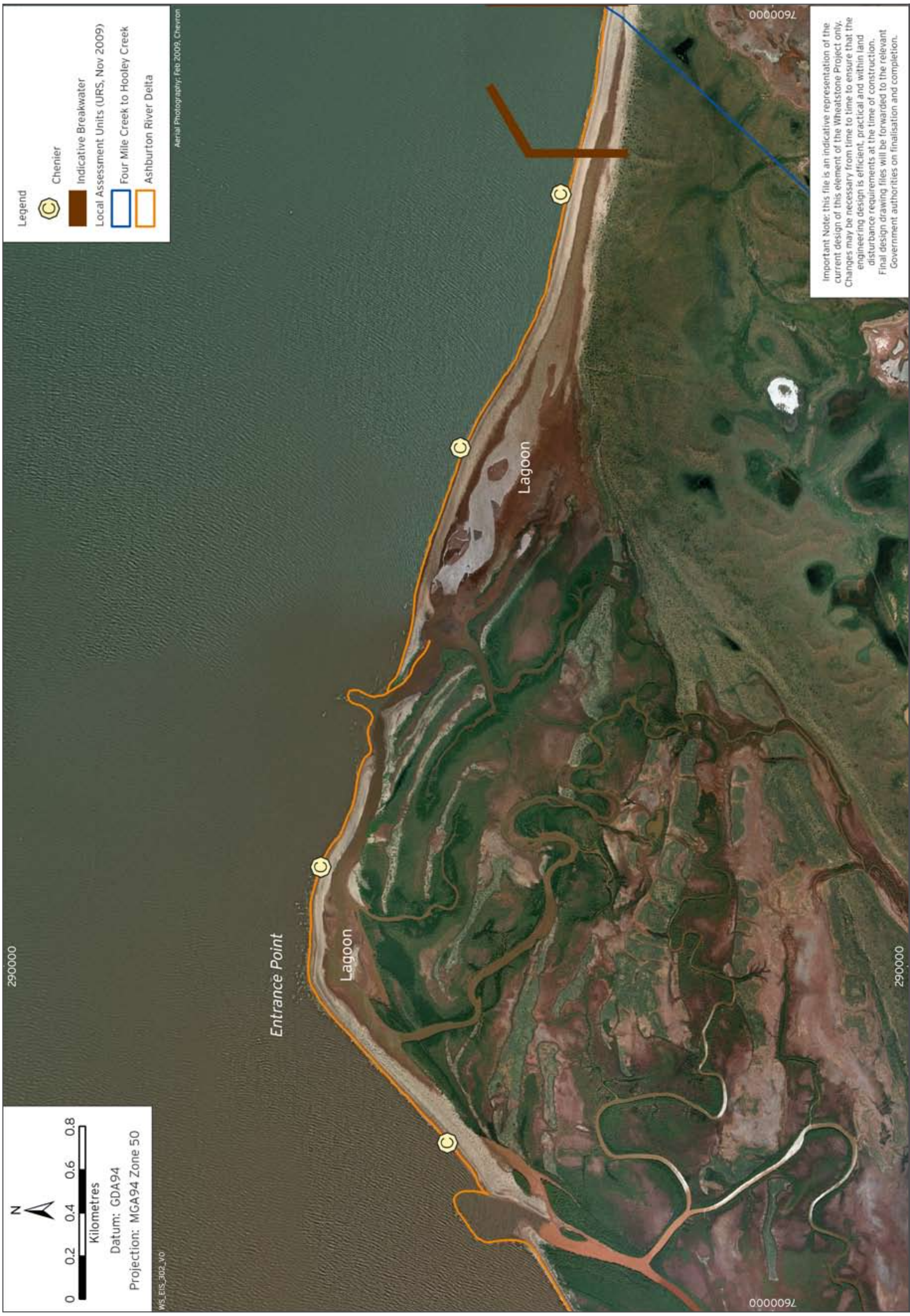

Figure 12.7: Coastal Processes: East Ashburton Delta

Table 12.4: Mangrove and Estuarine Habitat Management

2.	Proposed Outcome-based Condition 2: Mangrove and Estuarine Habitat Management
2.1	**Element I: Definition of Outcome**
2.1.1	The Proponent will manage its construction and operation activities to prevent, as far as practicable, Project-attributable impacts, within the East Hooley Creek – Four Mile Creek systems, as indicated in Figure 12.8 and Ashburton Delta as indicated in Figure 12.9 so as to ensure that: • Not more than 5% long-term (> 5 years) loss of mangrove habitat (as shown in Figure 12.8) in the Hooley Creek – Four Mile Creek mangrove system • No long-term (>5 years) net detectable loss of mangrove habitat (as defined in Figure 2.2) in the Ashburton Delta mangrove system.
2.1.2	The Proponent will manage its construction and operation activities to prevent, as far as practicable, a demonstrable reduction in the condition of estuarine habitats as a result of Project-attributable impacts within the Hooley Creek – Four Mile Creek systems and East Ashburton Delta, as shown in Figure 12.8 and Figure 12.9, respectively.
2.2	**Element II: Monitoring Program**
2.2.1	The Proponent will prepare a mangrove baseline report to be submitted to the OEPA for review prior to the commencement of dredging or the construction of the MOF or trunk-line shore crossing. The baseline report will provide the basis against which the predicted outcomes, described in Conditions 2.1.1 and 2.1.2, are assessed.
2.2.2	The Proponent will monitor the aerial extent of mangrove habitats within both the Hooley Creek – Four Mile Creek and East Ashburton Delta systems, as shown in Figure 12.8 and Figure 12.9, respectively, through a combination of on-ground surveys and aerial photography/satellite imagery. Monitoring will provide clear spatial delineation of the extent of direct and indirect Project-attributable impacts to mangroves against baseline mangrove habitat distribution as shown in Figure 12.8 and Figure 12.9. This will include an assessment of both seaward and shoreward mangrove habitat boundaries.
2.2.3	The Proponent will undertake monitoring in areas as shown in Figure 12.8 and Figure 12.9 of parameters which may indicate potential Project-attributable impacts to mangroves. Monitoring will include quantitative assessment of one or more mangrove condition indices such as: • Mangrove species health, composition and density • Groundwater salinity and water table depths • Sediment heights and ground levels • Hydrocarbon and heavy metals concentrations in mangrove sediments.
2.2.4	The Proponent will establish management criteria for parameters monitored under Condition 2.4.1 prior to the commencement of monitoring. The Proponent's monitoring program as described elsewhere in this Condition 2.2 will assess whether those management criteria have been reached.
2.2.5	The Proponent will establish monitoring sites adjacent to the Project site (Hooley Creek and the eastern section of the Ashburton Delta) and also at more distant representative locations considered to be outside the likely zone of influence from construction and operations (i.e. to serve as control or reference sites).
2.2.6	On-ground surveys of parameters described in Condition 2.2.4 will be conducted prior to construction of the MOF and thereafter at a frequency, and for durations, to be determined.
2.3	**Element III: Monitoring Program Reporting**
2.3.1	The Proponent shall report the results from the Monitoring Program required under Condition 2.2 on, at least, an annual basis. (Cont'd)

2.4	**Element IV: Contingency Actions**
2.4.1	In the event that management criteria described in Condition 2.2.4 are exceeded, one or all of the following will be undertaken as soon as practicable: • An increased level of observation and review of whether management measures are being implemented • A review of the effectiveness of management measures and identification of alternative or additional practicable management measures • Implement practicable alternative and/or additional management measures • An assessment of the aerial extent of mangrove loss (or potential for loss) with respect to allowable limits defined in Condition 2.1.1.
2.4.2	In the event that the monitoring program in Condition 2.2 shows that the limits of allowable loss of mangroves defined in Condition 2.1.1 have been exceeded: • The Proponent shall report such findings to the Chief Executive Officer of the OEPA within 21 days of receipt of an internal monitoring report confirming such findings.
2.4.3	In the event that the conclusion of the report required under Condition 2.4.2 confirms that a predicted outcome defined in Condition 2.1 is not being met, the Proponent shall undertake practicable management actions, which may include: • Maintaining an ongoing log of unintended mangrove loss • Undertaking a detailed mangrove survey at the end of construction and comparison against baseline to confirm extent of any loss • Undertake additional rehabilitation review to determine locations where further rehabilitation can be achieved • Undertaking actions to remediate the decline of mangroves and/or rehabilitate areas of mangrove loss.

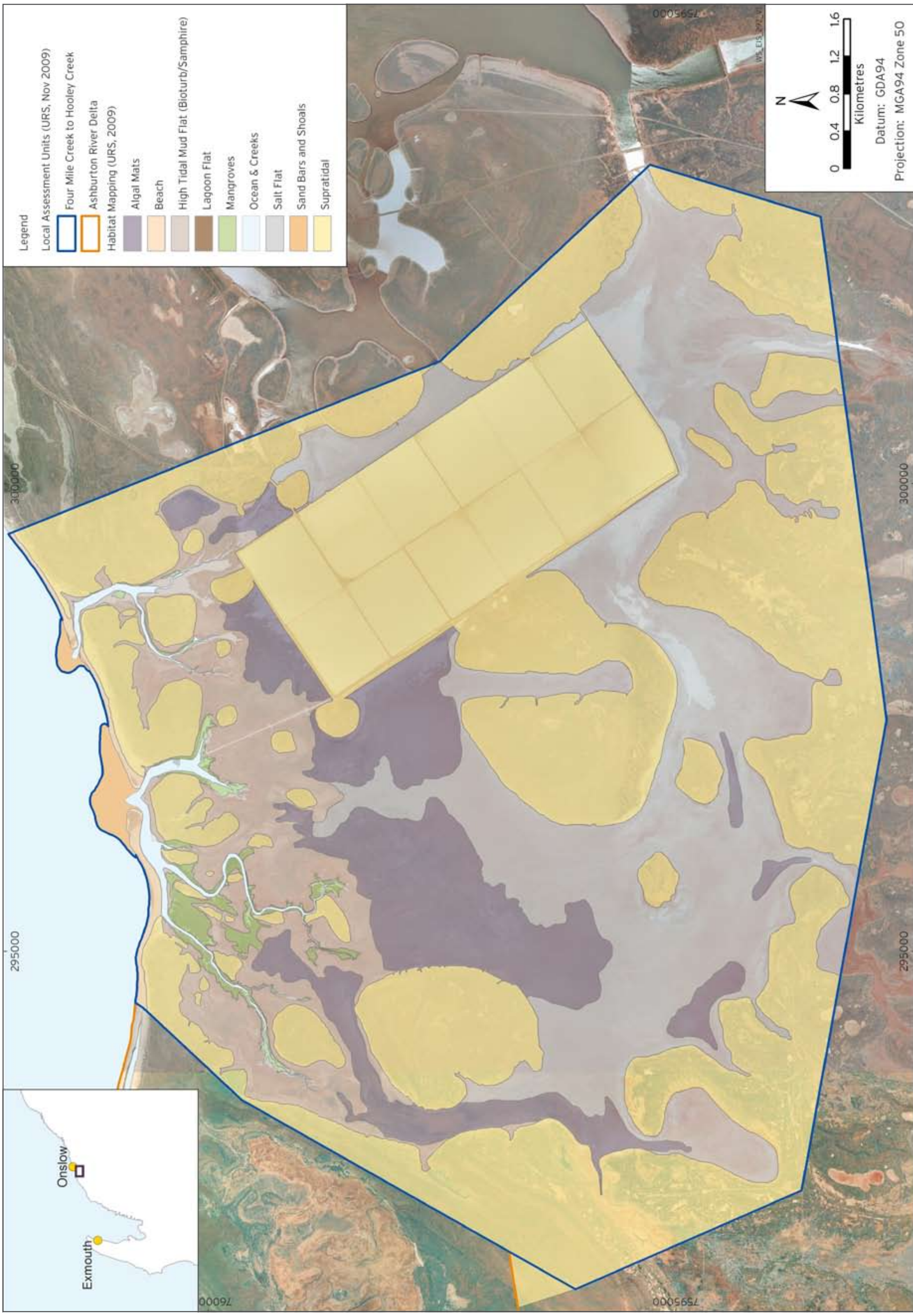

Figure 12.8: Mangrove and Estuarine Habitat Management Area: Hooley Creek – Four Mile Creek System

Figure 12.9: Mangrove and Estuarine Habitat Management Area: East Ashburton Delta

Table 12.5: Benthic Primary Producer Habitat Management

3.	**Proposed Outcome-based Condition 3: Benthic Primary Producer Habitat Management**
3.1	**Element I: Definition of Outcome and Associated Management Plans**
3.1.1	The Proponent will manage its dredging and spoil disposal activities, to prevent, as far as practicable, Project-attributable losses of marine benthic primary producer habitats[1] (BPPH) and communities shown in Figure 12.10 and Figure 12.11, so as not to exceed the predicted levels of acceptable loss[2]. *Notes for EIS/ERMP purposes - not to be included in actual condition:* *1. Within this predicted environmental outcome, hard corals are assumed to be the benthic primary producer type most sensitive to turbidity and sedimentation impacts and will be used as a proxy indicator for all other subtidal benthic primary producer (BPP) organisms (including soft corals; and, macroalgae and seagrasses).* *2. Final calculations regarding predicted BPPH losses will be confirmed on completion of the statutory review of the EIS/ERMP and presented in the final version of this condition.*
3.2	**Element II: Proposed Monitoring Program**
3.2.1	The Proponent will prepare a BPPH baseline report to be submitted to the OEPA for review prior to dredging activities. The baseline report will include data on water quality, and hard coral condition, as well as coral community composition, at locations containing sensitive receptors, to provide a record of background environmental conditions against which the predicted outcome described in Conditions 3.1.1 may be assessed.
3.2.2	The Proponent will monitor water quality, before, during and after dredging, in areas where Project-attributable impacts are predicted to be less than 100% loss of BPPH. Water quality parameters will be measured as an early warning indicator of BPPH loss. Specifically the program will include: • Monitoring water quality conditions around dredging and disposal sites and at representative locations containing hard corals during capital dredging and spoil disposal activities as an early warning of potential Project-attributable impacts.
3.2.3	The Proponent will monitor the status of hard coral communities before, during and after dredging, in areas where Project-attributable impacts are predicted to be less than 100% loss of BPPH. Project-attributable losses will be determined by comparing the relative loss at predicted impact locations with changes at comparable reference sites. Specifically the program will include: • Monitoring the condition of hard corals at representative locations during capital dredging and spoil disposal activities to assess condition against management criteria and confirm the effectiveness of water quality monitoring as an early warning mechanism • Monitoring the condition of hard corals and coral communities after the completion of capital dredging activities to confirm that predictions of Project-attributable coral loss have not been exceeded.
3.2.4	The Proponent will establish management criteria based on the results of a baseline monitoring program and the objectives of 3.1.1. Management criteria will include: • Interim water-quality management criteria to be used to initiate reactive coral health monitoring where and/or when Project-attributable impacts to corals are at risk of exceeding allowable limits • Interim coral health criteria to be used to initiate the implementation of management measures to ensure that Project-attributable BPPH losses do not exceed predicted levels.
3.2.5	The Proponent will establish monitoring sites adjacent to capital dredging and spoil placement locations as well as at more distant locations considered to be outside the likely zone of influence (i.e. to serve as control or reference sites).
3.2.5	Monitoring will be conducted: • Regularly during the dredging program for up to a period to be determined based on the monitoring results. (Cont'd)

