Technical Appendices
Q6, Q7, R1, S1, T1, U1, V1 and W1

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

July 2010

Wheatstone Project

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Title: Draft Environmental Impact Statement/Environmental Review and Management Programme for the Proposed Wheatstone Project: Technical Appendices Q6, Q7, R1, S1, T1, U1, V1 and W1

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Appendix Q6

Wheatstone Project Ashburton River Flow and Discharges Study

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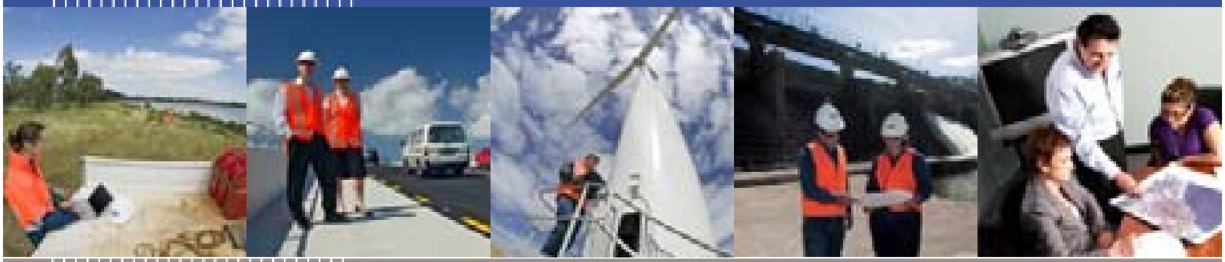

Report

Project Wheatstone Ashburton River Flow and Discharges Study

5 MAY 2010

Prepared for

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1 Introduction

1.1 Background and Objectives

Chevron Australia Pty Ltd proposes to construct and operate a multi-train Liquefied Natural Gas (LNG) and domestic gas (Domgas) plant 12 km south west of Onslow on the Pilbara Coast. The LNG and Domgas plant will initially process gas from fields located approximately 200 km offshore from Onslow in the West Carnarvon Basin and other yet-to-be determined gas fields. The project is referred to as the Wheatstone Project and "Ashburton North" is the proposed site for the LNG and Domgas plant. The Project will require the installation of gas gathering, export and processing facilities in Commonwealth and State Waters and on land. The LNG plant will have a maximum capacity of 25 Million Tonnes Per Annum (MTPA) of LNG.

The Wheatstone Project has been referred to the State Environmental Protection Authority (EPA) and the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA). The investigations outlined in this report have been conducted to support the environmental impact assessment process.

A large scale capital and maintenance dredging program, including dredge material placement, will be undertaken as part of this process. This involves the creation of a navigational channel, a turning basin, and port facilities, which are required for export tankers servicing the facilities. During the construction phase of these facilities significant quantities of sediments may be re-suspended within the coastal waters. To gain a realistic understanding of the significance of changes in water quality that result from construction and operational activities it is fundamental to first determine levels of natural variation. The Ashburton River is the largest river within the project area and could (particularly when it is in flood) make a significant contribution to the sediment and nutrient loads along the coast. Coastal hydrodynamic modelling of sediment plumes likely to arise from dredging operations in the construction of the shipping channel and port facilities (MOF) is being undertaken for Chevron in order to predict likely environmental impacts. However, a better quantitative understanding is required of the temporal variation in background suspended sediment and nutrient loads that are discharged from the Ashburton River.

Sediment cells are segments of the coast in which sediments derived from a common origin or source can be traced along transport paths to a sink where they are temporarily or permanently lost to the coast. The Ashburton sediment cell has two sectors; the shore between Tubridgi Point and Entrance Point at the mouth of the Ashburton River, and the eastern shore from the river mouth to Coolgra Point (Damara, 2010). The Ashburton River is typical of a pulsed tropical river system, which experiences high levels of rainfall almost exclusively during the summer months. Within the Ashburton River catchment (78,777 km^2) alluvial soils are varied as a result of a wide range of parent materials and climatic conditions encountered. Collectively these features will influence the magnitude and frequency of sediment and nutrient discharges from the Ashburton River.

The aim of this study is to estimate sediment particle size distribution, and the annual load of suspended sediment, and nitrogen and phosphorus content in water flowing from the Ashburton River into the Ashburton sediment cell.

1.2 History of Sediment Discharge at Onslow Port

Little historical data exists on sediment and nutrient discharges prior to official records which began in recent decades. However, anecdotal observations suggest the Ashburton River is historically associated with large sediment movements. The original town of Onslow was gazetted as a town site on 26 October 1885 (Shire of Ashburton, 2008). Agricultural stations developed along the Ashburton River and numerous gold mines developed throughout the hinterland. The port of Onslow was then developed at the head of the Ashburton River delta to support these industries.

Sediment build up at the mouth of the Ashburton River proved to be a problem for the port, and by 1925 the port facilities at the mouth of the Ashburton River were affected by the silting up of the river, preventing ships from servicing the port. Consequently, the town was moved some eighteen kilometres to the east to where it is today (Shire of Onslow, 2008).