3.2.6	The monitoring design and management framework will be reviewed periodically throughout the program for its effectiveness at meeting the objective of 3.1.1 and modified, if necessary.
3.3	**Element III: Proposed Monitoring Program Reporting**
3.3.1	The Proponent shall report the results from the monitoring required under Condition 3.2, including any Project-attributable exceedences of criteria, in accordance with the timelines and formats to be established to meet Condition 3.1.1.
3.4	**Element IV: Proposed Contingency Actions**
3.4.1	In the event that the monitoring program in 3.2 shows that interim criteria established in Condition 3.2.2 are reached, the following management responses shall be applied : • An investigation into whether there has been associated changes in coral health and water quality; and/or • Practicable reactive dredge management that may include a change in timing and location of dredge activity.
3.4.2	In the event that the monitoring required by Condition 3.2 indicate that predicted losses have been exceeded: • The Proponent shall investigate and report such findings to the Chief Executive Officer of the OEPA within 21 days of receipt of an internal monitoring report confirming such findings.
3.4.3	In the event that the conclusion of the report required under Condition 3.4.1 confirms that a predicted outcome defined in 3.1.1 is not being met, the Proponent shall undertake practicable management actions which may include: • Reviewing management procedures for dredging, and in particular audit compliance with management measures • Re-assessing vessel operations procedures to find ways to further reduce the risk to hard corals and water quality.

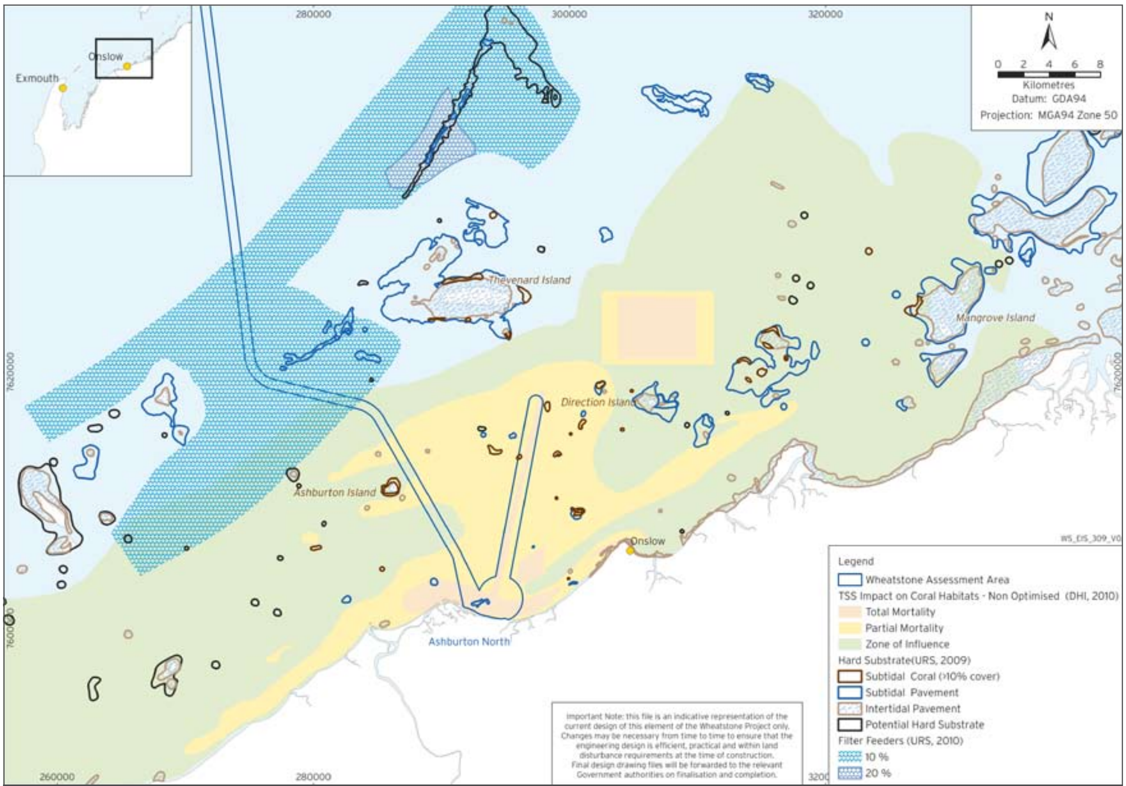

Figure 12.10: Maximum Predicted BPPH Loss: Corals and Filter-feeder Communities

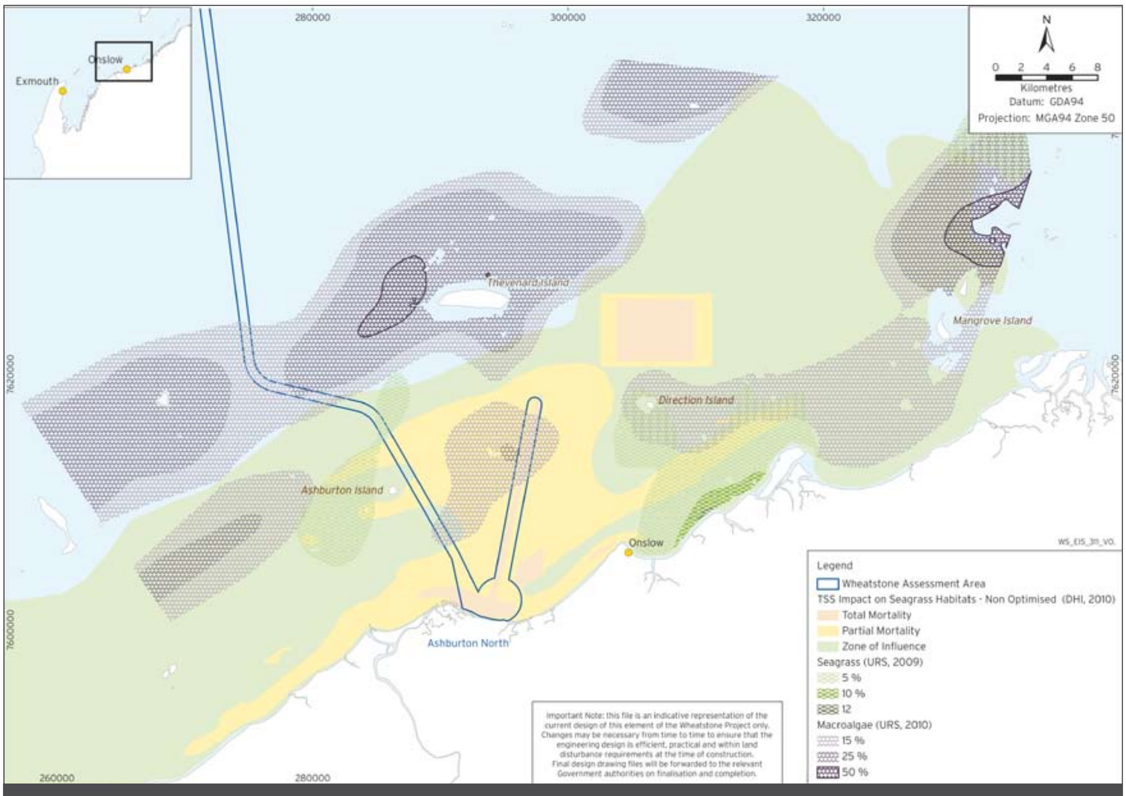

Figure 12.11: Maximum Predicted BPPH Loss: Seagrass and Macroalgae

Table 12.6: Marine Fauna Management

4.	**Proposed Outcome-based Condition 4: Marine Fauna Management**
4.1	**Element I: Definition of Outcome and Associated Management Plans**
4.1.1	The Proponent will manage its dredging activities during the construction phase of the Project to reduce, as far as reasonably practicable, Project-attributable impacts on marine fauna within the area indicated in Figure 12.12, Figure 12.13 and Figure 12.14, through the following measures: • Designated marine fauna observation and activity suspension zones will be established around dredging activities during daylight operations • When operating with less than five metres under keel clearance, the dredge will initially move slowly through the area before commencing dredging so that the noise and vibration disturb marine fauna in the vicinity and encourage them to leave. This will only be applied on dredging in new areas and not once the work area has been established • Dredge pumps will be stopped as soon as possible after completion of dredging and where reasonably practicable the drag head will remain within four metres of the seabed until the dredge pump is stopped.
4.1.2	The Proponent will manage its marine installation activities during the construction phase of the Project to reduce, as far as reasonably practicable, Project-attributable impacts on marine fauna within the area indicated in Figure 12.12, Figure 12.13 and Figure 12.14, through the following measures: • Designated marine fauna observation and activity suspension zones will be established around key marine construction activities such as piling, rock placement and blasting (if required)
4.1.3	The Proponent will manage its construction and operational workforce to reduce, as far as reasonably practicable, potential impacts on marine fauna associated with workforce recreational activities within the area indicated in Figure 12.12, Figure 12.13 and Figure 12.14, through the following measures: • The Proponent will provide marine fauna aerial sighting data (as presented in the EIS/ERMP) for DEC planning purposes in the Onslow region • Boats and recreational vehicles will not be permitted within the workforce accommodation village or the access road from the Onslow Road • Conservation and induction programs will be established to ensure staff/contractors are informed of DEC rules relating to offshore nature reserves.
4.2	**Element II: Monitoring Program**
4.2.1	The Proponent will monitor Project-attributable injury and mortality of marine fauna by undertaking the following: • Prior to the commencement of construction selected relevant crew will receive training, which will include details on procedures in the event of a fauna sighting, injury and/or death. • During dredging and construction activities, selected trained crew members will observe marine fauna within the designated observation zones relevant to each activity. All observed in-water incidents[1] will be recorded • Recording of marine fauna vessel-strikes. All vessels will keep a log of observed in-water incidents or injured/dead marine fauna.
4.2.2	The Proponent will establish management criteria for the purpose of Condition 4.4.1 prior to the commencement of the monitoring program. The Proponent's monitoring program as described elsewhere in this Condition 4.2 will assess whether those management criteria have been reached. Management criteria to be established will include: • Appropriately sized observation zones • Appropriately sized activity suspension zones • Criteria for contingency actions as described in Condition 4.4.3 (Cont'd)

4.3	**Element III: Monitoring Program Reporting**
4.3.1	The Proponent shall report any Project-attributable deaths of marine fauna listed under *Section 14(2)(ba) of the Wildlife Conservation Act 1950* to the DEC.
4.4	**Element IV: Contingency Action**
4.4.1	The following contingency actions will apply to dredging operations in response to the results of monitoring program in Condition 4.2: • If marine fauna are observed within the observation zone of any dredge vessel while on route to and from the dredge area to the dredge material placement grounds, direction/speed of the vessel will be adjusted, within the safety constraints of the vessel, to avoid impact. • In the event of marine fauna mortality incidents as a result of entrainment during dredging, revision of existing management controls will be undertaken to investigate additional procedures to reduce such incidents
4.4.2	The following contingency actions will apply to marine construction and installation operations in response to the results of monitoring program in Condition 4.2: • If a marine fauna enters the observation zone during active operations, the supervisor (or designated individual) will monitor the movements of the marine fauna in relation to the activity suspension zone • Active operations shall cease if a marine turtle is observed within the activity suspension zone.
4.4.3	If the monitoring program in 4.2 indicates that further mitigation is required the following management responses shall be applied: • Increase level of observation and review whether management measures are being implemented • Review effectiveness of management measures and determine alternative or additional practicable management measures • Implement practicable alternative and/or additional management measures such as temporary relocation or suspension of activities.

1. Definition: An in-water incident is defined as being any interaction between a marine fauna and a Project activity/ vessel which might result in its death or injury, including its presence within a designated activity suspension zone during active operations

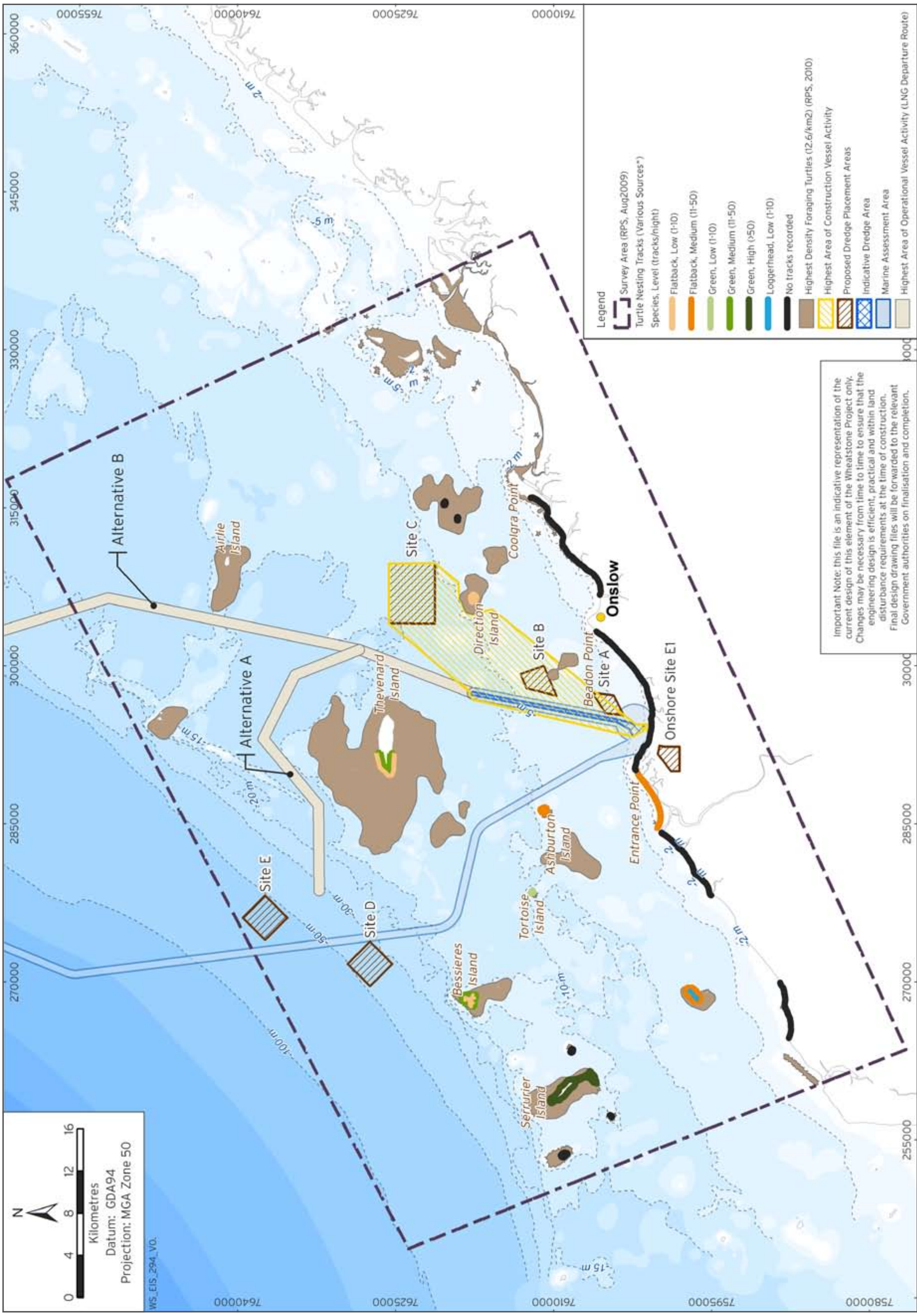

Figure 12.12: Marine Turtle Management Area

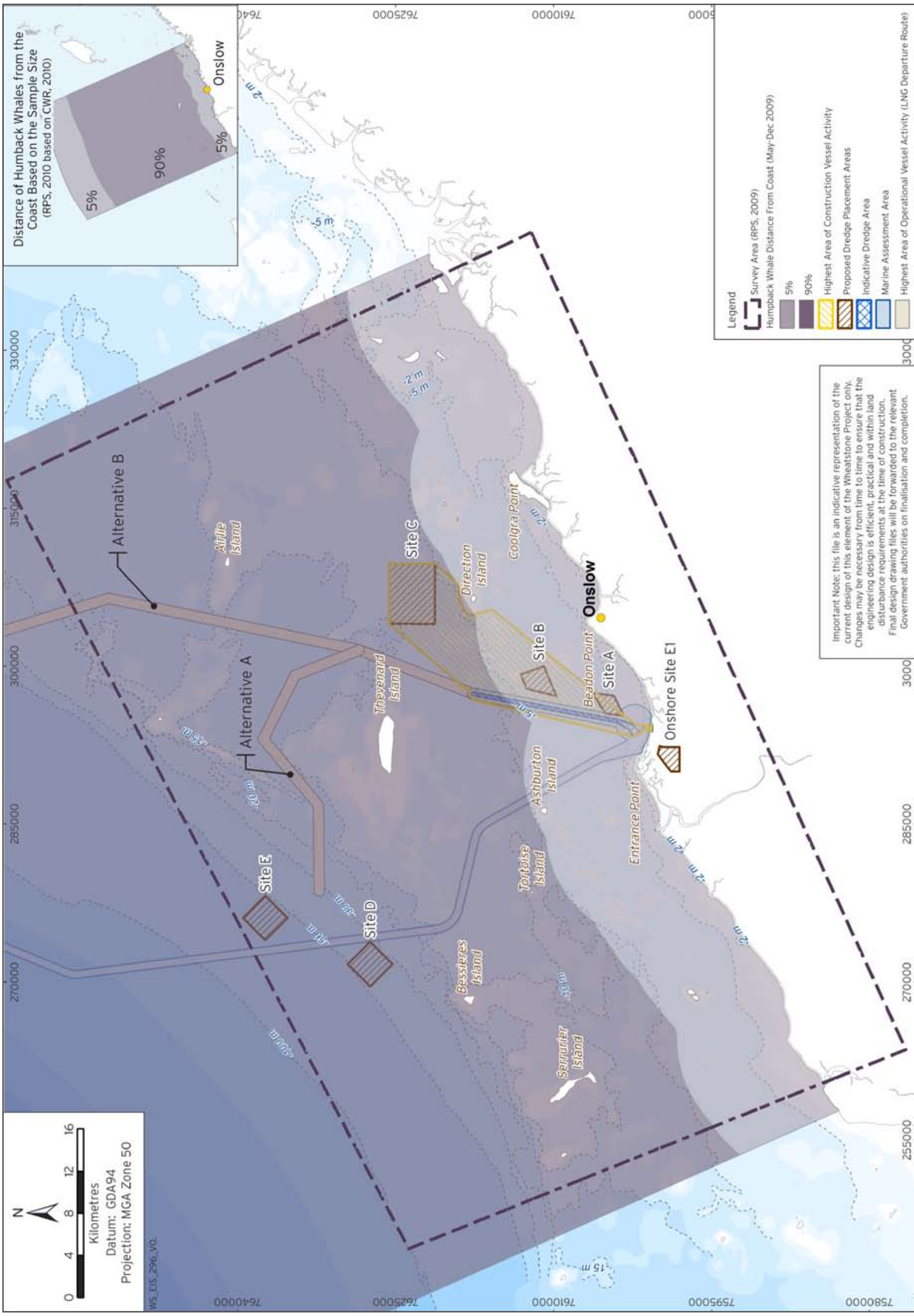

Figure 12.13: Cetacean Management Area

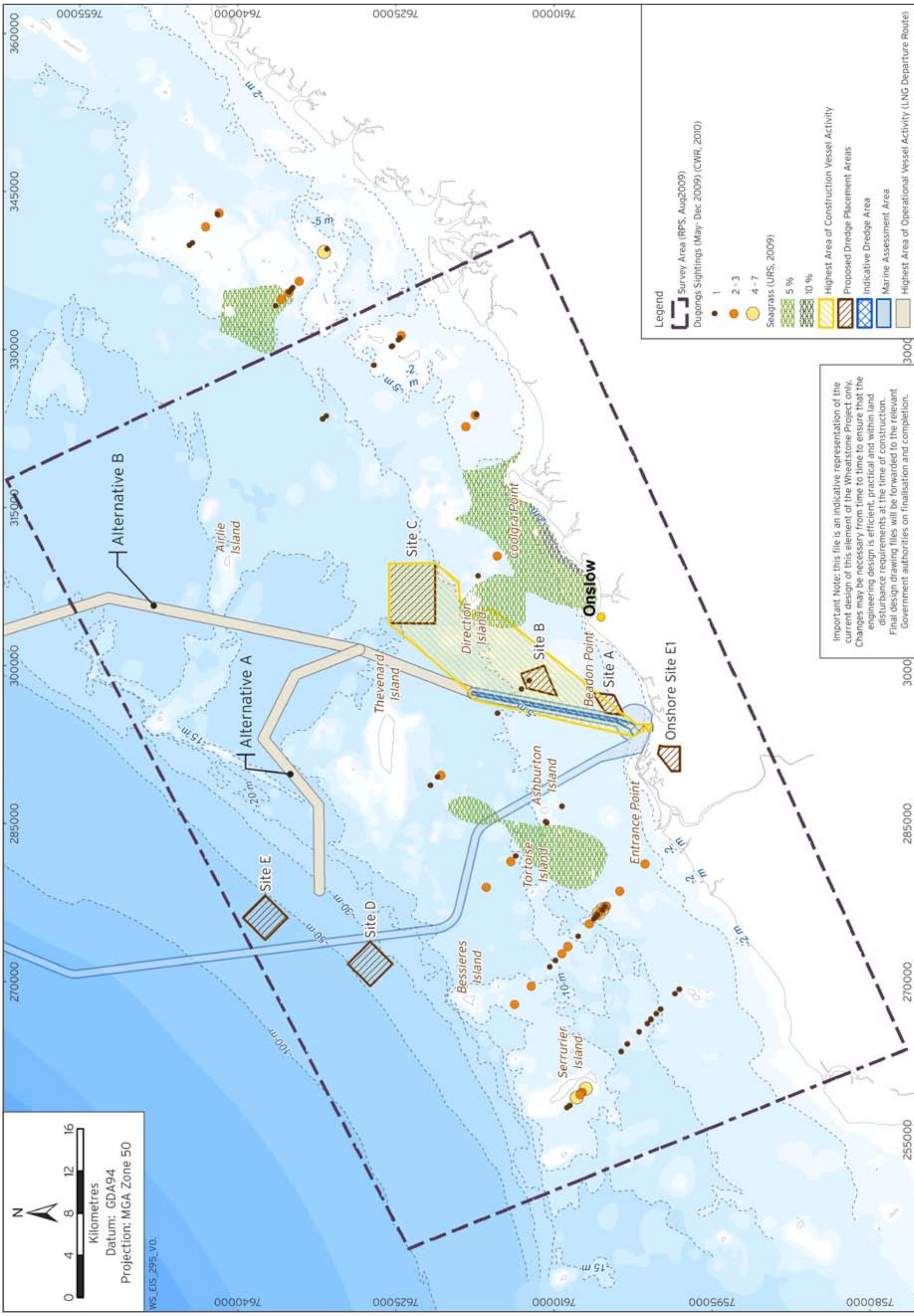

Figure 12.14: Dugong Management Area

Table 12.7: Terrestrial Flora and Vegetation Management

5.	**Proposed Outcome-based Condition 5: Terrestrial Flora and Vegetation Management**
5.1	**Element I: Definition of Outcome**
5.1.1	The Proponent will manage its vegetation clearing activities during construction and operational phases of the Project to reduce as far as practicable Project-attributable impacts on vegetation communities adjacent to the Terrestrial Assessment Area (TAA) as indicated in Figure 12.15. This will include designing and managing vegetation clearing to prevent clearing outside of the TAA and ongoing management with a focus on the conservation of vegetation communities with a high local significance and flora species of conservation significance.
5.1.2	The Proponent will manage its activities during construction and operational phases of the Project to reduce as far as practicable Project-attributable impacts on the health and condition of vegetation communities listed in Table 12.8, and threatened flora species, occurring within the TAA as indicated in Figure 12.15. This will include identifying activities which may impact the condition of vegetation communities and native flora species and implementing appropriate mitigation measures where practicable.
5.1.3	The Proponent will manage its activities during construction and operational phases of the Project to reduce as far as practicable Project attributable impacts associated with the spread of non-indigenous flora species in vegetation communities, listed in Table 12.8, and threatened flora species, occurring within the TAA as indicated in Figure 12.15. This will include identifying areas containing non-indigenous flora populations and implementing measures designed to limit the propagation of these species within the TAA.
5.2	**Element II: Proposed Monitoring Program**
5.2.1	The Proponent will monitor Project attributable disturbance of flora and vegetation communities in areas adjacent to the Terrestrial Assessment Area. Monitoring will occur prior to, during and immediately following vegetation clearing.
5.2.2	The Proponent will monitor ongoing Project-attributable changes to the condition of flora and vegetation communities in areas adjacent to the TAA through regular surveys which will assess: • Physical condition of vegetation • Species diversity of vegetation communities as compared with the established baseline • Presence or absence of non-indigenous species • Population density of threatened species • Monitoring will be conducted monthly throughout the construction period, starting from the commencement of construction of terrestrial infrastructure.
5.2.3	The Proponent will monitor ongoing Project-attributable impacts to flora and vegetation communities within and adjacent to the TAA as a result of the propagation of non-indigenous species. Monitoring will be conducted weekly, at a minimum, throughout the construction period, starting prior to vegetation clearing and ending at site release.
5.2.4	The Proponent will establish monitoring sites required under Conditions 5.2.1 - 5.2.3 within and adjacent to the TAA prior to the commencement of vegetation clearing activities.
5.2.5	The Proponent will establish management criteria for the purpose of Condition 5.4.1 prior to the commencement of the monitoring program. The Proponent's monitoring program as described elsewhere in this Condition 5.2 will assess whether those management criteria have been reached.
5.2.6	The requirements for monitoring during operations will be developed based on the results of the construction monitoring, six months prior to completion of construction activities. (Cont'd)

5.3	**Element III: Proposed Monitoring Program Reporting**
5.3.1	The Proponent shall report the results from the Monitoring Program required under Condition 5.2 on an annual basis.
5.4	**Element IV: Proposed Contingency Actions**
5.4.1	If the monitoring program in 5.2 shows that the management criteria established in Condition 5.2.4 are reached, the following management responses shall be applied: • Level 1 management criteria reached – Increase level of observation and review whether management measures are being implemented • Level 2 management criteria reached – Review effectiveness of management measures and determine alternative or additional practicable management measures • Level 3 management criteria reached – Implement practicable alternative and/or additional management measures, possibly temporary relocation or suspension of activities.
5.4.2	In the event that the monitoring required by Condition 5.2 shows that the level 3 management criteria established in Condition 5.1 are not being met: • The Proponent shall report such findings to the Chief Executive Officer of the OEPA within 21 days of receipt of an internal monitoring report confirming such findings.
5.4.3	In the event that the conclusion of the report required under Condition 5.4.2 confirms that a predicted outcome defined in Condition 5.1 is not being met, the Proponent shall undertake management actions which may include: • Maintaining an ongoing log of unintended vegetation loss • Undertaking a detailed vegetation survey at the end of construction and comparison against baseline to confirm extent of any loss • Undertaking additional rehabilitation review to determine locations where further rehabilitation can be achieved • Undertaking revegetation of impacted areas.

Table 12.8: Terrestrial Vegetation Units of Moderate or High Local Conservation Significance

Habitat	Code	Vegetation Unit Description
Tidal Mud Flats	VU02	*Avicennia marina* open scrub along tidal creeks.
Inland Sand Dunes	VU05	*Grevillea stenobotrya* tall open shrubland over *C. cunninghamii*, *T. zeylanicum var. grandiflorum* open shrubland over *T. epactia* open hummock grassland on red sand dunes.
	VU06	*G. stenobotrya* tall open shrubland over *C. cunninghamii*, *Hibiscus brachychlaenus* open shrubland over *Triodia schinzii*, (*T. epactia*) open hummock grassland on red sand dunes.
Coastal Sand Plains	VU08	*Acacia tetragonophylla* scattered shrubs over *T. epactia* hummock grassland occurring broadly over sandy plains.
Claypans	VU14	*Tecticornia spp.* low shrubland in saline claypans.
Clayey Plains	VU15	*Sporobolus mitchellii*, *Eriachne aff. benthamii*, *E. benthamii*, *Eulalia aurea* tussock grassland on low-lying clayey plains.

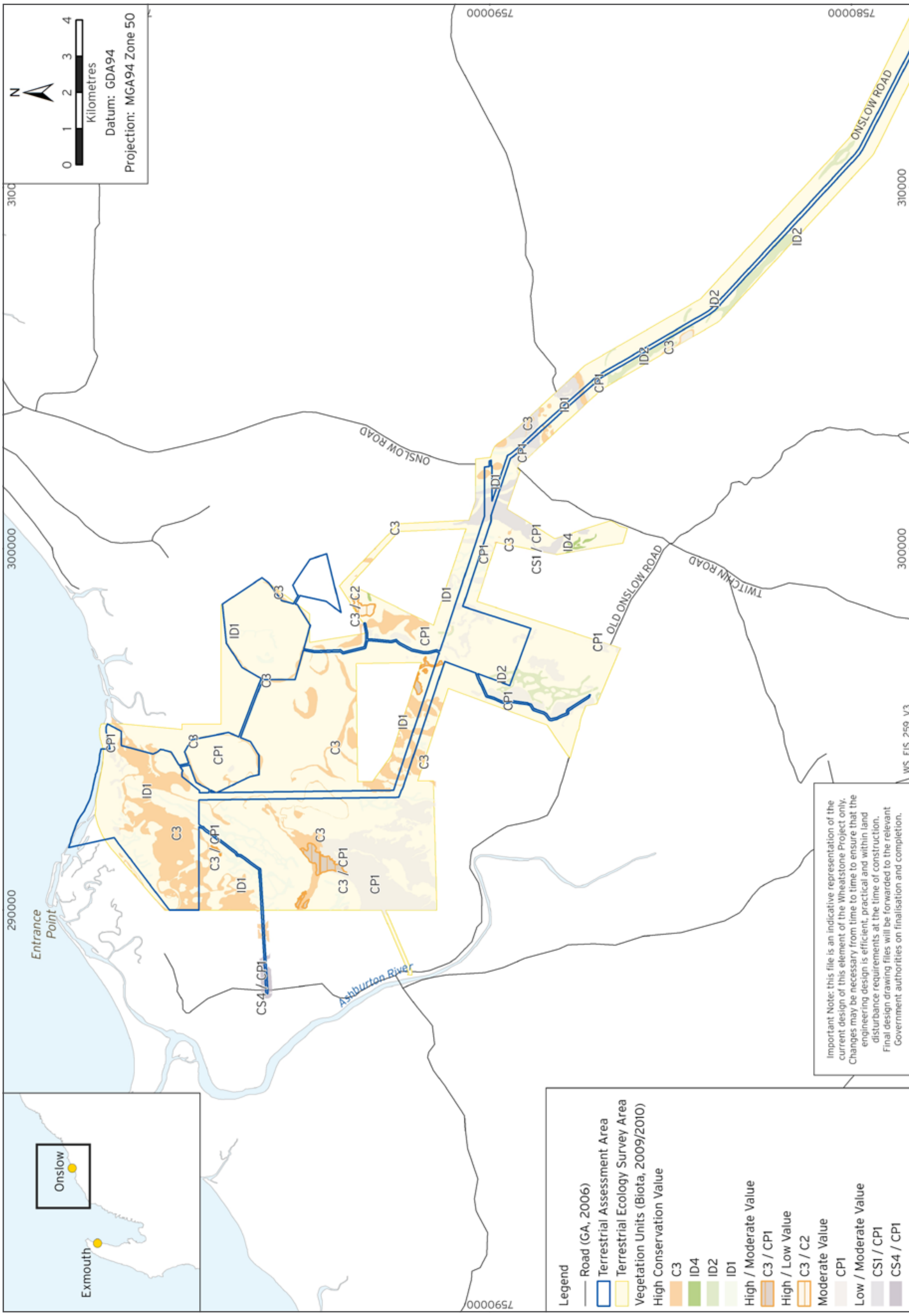

Figure 12.15: Terrestrial Vegetation Units Management Area

Table 12.9: Terrestrial Fauna Management

6.	**Proposed Outcome-based Condition 6: Terrestrial Fauna Management**
6.1	**Element I: Definition of Outcome**
6.1.1	The Proponent will manage its vegetation clearing activities during construction and operational phases of the Project to reduce as far as practicable Project-attributable impacts on terrestrial fauna within the Terrestrial Assessment Area (TAA) as indicated in Figure 12.16, by way of: • Inspection of cleared areas immediately following clearing activities for the presence of injured animals • Rehabilitation of temporarily cleared areas upon completion of activities
6.1.2	The Proponent will manage its earthworks, trenching and pipeline construction activities during construction and operational phases of the Project to reduce as far as practicable Project-attributable impacts on terrestrial fauna within the TAA, as indicated in Figure 12.16, by way of: • Installation of escape routes from trenches, or fencing trenches off, particularly during the night • Pre-work inspections of all open trenches and removal of any trapped fauna using appropriately trained personnel • Locating ponds within perimeter fences and installation of floats and/or fauna egress mats to enable fauna to exit constructed water bodies. Practicable management measures will be developed and implemented consistent with The Australian Pipeline Industry Association Ltd *Code of Environmental Practice Onshore Pipelines* (2009).
6.1.3	The Proponent will manage workforce conduct during construction and operational phases of the Project to reduce as far as practicable Project-attributable impacts on terrestrial fauna within the TAA, as indicated in Figure 12.16, by way of: • Developing and implementing an employee environmental education program/induction • Prohibiting construction workers from operating all terrain or four wheel drive vehicles outside of designated tracks or designated unsealed roads • Establishment of vehicle speeds and enforcement of speed limits within project work areas and access corridors under Chevron's control
6.2	**Element II: Proposed Monitoring Program**
6.2.1	The Proponent will monitor terrestrial fauna populations within the TAA and Project-attributable terrestrial fauna injuries and deaths including the following: • Monitoring will occur prior to, during and immediately following construction, as well as, during operation of the Plant • Start of day inspections of pipeline trenches will be conducted during pipeline construction, to identify and assist entrapped native terrestrial fauna • Daily inspections of ponds and waste disposal areas will be conducted to determine the effectiveness of terrestrial fauna management measures • Maintaining an ongoing log of terrestrial fauna injuries and mortalities.
6.2.2	The Proponent will establish management criteria for the purpose of Condition 6.1 prior to the commencement of the monitoring program. The Proponent's monitoring program as described elsewhere in this Condition 6.2 will assess whether those management criteria have been reached.
6.2.3	Any additional requirements for monitoring during operations will be developed based on the results of the construction monitoring, six months prior to completion of construction activities. (Cont'd)

6.3	**Element III: Proposed Monitoring Program Reporting**
6.3.1	The Proponent shall report the results from the Monitoring Program required under Condition 6.2 on an annual basis.
6.4	**Element IV: Proposed Contingency Actions**
6.4.1	If the monitoring program in 6.2 shows that the management criteria established in condition 6.2.2 are reached, the following management responses shall be applied: • Level 1 management criteria reached – Increase level of observation and review whether management measures are being implemented • Level 2 management criteria reached – Review effectiveness of management measures and determine alternative or additional practicable management measures • Level 3 management criteria reached – Implement practicable alternative and/or additional management measures possibly including temporary relocation or suspension of activities.
6.4.2	In the event that the monitoring required by Condition 6.2 shows that the level 3 management criteria established in Condition 6.1 are not being met: • The Proponent shall report such findings to the Chief Executive Officer of the OEPA within 21 days of receipt of an internal monitoring report confirming such findings.
6.4.3	In the event that the conclusion of the report required under Condition 6.4.2 confirms that a predicted outcome defined in Condition 6.1 is not being met, the Proponent shall undertake management actions which may include: • Maintaining an ongoing log of terrestrial fauna death or injury, including identifying cause of impact • Increasing inspection and policing of terrestrial fauna impact locations • Enhanced terrestrial fauna management actions.

Table 12.10: Operations Marine Water and Sediment Quality Management

7.	Proposed Outcome-based Condition 7: Marine Water and Sediment Quality during LNG Plant Operations
7.1	**Element I: Definition of Outcome and Associated Management Plans**
7.1.1	The Proponent shall manage its activities during operations to reduce Project-attributable impacts on the quality of marine waters and sediments within areas to be determined. The Proponent shall manage discharge so that it does not cause the quality of the marine waters outside of the agreed mixing zones to exceed ANAZECC/ARMCANZ default criteria for high levels of ecological protection applying to slightly-moderately disturbed ecosystems or, if more appropriate, guideline values derived locally after consideration of natural background water quality.
7.1.2	To manage water and sediment quality the Proponent shall: • Establish procedures for the monitoring of water quality including a pre-disturbance assessment of the receiving environment against which condition 7.1.1 can be assessed • Provide a monitoring and management framework relating to Project-attributable impacts on water quality with the aim of achieving condition 7.1.1 • Detail the monitoring programs as required by Condition 7.2 to be implemented to measure the achievement of Condition 7.1.1 • Outline management and reporting timelines • Detail a reporting framework as required in Condition 7.3.
7.1.3	The Proponent shall implement these activities.
7.2	**Element II: Proposed Monitoring Program**
7.2.1	The Proponent shall monitor the quality of water: • At the source of the marine discharge using "end of pipe" guideline levels derived from a validated mixing zone dilution model; and/or • At the edge of the mixing zone using methods consistent with ANZECC/ARMCANZ Guidelines for Water Quality Monitoring and Reporting. Monitoring shall commence before ground breaking activities in order to collect baseline data.
7.2.2	The Proponent will establish management criteria for the purpose of Condition 7.4.1, consistent with ANZECC/ARMCANZ Guidelines for Water Quality Monitoring and Reporting, prior to the commencement of the monitoring program. The Proponent's monitoring program as described elsewhere in this Condition 7.2 will assess whether those management criteria have been reached.
7.3	**Element III: Proposed Monitoring Program Reporting**
7.3.1	The Proponent shall report annually the results from the Monitoring required under Condition 7.2 to the CEO of EPA. (Cont'd)

7.4	**Element IV: Proposed Contingency and Management Action**
7.4.1	In the event that the monitoring program in 7.2 shows that water quality criteria established in Condition 7.2.2 are reached, the following management responses shall be applied : • An investigation into whether there has been associated changes in sediment quality and/or • Practicable reactive management that may include a change in timing of routine discharges.
7.4.2	In the event that the monitoring required by Condition 7.2 indicate that the predicted outcome established in Condition 7.1 is not being achieved: • The Proponent shall investigate and report such findings to the Chief Executive Officer of the OEPA within 21 days of receipt of an internal monitoring report confirming such findings.
7.4.3	In the event that the conclusion of the report required under Condition 7.4.1 confirms that a predicted outcome defined in 7.1.1 is not being met, the Proponent shall undertake practicable management actions which may include: • Reviewing management procedures for routine discharges, and in particular audit compliance with management measures • Implementing actions to remediate the decline in water / sediment quality standards.

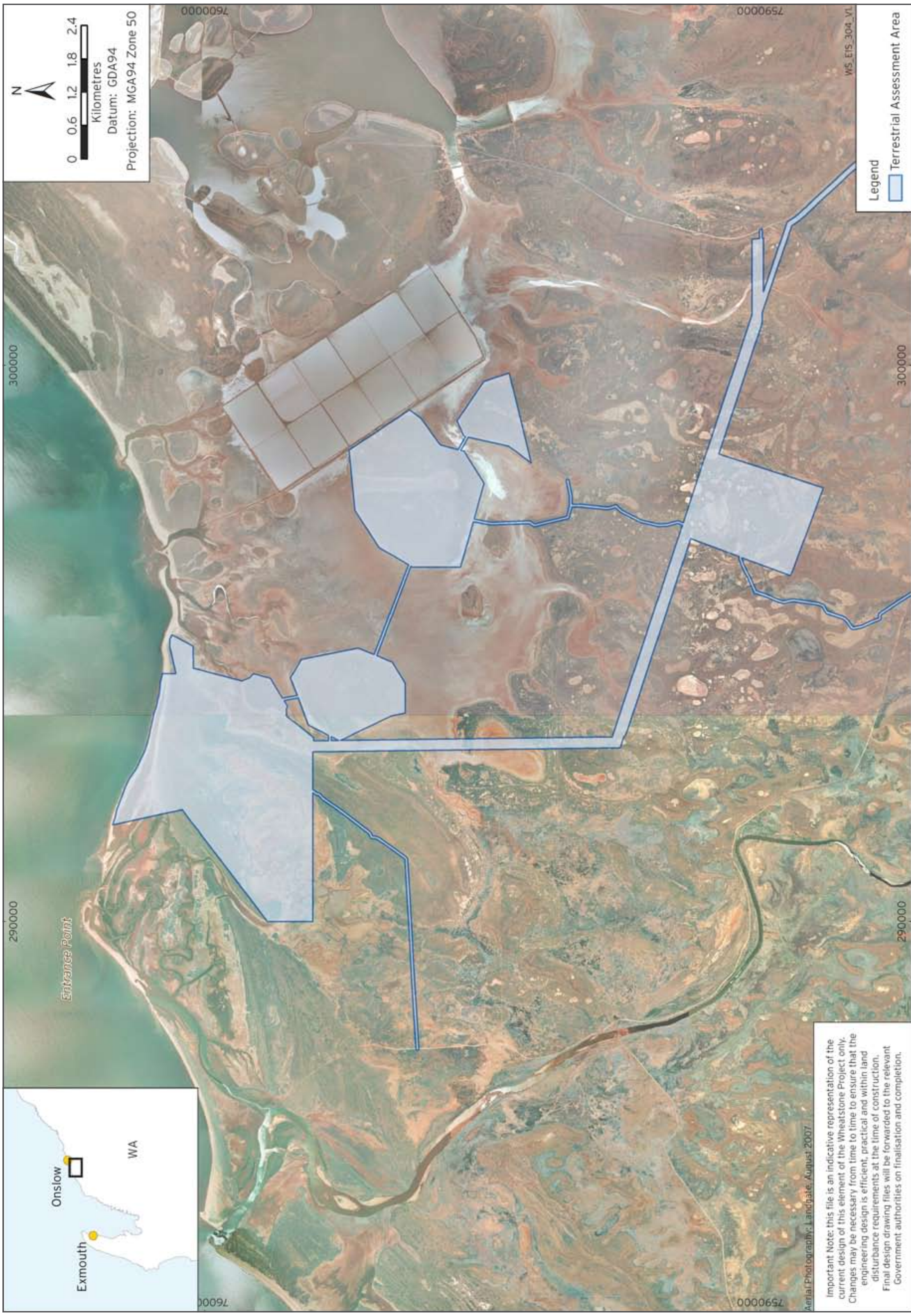

Figure 12.16: Terrestrial Assessment Area for Terrestrial Fauna Management

12.2.2.2 Statutory Environmental Management Plans

Introduction

The purpose of Statutory EMPs is to demonstrate to the EPA and DEWHA how Chevron and its contractors will maintain an acceptable standard of environmental performance in areas of medium or high risk throughout the Project. Statutory EMPs will set out the overarching objectives, strategies, performance criteria and relevant external guidance documents (such as EPA guidance statements) for all subsequent Subsidiary Plans.

The approach will also streamline the EMP review and approval process by providing EPA/DEWHA with fewer documents which require regulatory approval, without reducing the level of confidence that the Project will successfully manage its environmental risks.

In general, each Statutory EMP will:

- Describe the methods to be employed to reduce the likelihood of detrimental Project-attributable impacts the environment
- Provide a management structure to achieve the environmental objectives (to be developed) addressing detrimental Project-attributable impacts
- Detail the programs to be implemented to monitor the potential detrimental Project-attributable impacts and the effectiveness of management measures
- Audit compliance with relevant environmental objectives and conditions.

Chevron will submit the Statutory EMPs for EPA review and, where relevant, DEWHA approval, prior to the commencement of construction.

Chevron will, where necessary refine Statutory EMPs as construction and operation phases progress taking into account the local conditions experienced during initial associated activities.

Proposed Statutory EMPs

A summary of proposed Statutory EMP to be developed for the Project is provided in Table 12.11.

Table 12.11: Statutory EMPs

Plan	Purpose	Draft
Marine Fauna Management Plan (MFMP)	The purpose of the MFMP is to reduce the risk of potential Project-attributable impacts to marine fauna as a result of marine based project activities such as nearshore installation (rock placement, piling, pipeline installation) and shipping associated with the Wheatstone Project.	Appendix O6
Dredging and Spoil Disposal Management Plan (DSDMP)	The purpose of the DSDMP is to reduce additional loss of benthic primary producer habitat (BPPH) to that specified in the EIS/ERMP for the nearshore coastal waters as a result of Chevron's dredging and spoil disposal operations.	Appendix S1
Coastal Processes Management Plan (CPMP)	The purpose of the finalised CPMP is to reduce potential Project-attributable impacts to coastal processes associated with the placement of project marine infrastructure of the Wheatstone Project.	Appendix T1
Construction Environmental Management Plan (CEMP)	The purpose of the CEMP is to reduce the Project-attributable impacts of onshore construction (vegetation clearing, earthworks, vehicle access) and nearshore installation (rock placement, piling, and shipping) associated with the Wheatstone Project.	Appendix U1
Operations Environmental Management Plan (OEMP)	The purpose of the OEMP is to reduce the Project-attributable impacts of onshore operations and associated activities including, LNG and Domgas production, FIFO operations, vehicle access and product shipping associated with the Wheatstone Project.	To Be Developed
Decommissioning Environmental Management Plan (DEMP)	The purpose of the DEMP is to reduce Project-attributable impacts of all activities associated with the shutdown and decommissioning of the Wheatstone Project at the end of the project lifespan.	To Be Developed

Coastal Processes Management Plan

Chevron has prepared a draft Coastal Processes Management Plan (CPMP) which will be finalised prior to the commencement of coastal marine infrastructure installation.

The purpose of the draft CPMP is to identify potential changes to coastal processes associated with nearshore infrastructure; to define the potential environmental impacts of these changes; and to develop a framework for managing those impacts within acceptable limits.

The most important element addressed by the draft CPMP is the management of alongshore littoral drift, which will be interrupted by the Materials Offloading Facility breakwaters. The area of interest is the coast between Ashburton River and Beadon Creek, including the Ashburton River delta and Hooley Creek tidal complex.

The scope of the draft CPMP also includes social impacts in recognition of the value placed on the coast by the local community. The final CPMP will also include a plan for an adaptive sand-management program based on beach monitoring between the mouths of the Ashburton River and Beadon Creek. These works will aim to replicate the existing littoral transport system of the coastline but will consider if an alternative regime(s) can be shown to provide greater benefit to the down drift stability of the coast.

The key objectives of the CPMP will be to:

- Conserve the physical integrity and functionality of the eastern delta of the Ashburton River between the active river mouth and Cosigny Point
- Conserve the physical integrity and functionality of the existing beach and dune systems of the coast between the mouths of the Ashburton River and Beadon Creek
- Maintain ocean and flood water exchange via the Hooley Creek network and the adjoining mudflats through an adaptive program to mitigate potential nearshore infrastructure impacts on the physical integrity and functionality of habitats supported by this system.

The draft CPMP is included in Appendix T1.

Dredging and Spoil Disposal Management Plan

Chevron has prepared a draft Dredging and Spoil Disposal Management Plan (DSDMP) which will be finalised prior to the commencement of dredging and spoil management operations.

The aim of the DSDMP is to manage potential environmental impacts associated with the capital dredging and dredge material placement activities in a manner that achieves the environmental objectives as detailed within the Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP).

The draft DSDMP covers the proposed environmental management and monitoring of the capital dredging and dredge material management activities associated with the Project which includes:

- Dredging of the access channel to the Materials Offloading Facility (MOF)
- Dredging associated with the construction of the export facilities including the access channel and Product Loading Facility (PLF) incorporating the turning basin and berth pockets
- Potential placement of dredge material to the proposed onshore dredge material placement area
- Disposal of dredge material at the nearshore and offshore dredge material placement sites.

The key objectives for the DSDMP will be to:

- Ensure that the Limits of Acceptable loss of Benthic Primary Producer Habitat (BPPH) are not exceeded
- Reduce the likelihood of potential Project-attributable impacts to coral reproduction during mass spawning events
- Reduce the likelihood injury/mortality to Humpback Whales and Dugongs from dredge operations
- Minimise injury/mortality to turtles through entrapment/entrainment
- Reduce the likelihood of the introduction and establishment of non-indigenous marine pest species to the waters adjacent to the proposal in order to protect BPPH, fisheries, and pearling
- Meet the overall water quality criteria in accordance with the State Water Quality Management Strategy (SWQMS) and the Pilbara Water Quality Outcomes (PWQCO)
- Reduce the likelihood of long-term (>5 years) loss of the dense seagrass habitat outside of the project's "direct impact area"
- Reduce the likelihood of impact to mangrove habitat beyond the approved amount.

The Draft DSDMP is included in Appendix S1.

Marine Fauna Management Plan

Chevron has prepared a draft Marine Fauna Management Plan (MFMP) which will be finalised prior to commencement of marine construction and offshore installation activities.

The purpose of the draft MFMP is to clearly outline the Project's environmental objectives in relation to Protected Marine Fauna and to describe the associated management measures in achieving these, including responsibilities, training, timing, monitoring, auditing, adaptive management, review and contingency procedures. It is inclusive of both construction phase and operational phase activities, associated with both downstream and upstream Project components.

The key objectives of the MFMP will be to:

- Reduce the likelihood injury/mortality to marine fauna through vessel strike
- Reduce the potential Project-attributable impacts to marine fauna associated with noise emissions
- Reduce the potential Project-attributable impacts to marine fauna associated with light emissions
- Minimise injury/mortality to marine fauna from non-dredge related construction activities including workforce recreation.

Construction Environmental Management Plan

Chevron has prepared a draft Construction Environmental Management Plan (CEMP) which will be finalised prior to commencement of construction. The aim of the CEMP is to set out the framework by which environmental risks associated with the onshore construction and near-shore marine installation activities will be managed.

The scope of the CEMP includes the major onshore and nearshore components for the Project (e.g. feed gas pipeline and gas processing facility) and associated construction (e.g. drilling, pipe laying and earthworks) and commissioning activities including:

- Product Loading Facility (PLF)
- Materials Offloading Facility (MOF) and breakwaters
- Pipeline shore crossing
- LNG and domgas plant
- Onshore support facilities
- Access roads
- Domgas pipeline.

The Draft CEMP is included in Appendix U1.

Operations Environmental Management Plan

Chevron will prepare a draft Operations Environmental Management Plan (OEMP) which will be finalised prior to commencement of operations. The purpose of the OEMP will be to manage the Project-attributable impacts that arise from onshore operations and associated activities including, LNG and Domgas production, FIFO operations, vehicle access and product shipping.

A key component of the Operations Environmental Management Plan will be to address the management of the Projects greenhouse gas emissions. The OEMP will set out the GHG objectives for initial operations and will set the long term Greenhouse Gas Emissions Targets for the Project.

The Operations Environmental Management Plan shall also require continued monitoring of advances technology in the area of offshore gas production and gas processing with the objective to deliver lower emission and improved energy efficiency. Where practicable these technologies may be incorporated into the design of future gas production systems, gas processing trains which may be retrofitted to existing Project facilities, where cost effective to do so.

Decommissioning Environmental Management Plan

Chevron will prepare a draft Decommissioning Environmental Management Plan (DEMP) to be approved by the EPA prior to the commencement of decommissioning.

The purpose of the DEMP will be to manage all activities associated with the shutdown and decommissioning of the project at the end of the project lifespan.

12.2.3 Tier 3 - Subsidiary Plans

As planning and design associated with construction, commissioning, operations, and decommissioning phases are finalised, a set of additional or Subsidiary Plans are likely to be required for the implementation of the Project. Subsidiary Plans may include:

- Environmental Plans which are required under legislation and/or impose relevant legal obligations on Chevron, but are not legally binding under the Ministerial Approvals of this EIS/ERMP.
- Management plans which are required for Chevron internal purposes but which are not legally binding in their own right.

Table 12.12: Subsidiary Plans and Secondary Permit Requirements

Plan / Permit	Legislation	Regulator
Shipping & Navigation Plan	*Navigable Waters Regulations 1958 - (WA)*	WA Department of Infrastructure and Planning
SAP Report and Sea Dumping Permits	*Environmental Protection (Sea Dumping) Act 1981 - (Cth)*	WA Department of Mines & Petroleum (DMP)
Offshore Drilling Environment Plans (for each campaign)	*Offshore Petroleum and Greenhouse Gas Storage Act 2006 (OPGGSA) - (Cth)*	DMP
Offshore Installation and Commissioning EP	*OPGGSA*	DMP
Offshore Operations EP	*OPGGSA*	DMP
Offshore Decommissioning EP	*OPGGSA*	DMP
Marine Pipeline Installation EMP (WA) and EP (Cth)	*Petroleum (Submerged Lands) Act 1982 (PSLA) - (WA)* *OPGGSA*	DMP
Offshore Oil Spill Contingency Plans	*PSLA* *OPGGSA*	DMP
Onshore Pipeline Installation EMP	*Petroleum Pipelines Act 1969 - (WA)*	DMP
Onshore Oil Spill Contingency Plan	*Petroleum and Geothermal Energy Resources Act 1967 -(WA)*	DMP
Mosquito Management Plan	*Environment Protection Act 1986 (WA)*	WA Department of Health
Aboriginal Cultural Heritage Plan	*Aboriginal Heritage Act 1972 -(WA)*	WA Department of Indigenous Affairs
Old Onslow Townsite Development and Impact Mitigation Plan	*Heritage of WA Act 1990 - (WA)*	Heritage Council of WA

Subsidiary Plans will be developed to satisfy regulatory requirements other than the EP and EPBC Acts, such plans will be submitted for regulatory approval to the relevant agencies independent of the submission of the EIS/ERMP.

Table 12.12 lists a number of key Subsidiary Plans which Chevron has identified as potentially required for the project to satisfy "other" regulatory processes. This list may change dependent on changes to project design and subsequent consultation with relevant agencies.

Subsidiary Plans developed for internal purposes will manage environmental risks specifically related to the Project's various works programs. Such plans will contain relevant policies, processes and work procedures agreed to between Chevron and its contractors designed to ensure that practicable environmental management measures are implemented and monitored for their effectiveness.

12.3 Conclusion

Chevron is committed to protecting the conservation values of the Project area during the construction, operation and decommissioning of the Project. To assist in meeting this commitment a comprehensive environmental management program has been developed that is consistent with recognised international standards and Chevron's OEMS. As part of this program a series of Outcome-based Conditions and Statutory EMPs will be developed and submitted for regulatory review.

Chevron will ensure that adequate resources, with clearly defined responsibilities and authorities, are committed to the Project's Environmental Management Program.

Chevron is confident that through the thoughtful implementation and strict adherence to the Environmental Management Program, which will include as a minimum the commitments and plans listed in Table 12.13, the environmental values of the Project and surrounding area will be protected.

Table 12.13: Wheatstone Environmental Management Commitments and Plans

Wheatstone Management Commitments	
Outcome-based Conditions	Coastal Processes: Management
	Mangrove Habitat Management
	Subtidal Benthic Primary Producer Habitat Management
	Marine Fauna Management
	Terrestrial Flora and Vegetation Management
	Terrestrial Fauna Protection
	Operational Marine Water and Sediment Quality Management
Statutory Management Plans	Coastal Processes Management Plan
	Dredging and Spoil Disposal Management Plan
	Marine Fauna Management Plan
	Construction Environmental Management Plan
	Operations Environmental Management Plan
	Decommissioning Environmental Management Plan
Subsidiary (Regulatory) Management Plans	Shipping and Navigation Plan
	SAP Report and Sea Dumping Permits
	Offshore Drilling Environment Plans (for each campaign)
	Offshore Installation and Commissioning EP
	Offshore Operations EP
	Offshore Decommissioning EP
	Marine Pipeline Installation EMP (WA) and EP (Cth)
	Onshore Pipeline Installation EMP
	Onshore Oil Spill Contingency Plan
	Offshore Oil Spill Contingency Plans
	Mosquito Management Plan
	Aboriginal Cultural Heritage Plan
	Old Onslow Town Site Development and Impact Mitigation Plan

EIS/ERMP Glossary, Abbreviations and Acronyms

Wheatstone Project EIS/ERMP Glossary

Term	Definition
Abiotic	Not associated with or derived from living organisms. Abiotic factors in an environment include such items as sunlight, temperature, wind patterns, and precipitation.
Abrasive blasting	Cleaning or abrading the surface of an object using an abrasive material propelled by compressed air, water or steam or by a wheel.
(Acid) Fizz test	The field test used for soils to test for the presence of carbonate minerals, whereby dilute hydrochloric acid is added to the soil. An effervescent fizzing reaction indicates the presence of carbonate minerals.
Acid Base Accounting (ABA)	The process by which the various acid producing components of the soil are compared with the acid neutralising components so that the soil's net acidity can be calculated.
Actual Acidity	A component of existing acidity. The soluble and exchangeable acidity already present in the soil, often as a consequence of previous oxidation of sulfides. It is this acidity that will be mobilised and discharged following a rainfall event. It is measured in the laboratory using the TAA method. It does not include the less soluble acidity (i.e. retained acidity) held in hydroxy-sulfate minerals such as jarosite.
Algae	Simple plant-like organisms that contain chlorophyll, allowing them to derive their energy needs from photosynthesis. Types of algae range from microscopic forms such as phytoplankton that are suspended in the water column to giant kelp.
"As far as practicable", "where practicable" and "practicable"	All mean reasonably practicable having regard to, among other things, local conditions and circumstances (including costs) and to the current state of technical knowledge.
Atmospheric emissions	Any emission or discharge to air, for any period of time, of solid, liquid or gaseous matter. Examples include, but are not limited to, dust and greenhouse gases.
Average net detectable mortality	The result of averaging the net detectable mortality of all monitoring sites within the zone, i.e. the mean of net detectable mortality of any zone.
Avifauna	All of the bird species of a given region, taken collectively.
Behavioural impact	Disruption of established behavioural patterns affecting reproductive or survival success.
Benthic habitats	Areas on the sea floor or seabed that support living organisms. Examples include, but are not limited to, limestone pavement, reefs, bare sand and deepwater soft sediments.
Benthic zone	The lowest levels in a body of water such as a sea or a lake, including the upper subsurface layers of the sediment.
Bioaccumulation	The increase in concentration of a usually toxic substance (such as a heavy metal like lead or mercury or a pesticide like DDT) in the tissues of a plant or an animal at a particular level in a biological food chain. Such toxins accumulate because they are absorbed at a faster rate than they can be excreted or broken down.

Wheatstone Project EIS/ERMP Glossary

Term	Definition
Biodiversity	The variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part. This includes diversity within species, between species and of ecosystems.
Biofouling	The unwanted build-up of organisms on human-made structures, in the marine environment especially on the submerged portions of ships' hulls, oil and gas platforms, jetties, etc. It also applies to similar growths on filters, inside pipelines, and on other items of equipment used, for example, in the wastewater treatment industry.
Bioregion	A bioregion is a biogeographical region characterised by a distinctive fauna and flora and made up of a group of interacting and related ecosystems. Terrestrial bioregions are defined in terms of their climate, geology, landforms and vegetation.
Biosecurity	Protection of all natural resources from biological invasion and threats.
Biosequestration	The process of converting a chemical compounds through biological processes to a chemically or physically isolated or inert form. The term is most commonly used to refer to the "locking", through photosynthesis, of atmospheric carbon dioxide (CO_2) into plant biomass (usually trees) to offset the effect of the CO_2 and other greenhouse gases released by the development of natural gas fields, the burning of fossil fuels, etc.
carbon dioxide equivalent (CO_2-e)	A measure, using carbon dioxide as the standard, used to compare the global warming potentials of the different greenhouse gases. For example, the global warming potential for methane over 100 years is 25; this means that the emission of one million tonnes of methane is equivalent to emissions of 25 million tonnes of carbon dioxide.
Chromium Suite	The acid base accounting approach used to calculate net acidity which uses the chromium reducible sulfur method to determine potential sulfidic acidity. A decision tree approach based on the pHKCl result is then used to determine the other components of the acid base account.
Cetacean	Various aquatic (mainly marine) mammals of the order *Cetacea*, (including whales, dolphins and porpoises) characterised by a nearly hairless body, front limbs modified into broad flippers and a flat notched tail.
Claypan	A type of ephemeral wetland often found in arid or semi-arid regions of the world.
Clearing	1. The killing, destruction, removal, severing, ringbarking or doing substantial damage to native vegetation including grass, shrubs, trees, tree stumps, tree roots, logs and brush. 2. The removal of noxious weeds and decayed vegetable matter. 3. The removal of surface obstructions such as concrete paving, concrete edging, drainage pits, foundations, fences and disused structures, but not underground obstructions such as drainage pipes or service conduits. 4. The removal of refuse such as pole stumps and rubbish resting on or protruding from the ground surface.

Wheatstone Project EIS/ERMP Glossary

Term	Definition
Condensate	In the oil and gas industry, condensate is the name given to the mixture of heavier hydrocarbons which are present in hydrocarbon containing reservoirs in gaseous form, but which condense into liquid form when extracted.
Consequence	The implication of the impact (as defined).
Construction	Construction includes any proposal-related construction and commissioning activities within the terrestrial and marine disturbance footprints, excluding investigatory works such as, but not limited to, geotechnical, geophysical, biological and cultural heritage surveys, baseline monitoring surveys and technology trials.
Construction period	The period from the date on which Chevron first commences construction of the Proposal until the date on which Chevron issues a notice of acceptance of work under the EPCM, or equivalent contract entered into in respect of the second LNG train of the gas treatment plant.
Contrast	The relationship between the luminance of an object and its background.
Controls	The methods used to eliminate or reduce the risk of an activity on the receiving environment.
Controlled Action	Category of DEWHA approvals process, means that the proposal requires approval by the Minister under the EPBC Act.
Controlled waste	Defined by the DEC as all liquid waste, and any waste that cannot be disposed at a Class I, II or III landfill site. Controlled Waste also includes asbestos, clinical or related waste, tyres and waste that has been immobilised or encapsulated.
Coral mortality definitions	Direct loss is defined as permanent removal of Benthic Primary Producer Habitat (BPPH) substrate and mortality of coral. Indirect loss is defined as mortality of coral with no removal BPPH. BPPH may return at some future time, but this will be dependent upon the condition of the substrate and successful recruitment. The change in coral mortality is determined by subtracting the baseline extent of gross coral mortality from the extent of gross coral mortality measured on a sampling occasion. Net detectable coral mortality at a monitoring location is the result of subtracting the change in coral mortality at the Reference Site from the change in coral mortality at that Monitoring Site. Average net detectable coral mortality is the result of averaging the net mortality of all monitoring locations within the Zone i.e. the mean of net mortality of any Zone. Gross coral mortality at a site is expressed as a percentage of total coral cover at the time of sampling at that monitoring location. In determining the coral loss, measurement uncertainty is to be taken into consideration.
Cumulative	Increasing or enlarging by successive addition.
Decibel (dB)	A unit used to measure sound.

Wheatstone Project EIS/ERMP Glossary

Term	Definition
Declared rare flora (DRF)	Taxa which have been adequately searched for, and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such, following approval by the Minister for the Environment, after recommendation by the State's Endangered Flora Consultative Committee.
Decrease in abundance	Loss of individual animals/plants.
Dominant coral species	Species with the highest relative percentage cover. Percentage cover is expressed as the proportion of total coral cover.
Dredge material	Material unearthed during the dredging program.
Dry break coupling/ break-away coupling	A coupling design to allow an operator to connect/disconnect hoses manually without spillage.
Duration	In relation to marine water quality, duration refers to the length of time, in hours, days or weeks, that a predetermined threshold of suspended sediment concentration is exceeded.
Dust	Generic term used to describe fine particles that are suspended in the atmosphere. This term is non-specific with respect to the size, shape and chemical make up of the particles, including PM10.
Earthworks	The movement or removal of dirt, rocks and soil. Earthworks include activities such as grading (removing topsoil), scraping, digging, and creating embankments and stockpiles.
Ecological community	All the interacting organisms living together in a specific habitat.
EIS/ERMP	The Environmental Impact Statement/Environmental Review and Management Programme for the proposed Wheatstone Project.
Endemic	Unique to an area; found nowhere else.
Endemism	Ecological state of being unique to a particular geographic location, such as a specific island, habitat type or other defined area.
Environmental aspect	An element or activity of a project or operation that may result in an impact upon the environment, e.g. gas emissions, light emissions, production of waste material or clearing of vegetation.
Environmental factor	An environmental receptor such as marine fauna or terrestrial flora.
Environmental harm	Direct or indirect harm to, or detrimental alteration of the environment. Further definition of the term can be found in section 3A(2) of the *Environmental Protection Act 1986*.
Environmental risk analysis	The systematic process undertaken to understand the nature of, and deduce the level of, environmental risk.

Wheatstone Project EIS/ERMP Glossary

Term	Definition
Environmental risk assessment	The overall process of environmental risk identification, analysis and evaluation.
Environmental risk evaluation	The process of comparing the level of risk against a set of risk criteria.
Environmental risk identification	The process of determining what might happen to impact the environment as the result of the implementation of a project etc., and where, when, why and how this could happen.
Ephemeral	Something that exists for a short period of time e.g. an ephemeral water body is a wetland, river or lake that only exists for a short period following precipitation.
Equivalent continuous sound level (LAeq)	The level of a notional steady sound that at a given position and over a defined period of time would have the same A-weighted acoustic energy as the fluctuating noise.
Fauna relocation	The capture of fauna in work areas for release elsewhere.
Fauna removal	The release of fauna from trenches, dams, bunded areas etc.
Frequency	In relation to marine water quality, frequency refers to how often a predetermined threshold of suspended sediment concentration is exceeded.
Fuel NO_x	NO_x emissions generated from combustion of organic nitrogen in fuel.
Geotechnical	Relating to engineering study of subsurface soils, involving specialised drilling or sampling for soil analysis and testing.
Greenfield	Projects constructed on previously undeveloped land.
Greenhouse gas abatement "beyond no regrets measures"	Measures that involve additional costs to the Proposal which are unlikely to be recovered.
Greenhouse gas abatement "no regrets measures"	Measures that are cost-neutral and do not add additional cost to the Proposal.
Groundwater dependant vegetation	Vegetation units comprising species that source some or all of their water requirements from groundwater.
Habitat	The area or environment where an organism or ecological community normally lives or occurs.
Hazard	A source of potential harm, or a situation with a potential to cause loss or adverse effect. Hazard has the same meaning as "threat".

Wheatstone Project EIS/ERMP Glossary

Term	Definition
Hazardous materials	Any substance (liquid or solid) that has the potential to cause harm to the environment or living organisms. Examples include concentrated RO brine, cement dust, paint, fuels and solvents.
Herpetofauna	All of the reptile and amphibian species of a given region, taken collectively.
Hot work	Any activity in a restricted/designated area, which either uses or could generate a fire through a naked flame, heat or sparks.
IBRA	Interim Biogeographic Regionalisation of Australia.
Illuminance	A photometric term that quantifies light incident on a surface or plane. Illuminance is commonly called light level. It is expressed as lumens per square foot (footcandles), or lumens per square meter (lux).
IMCRA	Interim Marine and Coastal Regionalisation for Australia.
Impact	Direct interaction of a stressor with the environment.
Intensity	In relation to marine water quality, intensity refers to the concentration of suspended sediment in the water.
Introduced fauna	An animal (either established or not) in any given ecosystem, which is not native to that ecosystem and has arrived there usually as a result of human activities.
Introduced flora	Flora species that have been introduced to an area. May include species considered to be "weeds".
Introduced marine species	Species other than native species known or those likely to occur in the waters of the Pilbara Inshore and Offshore Region. (Some of these may be southern Australian or west coast endemics that do not occur in the Indo-West Pacific.)
Introduced marine pests	Introduced marine species that do, or may, threaten biodiversity in the Pilbara Inshore and Offshore Region, as determined by the National Introduced Marine Pests Coordination Group (2006), or any subsequent NIMPCG revisions.
Invertebrate fauna	Animals that do not have a backbone (vertebrae). Examples include, but are not limited to, spiders, scorpions, land snails, millipedes and some subterranean fauna.
Jarosite	Jarosite is a characteristic pale yellow mineral deposit that can precipitate as pore fillings and coatings on fissures. Where there is a fluctuating watertable, jarosite may be found along cracks and root channels in the soil. However, jarosite is not always found in AASS.
Light Emitting Diode (LED)	A semiconductor device that emits incoherent narrow-spectrum light.
Light glow	Atmospheric scattering of light particles that result in a luminescent background or sky.
Light spill	Excessive brightening of the environment from both direct light and light glow.

Wheatstone Project EIS/ERMP Glossary

Term	Definition
Likelihood	The probability of a stressor impacting on the key receptors.
Liquefied natural gas (LNG)	Natural gas that has been converted to liquid form by cooling to under –160 °C. It contains only the lightest gaseous hydrocarbons of the alkane series, predominantly methane (CH_4), but also ethane (C_2H_6), a small amount of propane (C_3H_8), and a very small amount of butane (C_4H_{10}).
Liquefied petroleum gas (LPG)	The generic name for mixtures of the heavier gaseous hydrocarbons of the alkane series, which are converted to liquid form by slight compression. It is usually predominantly propane (C_3H_8) and butane (C_4H_{10}), but may contain small quantities of pentane (C_5H_{12}).
Listed marine fauna	Marine fauna that are included on lists of threatened species (State, Commonwealth or international).
Local area	In relation to marine environment, the local area refers to areas within the defined BPPH Management Units. In relation to the terrestrial environment, the local area refers to an approximate 2 km radius of the onshore Project area.
Long term	In relation to marine impacts, long term refers to greater than ten years. In relation to terrestrial impacts, long term refers to greater than five years.
Low pressure sodium-vapour (LPS) lamp	Electric lamp that contains sodium, neon and argon and produces amber yellow light.
Luminaries	A complete lighting unit that produces and distributes light, including the fixture, ballast, mounting and lamp(s).
Lux	A unit of measure of illuminance and luminous emittance.
Macroalgae	Macroscopic (visible to the naked eye) and multicellular algae (e.g. seaweed, kelp), in contrast with microscopic algae.
Marine disturbance footprint	The area of the seabed to be disturbed by construction or operations activities associated with the marine facilities.
Material environmental harm	Environmental harm that is neither trivial nor negligible.
Material Safety Data Sheet (MSDS)	A widely used system for cataloguing information on substances, such as chemicals, chemical compounds, and chemical mixtures. MSDS information may include instructions for the safe use and potential hazards associated with a particular material or product.

Wheatstone Project EIS/ERMP Glossary

Term	Definition
Matters of National Environmental Significance	Under the EPBC Act, matters of National Environmental Significance are: • Listed threatened species and ecological communities • Migratory species protected under international agreements • Ramsar wetlands of international importance • The Commonwealth marine environment • World Heritage properties • National Heritage places • Great Barrier Reef Marine Park • Nuclear actions.
Minister	Western Australian Minister for the Environment.
Monochromatic	Description of a light source emitting a very narrow set of wavelengths (i.e. a single colour).
Nearshore	Marine habitat from the 20m contour to the shoreline.
Net acidity	The result obtained when the values for various components of soil acidity and acid neutralising capacity are substituted into the Acid Base Accounting equation. Calculated as: Net Acidity = Potential Sulfidic Acidity + Existing Acidity – (Acid Neutralising Capacity).
Noise pollution	Unwanted, harmful or offending sound.
Non-hazardous liquid waste	Used or waste liquids that are considered harmless to the environment and living organisms.
North West Shelf	A geographic province rather than a physiographic feature. The North West Shelf extends about 2400 km along the northwest margin of the continent, and includes the continental shelf proper and the marginal platforms and plateaus, out to about the 2000 m isobath. The entire region lies within the tropics.
Obligate	Restricted to a particular set of environmental conditions.
Offshore	Marine habitat beyond the 20m contour.
Onshore	Above the water level at the low tide.
Operations	For the respective LNG trains, this is the period from the date on which Chevron issues a notice of acceptance of work under the Engineering, Procurement and Construction Management (EPCM) contract, or equivalent contract entered into in respect of that LNG train of the Gas Treatment Plant; until the date on which Chevron commences decommissioning of that LNG train.
Outcome-based Conditions	Conditions contained within this EIS/ERMP which are legally binding under the Ministerial Approvals of this EIS/ERMP.

Wheatstone Project EIS/ERMP Glossary

Term	Definition
Ozone depleting substances (ODS)	Includes: • Chlorofluorocarbons (CFCs) • Halon • Carbon tetrachloride • Methyl chloroform • Hydrobromofluorocarbons (HBFCs) • Hydrochlorofluorocarbons (HCFCs) • Methyl bromide • Bromochloromethane (BCM).
Particulate matter (PM)	A term used to describe a complex group of air pollutants that are regarded as a severe health hazard. These pollutants are a mixture of fine airborne solid particles and liquid droplets (aerosols) and include, for example, smoke and dust particles, pollen, a variety of chemical compounds, trace metals, and nitrogen oxides (NO_x). Particulate matter is usually categorised as PM_{10} or $PM_{2.5}$. The fraction of suspended particles whose diameter is less than 10 micrometres (10 µm or ten millionths of a metre) is PM_{10}; these particles can enter the main passages in the lungs. The smallest particles, designated $PM_{2.5}$ (less than 2.5 µm in diameter), can enter the fine tubules deep in the lungs.
Pollution	Direct or indirect alteration of the environment to its detriment or degradation.
Population	A group of organisms of the same species occupying an area.
Population viability	The ability of a group of organisms (occupying an area) to survive in that area.
Porites	An important genus of long-lived, reef building corals.
Potential (sulfidic) acidity	The latent acidity in ASS that will be released if the sulfide minerals they contain (e.g. pyrite) are fully oxidised. It can be estimated by titration (i.e. TSA) if no acid neutralising material is present, or calculated from SPOS or SCR results.
Primary air pollutants	Gaseous emissions containing toxic gases, often produced by burning fossil fuels (e.g. diesel). Examples include, but are not limited to: oxides of nitrogen (NOx), oxides of sulfur (SOx), hydrogen sulfide (H2S), volatile organic compounds (e.g. hydrocarbons) and carbon monoxide.
The Project	The Wheatstone Project: the Proposal (under the WA EP Act); or the Controlled Action (under the Commonwealth EPBC Act), that is the subject of this assessment.
Project area	The geographic locations in, at or through which the work or part thereof is to be performed.
Proposal	Term used by EPA to refer to the Project.
Putrescible solid waste	Solid waste that easily decomposes. Examples include food scraps and green waste.
Receptor	An ecological entity (e.g. species, population, community or habitat) exposed to a stressor.
Reduced viability	Reduced ability of a population to persist through time.

Wheatstone Project EIS/ERMP Glossary

Term	Definition
Region	In relation to the marine environment, Region refers to the Pilbara bioregion as defined by the Interim Marine and Coastal Regionalisation for Australia (IMCRA). In relation to the terrestrial environment, Region refers to the Carnarvon and Pilbara Bioregions as defined by the Interim Biogeographic Regionalisation of Australia (IBRA).
Registered Site	An indigenous heritage site that is listed on the State (WA) Aboriginal Sites Register.
Rehabilitation	The ongoing management and monitoring of the site after reinstatement works are completed and handover of the site has been accepted by the Company.
Reef	Sedimentary features, built by the interaction of organisms and their environment, that have synoptic relief and whose biotic composition differs from that found on and beneath the surrounding sea floor. A reef lies beneath the surface of the water. Reefs are held up by a macroscopic skeletal framework. Coral reefs are an excellent example of this kind. Corals and calcareous algae grow on top of one another and form a three-dimensional framework that is modified in various ways by other organisms and inorganic processes.
Reinstatement	Clean up and reconstruction of a site or area to mimic pre-existing landform. Reinstatement also includes ground preparation (ripping, scarifying etc.) prior to the spread of topsoil and vegetative material.
Residual risk	In environmental risk management, the "residual risk" is the level of risk remaining after the implementation of risk control strategies.
Riparian vegetation	Riparian areas are those plant communities adjacent to and affected by surface or ground water of perennial or ephemeral water bodies such as rivers, streams, lakes, ponds, playas, or drainage ways. These areas have distinctly different vegetation than adjacent areas or have species similar to surrounding areas that exhibit a more vigorous or robust growth form.
Retained Acidity	The "less available" fraction of the existing acidity (not measured by the TAA) that may be released slowly into the environment by hydrolysis of relatively insoluble sulfate salts (such as jarosite, natrojarosite, and other iron and aluminium hydroxy-sulfate minerals).
Seagrass	Unrelated to seaweed, seagrasses are the flowering plants of the ocean, having roots, stems, leaves and inconspicuous flowers with fruits and seeds much like the flowering plants of the land.
Sediment pond	A pond or sump that allows solid particles to sink to the bottom and water to flow through.
Self-neutralising soils	This term is given to acid sulfate soils where there is sufficient acid neutralising capacity (with the relevant safety factor applied) to neutralise the potential sulfidic acidity held in the soil (i.e. the net acidity from the Acid Base Account is zero or negative). Soils may be "self-neutralising" due to an abundance of naturally occurring calcium or magnesium carbonates (e.g. crushed shells, marine animal exoskeletons, coral) or other acid-neutralising material.

Wheatstone Project EIS/ERMP Glossary

Term	Definition
Serious environmental harm	Environmental harm that: a. is irreversible, of a high impact or on a wide scale b. is significant or in an area of high conservation value or special significance and is neither trivial nor negligible.
Short-range endemic (SRE)	A taxonomic group of invertebrates that are unique to an area; found nowhere else and have naturally small distributions (i.e. < 10 000 km^2).
Short term	Less than five years.
Socioeconomic environment	The combination of external social and economic conditions that influence the operation and performance of the Project.
Species viability	The ability of the species to persist over time.
Statistical power	The probability of detecting a meaningful difference, or effect, if one was to occur.
Statutory Environmental Management Plans (EMP)	Environmental Management Plans which are required to be submitted for regulatory review/ approval as part of the Project's Ministerial Approvals process. Statutory EMPs are triggered by the requirements of the West Australian *Environmental Protection Act 1986*, the Commonwealth *Environment Protection Biodiversity Conservation Act 1999*, and / or the requirements of specific guidelines that have been approved by the EPA and DEWHA for this Project
Stormwater	Natural rainwater runoff that occurs during or after storms or heavy rainfall events.
Sub-dominant coral species	Species, excluding dominant coral species, which have greater than or equal to 5% cover. Percentage cover is expressed as the proportion of total coral cover.
Substantially commenced	Physical construction activities for, and progress of, an important or essential element or elements of the Project scope.
Subsidiary Plans	Environmental plans which are required by and/or impose relevant legal obligations on Chevron under legislation, but are not legally binding under the Ministerial Approvals of this EIS/ERMP. Management plans which are required for Chevron internal purposes but which are not legally binding in their own right are also included in the list of Subsidiary Plans. Subsidiary Plans will not be submitted for Ministerial Approval with this EIS/ERMP.
Subterranean fauna	Fauna that live in sub-surface habitats. In Western Australia these include: • Stygofauna - groundwater-dwelling aquatic fauna. • Troglofauna - terrestrial fauna that inhabit sub-surface air-filled cavities above the groundwater table.
Taxon	A taxonomic category or group, such as a phylum, order, family, genus, or species. Taxa is the plural of taxon.

Wheatstone Project EIS/ERMP Glossary

Term	Definition
Terrestrial disturbance footprint	The area to be disturbed by construction or operations activities associated with the terrestrial facilities.
Thermal NOx	NO_x emissions generated by the oxidation of atmospheric nitrogen at flame temperatures >1300 °C.
Topsoil	The top layer of soil that stores seed and acts as the growth medium in which vegetation can establish itself.
Translocation	The capture of fauna from the Project footprint area (including work areas) for release elsewhere.
Trunkline	A main pipeline.
Upstream	The upstream scope of work for the Wheatstone Project. The battery limit extends from the wellheads on the seabed at the gas fields through a network of subsea infrastructure and pipelines to the first valves upstream of the LNG plant inlet facilities.
Vegetation	Any aquatic or terrestrial plant, whether it is dead or alive. Examples include, but are not limited to, grass, shrubs, trees, tree stumps, tree roots, logs, seeds and brush.
Vegetation association	Comprises unique flora assemblages, or unique vegetation communities, that help to identify the association.
Vertebrate fauna	Animals that have a backbone (vertebrae).
Vuggy	Rock containing small cavities, often with a mineral lining.
Weed	Any plant that requires some form of action to reduce its effect on the economy, the environment, human health and amenity. Weeds are also known as invasive plants.
Widespread	Impacts extending to areas outside the identified impact zone of the Project.

Wheatstone Project Abbreviations and Acronyms

Abbreviation	Meaning
°C	Degrees Celcius
2D	Two-dimensional
3D	Three-dimensional
4WD	Four-wheel drive
ABS	Australian Bureau of Statistics
ABU	Chevron Australasian Business Unit (previously ASBU)
ADCP	Acoustic Doppler current profilers
ADSL	Asymmetric Digital Subscriber Line
AGC	Activated granular carbon
AGRU	Acid Gas Removal Unit
AH Act (WA)	Western Australian *Aboriginal Heritage Act 1972*
AHD	Australian height datum
AIHW	Australian Institute of Health and Wellbeing
ALARP	As low as reasonably practicable
aMDEA	Activated methyl diethanolamine
AMSA	Australian Maritime Safety Authority
ANC	Acid neutralising capacity
ANL	Assigned Noise Level
ANRA	Australian Natural Resource Atlas
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZSIC	Australia New Zealand Standard Industry Classifications
APPEA	Australian Petroleum Production and Exploration Association Limited
AQIS	Australian Quarantine and Inspection Service
ARI	Average recurrence interval
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AS	Australian Standard
ASBU	Chevron Australasian Business Unit
ASS	Acid sulfate soils
BAM Act	WA Biosecurity and Agricultural Management Act 2007
bbl	barrels
BEMP	Blasting Environmental Management Plan
BFA	Barmah Forest Virus
BOD_5	Five day biochemical oxygen demand
BOG	Boil Off Gas
BoM	Bureau of Meteorology
Bonn Convention	Convention on the Conservation of Migratory Species of Wild Animals
BPD	Barrels per day
BPP	Benthic primary producers

Wheatstone Project Abbreviations and Acronyms

Abbreviation	Meaning
BPPH	Benthic Primary Producers Habitat
BSP	Benthic secondary producers
BSPH	Benthic secondary producers habitat
BTAI	Burrabalayji Thalanyji Association Incorporated
BTEX	Benzene, toluene, ethyl-benzene, xylene
bwpd	Barrels of water per day
$CaCO_3$	Calcium carbonate
CALM	Western Australian Department of Conservation and Land Management
CAMBA	China-Australia Migratory Birds Agreement
CAR	Carnarvon IBRA bioregion
CD	Chart Datum
CEMP	Construction Environmental Management Plan
CEO	Chief Executive Officer
CH_4	Methane
CHARM	Chemical Hazard Assessment and Risk Management
Chevron	Chevron Australia Pty Ltd.
CHMP	Cultural Heritage Management Plan
CLG	Cumulative loss guideline
CLT	Cumulative loss threshold
CMST	Centre for Marine Science and Technology
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CO	Carbon monoxide
Condensate	Natural gas condensate
COPC	Contaminants of potential concern
CORMIX	Cornell Mixing Zone Expert System
COS	Carbonyl sulfides
CPI	Coalescing plate interceptor
CPMP	Coastal Processes Management Plan
CPRS	Carbon Pollution Reduction Scheme – White Paper
CRCP	Cane River Conservation Park
CRG	Community Reference Group
CSD	Cutter Suction Dredge
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cth	Commonwealth

Wheatstone Project Abbreviations and Acronyms

Abbreviation	Meaning
CUCA	Common User Coastal Access
CW	Cooling water
CWR	Centre for Whale Research
dB	Decibels
dB(A)	Noise measures weight to approximate human hearing
DBNGP	Dampier to Bunbury Natural Gas Pipeline
DDP	LWI/Bechtel Dredging and Disposal Plan
DEC	Western Australian Department of Environment and Conservation
DEH	Commonwealth Department of Environment and Heritage (now DEWHA)
DEMP	Decommissioning Environmental Management Plan
DET	Western Australian Department of Education and Training
DEWHA	Commonwealth Department of the Environment, Water, Heritage and the Arts
DHI	DHI WA Pty Ltd
DIA	Western Australian Department of Indigenous Affairs
DLE	Dry Low Emissions
DMP	Department of Mines and Petroleum
DO	Dissolved oxygen
DoE	Western Australian Department of Environment (now DEC)
DoF	Western Australian Department of Fisheries
DoH	Department of Health
Domgas	Domestic gas plant
DoW	Western Australian Department of Water
DPI	Western Australian Department for Planning and Infrastructure
DPS	Dynamic Positioning System
DRF	Declared Rare Flora
DSD	Western Australian Department of State Development
DSDMP	Dredging and Spoil Disposal Management Plan
dwt	Dry weight
E	Light attenuation coefficient (interchangeable with K)
EAG	Environmental Assessment Guideline
EC	Electrical conductivity
EC_{50}	Half maximal effective concentration
ECU	Ecosystem unit
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EMS	Environmental Management System

Wheatstone Project Abbreviations and Acronyms

Abbreviation	Meaning
ENGO	Environmental Non-government Organisation
EP	Environmental Plan
EPA	Western Australian Environmental Protection Authority
EP Act (WA)	Western Australian *Environmental Protection Act 1986*
EPBC Act (Cth)	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EQC	Environmental Quality Criteria
ERMP	Environmental Review and Management Programme
EZI	Estimated Zone of Impact
FEED	Front End Engineering Design
FESA	Fire and Emergency Services Authority of Western Australia
FID	Final Investment Decision
FIFO	Fly-in, fly-out
Framework	Wheatstone Environmental Management Framework
g/m^2/month	Grams per square metre per month
GDE	Groundwater dependent ecosystem
GDP	Gross Domestic Product
GEMS	Global Environmental Modelling Systems Pty Ltd.
GHG	Greenhouse Gas
GL	Giga litres
GS	Guidance Statement
GSWA	Geological Survey of Western Australia
H_2S	Hydrogen sulfide
ha	Hectare(s)
HACC	Home and Community Care
HAT	Highest astronomical tide
HCWA	Heritage Council Western Australia
HDD	Horizontal directional drilling
HES	Health, Environment and Safety
HP flare	High pressure flare
HPS	High Pressure Sodium
HQ	Hazard quotient
hr	Hour(s)
Hz	Hertz
I & B	Insulate and Blowdown
IBRA	Interim Biogeographic Regionalisation for Australia
IMCRA	Integrated Marine and Coastal Regionalisation for Australia
IMP	Introduced marine pest

Wheatstone Project Abbreviations and Acronyms

Abbreviation	Meaning
IPIECA	International Petroleum Industry Environmental Conservation Association
ISO	International Organisation for Standardisation
ISO 14001	ISO 14001:2004 Environmental Management Systems – Requirements with guidance for use
JA	Joint Authorities
JAMBA	Japan Australia Migratory Birds Agreement
JV	Joint Venture
kg/ha/yr	Kilograms per hectare per year
$kg/m^2/day$	Kilograms per square metre per day
kg/m^3	Kilogram per cubic metre
kg/s	Kilograms per second
KHI	Kinetic hydrate inhibitor
kL	10^3 Litres
kL/day	Kilolitres per day
km	Kilometre
kt	Kilotonnes
kWA	Kilowatt amps
LA_1	A noise level that is not to be exceeded for more than 1% of the time
LA_{10}	A noise level that is not to be exceeded for more than 10% of the time
LA_{90}	A noise level that is not to be exceeded for more than 90% of the time
LAT	Lowest astronomical tide
LAU	Local Assessment Unit
LC_{50}	Lethal concentration for 50% of an aquatic population
LEC	LeProvost Environmental Consultants
LEP	Levels of ecological protection
London Convention	International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
LP flare	Low pressure flare
Lux	$Lumens/m^2$
LWI	Lanier Walingford International
m	metres
m^2	Square metres
m^3	Cubic metres
m^3/sec	Cubic metres per second
m^3/hr	Cubic metres per hour
m^3/day	Cubic metres per day
MA	Million years ago

Wheatstone Project Abbreviations and Acronyms

Abbreviation	Meaning
Macedon	BHP Billiton/Apache Macedon Gas Development
MARPOL	"Marine Pollution". Refers to the International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978.
mbgl	Metres below ground level
MCA	Multi-Criteria Analysis
MCMP	Marine and Coastal Management Plan
MEG	Mono ethylene glycol
MFMP	Marine Fauna Management Plan
$mg/cm^2.d$	Milligrams per square centimetre per day
mg/L	Milligrams per litre
MHWS	Mean high water springs
ML	Megalitres
mm	Millimetres
Mm^3	Million cubic metres
MMscfd	Million standard cubic feet per day
MODIS	Moderate-Resolution Imaging Spectroradiometer
MODU	Mobile offshore drilling unit
MOF	Materials Offloading Facility
MOPP	Marine Oil Pollution Plan
MPA	Marine Protected Area
MPB	Red microalgal mats
MPRSWG	Marine Parks and Reserves Selection Working Group
MSL	Mean sea level
MTPA	Million tonnes per annum
MVA	Million volt amps
MVE	Murray Valley Encephalitis
MW	Megawatts
MWSQMP	Marine Water and Sediment Quality Management Plan
N_2	Nitrogen
N_2O	Nitrous oxide
NAGD	National Assessment Guidelines for Dredging
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NES	National Environmental Significance
NGL	Natural Gas Liquids
NGO	Non-government organisation
N/ha/yr	Nitrogen depositions per hectare per year
NIMPCG	National Introduced Marine Pests Coordination Group

Wheatstone Project Abbreviations and Acronyms

Abbreviation	Meaning
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_3-	nitrate
NOEC	No Effect Concentration
NOPSA	National Offshore Petroleum Safety Authority
NORM	Naturally occurring radioactive material
NO_x	General terms for oxides of nitrogen
NPI	National Pollution Inventory
NRM	Natural Resource Management
NRMMC	National Resource Management Ministerial Council
NRU	Nitrogen Rejection Unit
NTU	Nephelometric turbidity units
NWCH	North West Coastal Highway
NWS	North West Shelf
NWSJV	North West Shelf Joint Venture
O_3	Ozone
OBC	Outcome-based condition
OCNS	Offshore Chemical Notification Scheme
OE	Operational Excellence
OEC	Onshore Environmental Consultants
OEMP	Operations Environmental Management Plan
OEMS	Operational Excellence Management System
OEPA	Office of the Environmental Protection Authority
ONPMF	Onslow Prawn Managed Fishery
OPGGS Act (Cth)	Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006*
OSPAR	Oslo and Paris Commissions
OSSP	Onslow Solar Salt Project
PACC	Pilbara Area Consultative Committee
PAGERA	*Petroleum and Geothermal Energy Resources Act* 1967
PAH	Polycyclic aromatic hydrocarbon
PASS	Potential acid sulfate soils
Pb	Lead
PCWQCO	Pilbara Coastal Water Quality Consultation Outcomes
PEC	Priority Ecological Community
PG	Perspectives Group
PIANC	World Association for Waterborne Transport Infrastructure
PICC	Pilbara Industry's Community Council

Wheatstone Project Abbreviations and Acronyms

Abbreviation	Meaning
PIL	Pilbara IBRA bioregion
PIN	Pilbara Nearshore Region
PLF	Product Loading Facility
PLONOR	Posing little or no risk
$PM_{2.5}$	Particulate matter of 2.5 microns or less
PM_{10}	Particulate matter of 10 microns or less
PNEC	Predicted No Effect Concentration
PoM	Port of Melbourne
PON	Pilbara Offshore Region
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per thousand
Program	Environmental Management Program
Project	Proposed Wheatstone Project
PW	Produced water (including formation water)
PCWQCO	Pilbara Coastal Water Quality Consultation Outcomes
RAN	Royal Australian Navy
RFDS	Royal Flying Doctor Service
RFSU	Ready for Start-Up
RO	Reverse osmosis
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RORO	Roll-on, roll-off
ROV	Remotely-operated underwater vehicle
R-SH	Mercaptans
RRV	Ross River Virus
RWM Act	*Radioactive Waste Management Act 2005*
SAP	Sampling and Analysis Plan
SBM	Synthetic based mud
Scarborough	Exxon Mobil/BHP Billiton Scarborough (North West Shelf) Pilbara LNG Processing Plant
Scoping Document	Wheatstone Environmental Scoping Document
SHIA	Social and Health Impact Assessment
SIA	Strategic Industrial Area
SKM	Sinclair Knight Merz Pty Ltd.
SIC	Shared infrastructure corridor
Sm^3	Standard cubic metres
SMFG	Size Management Fish Grounds
SO_2	Sulfur dioxide
SO_x	General term for sulfur oxides

Wheatstone Project Abbreviations and Acronyms

Abbreviation	Meaning
SOPEP	Ship based oil spill emergency plans
SPP	State Planning Policy
SQ	Sediment quality
SRE	Short range endemic
SSC	Suspended sediment concentrations
SST	Sea surface temperatures
STD	Sexually transmitted disease
SVT	SVT Engineering Consultancy
SWQMS	State Water Quality Management Strategy
TAPM	The air pollution model
TBT	tributyltin
TC	Tropical cyclone
tCO_{2e}/yr	Tonnes carbon dioxide per year
T/day	Tonnes per day
TDS	Total dissolved solids
TEC	Threatened Ecological Community
TEG	Tri-ethylene glycol
TN	Total nitrogen
TP	Total phosphorus
TPA	Tonnes per annum
TSHD	Trailing Suction Hopper Dredge
TPH	Total petroleum hydrocarbons
TSP	Total suspended particulates
TSS	Total suspended solids
t/yr	Tonnes per year
UKFWR	United Kingdom Foundation for Water Research
UNEP	United Nations Environment Program
URS	URS Australia Pty Ltd
USA	United States of America
USEPA	United States Environmental Protection Authority
UWA	University of Western Australia
VOCs	Volatile organic compounds
VSP	Vertical seismic profiling
VU	Vegetation Unit
WA	Western Australia
WAA	Wheatstone Assessment Area
WAPC	Western Australian Planning Commission

Wheatstone Project Abbreviations and Acronyms

Abbreviation	Meaning
WAPET	West Australian Petroleum Pty Ltd
WBM	Water based mud
WC Act (WA)	*Western Australian Wildlife Conservation Act 1950*
WHO	World Health Organisation
WHR	Waste heat recovery
WHRU	Waste heat recovery unit
WLNG	Wheatstone LNG Plant
WP	Wheatstone Platform
WQ	Water quality
WSQMP	Water sediment and quality management plan
WWF	World Wildlife Fund
WWTP	Waste water treatment plant
Xi	Irritant material
µg/L	Micrograms per litre
$\mu g/m^3$	Micrograms per cubic metre
µPa	micropascal
µS/cm	Microseimens/centimetre

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AMSA – see Australian Maritime Safety Authority

ANRA – see Australian Natural Resources Atlas

ANZECC/ARMCANZ – see Australia and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand

APPEA – see Australian Petroleum Production & Exploration Association Limited

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