1.3 Suspended Sediment and Nutrient Loads in Rivers

A number of factors determine the occurrence and movement of sediment in river water including water discharge, sediment concentration and size, shape, velocity and bulk density of the sediment particles.

The amount of sediment generated by a catchment is primarily from three processes (Bowyer, 1973, Prosser et al., 2002):

- Runoff on the land (termed surface wash, rill erosion and hill slope erosion);
- Erosion of gullies formed as a result of land clearing or grazing (channel erosion); and
- Erosion of the banks of streams and rivers.

Steep slopes, high channel density and high rainfall erosivity are the other factors contributing to inherent risk of sediment transport to streams.

In a major river, the amount of sediment delivered depends on the erodability of each of its sub-catchments and the intensity of the rainfall on each of them. Therefore, for any given flow in the main river, the concentration of sediment carried depends upon the rainfall distribution and intensities within the sub-catchments and the characteristics (vegetation cover, erosion potential etc) of the sub-catchments.

The settling rate of particles is dependent on particle size, with larger particles settling first. Larger sand particles (generally classified as greater than 63 µm diameter) are generally found at higher concentrations closer to the river bed, while finer clay and silt particles (less than 63 µm diameter) are generally fairly uniformly distributed through the river body. As the stream velocity increases, larger particles will be collected and suspended in the river body (Bowyer, 1973).

There are two main types of sediment load in rivers (Bowyer, 1973):

- Suspended load – Consisting of largely the fine particles which are carried along in suspension in the body of the river. Suspended load can constitute as much as 80 – 90% of the total sediment load. In general, the amount of these smaller particles suspended in the river body is less than the maximum capacity that the river could support, since the availability of these smaller particles is limited by their relatively slow rate of supply to the system.

1 Introduction

- Bed load – Consisting of coarser particles which are transported by rolling or bouncing along the river bed. These larger particles are transported up to the limit of the ability of the flow to carry them along, since there is usually a ready supply of these particles in the bed and banks of the river.

Suspended sediment discharge can be accurately measured, however measuring bed loads can be a challenge. This is because it is difficult to collect a sample without the sampler increasing the turbulence of the river and stirring up the sediments. Therefore, in most studies, the total sediment discharge is estimated based on the field measurement of the suspended load, which is added to a calculation of the bed load (Bowyer, 1973).

Nitrogen (N) and phosphorus (P) are considered to be key nutrients in river systems due to their influence on biological activity in estuarine and marine environments. Terrigenous sediments inherently contain N and P as a consequence of the degeneration of organic matter. During periods of increased river discharge, the release of N and P can play important roles in structuring primary productivity. An understanding of the nutrients contained within river discharge waters is of critical importance in order to assess the influence of nutrient loads on the receiving waters.

1.3.1 Sediment Transport Curves

The relationship between water discharge and sediment discharge for a sediment-sampling site is frequently expressed by an average curve. This curve, generally referred to as a sediment-transport curve, is constructed on logarithmic axes. It is widely used to estimate sediment concentration or sediment discharge for periods when water discharge data are available but sediment data are not. This relation is sometimes referred to as a “sediment – rating” curve (Glysson, 1987).

1.3.2 Suspended Sediment Sampling in Rivers in North West Western Australia

In Australian rivers, the sediment loads are largely determined by extreme rainfall events (Harris, 2000). Preparation of sediment transport curves can be difficult as these rainfall events are unpredictable and large flood events make sampling difficult and unsafe in remote areas (Robson et al., 2008). Moreover, the sediment discharged into the sea during one major flood event could exceed the amount delivered over several years of ‘normal’ river conditions (Harris, 2000). Hence, a monitoring programme of suspended sediment concentrations over long time intervals, spanning perhaps tens of years, must be examined before accurate sediment discharge may be determined.

A review of the hydrological characteristics of rivers in the North-west of Western Australian provided a consolidation of hydrographic data collected by the Department of Water since 1972 (Ruprecht & Ivanescu, 2000). Suspended sediments have been measured directly on a few occasions however the majority of suspended sediment concentrations have been indirectly measured as turbidity. Very little data currently exists for the north west of Western Australia for both suspended sediment concentrations and estimated sediment loading to marine environments via rivers.

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2

Data Review

2.1 Geology

At a regional scale, the Chevron site lies north of the Gascoyne sub-basin and on the Peedamullah Shelf. Major structural elements in the region appear to control the thickness of sediments. Surficial geology comprising unconsolidated alluvial and colluvial sediments of the Ashburton River system dominate the landscape.

Sediments in the upper catchment are dominated by claypan terrain consisting of claypans with longitudinal and net dunes, and/or deflation lag surfaces made up of clay, silt, sand and gravel. Throughout the upper catchment are also areas of Quarternary to Pliocene Colluvium, consisting of poorly sorted clays, silt, sand and gravel, formed by sheet flood and deflation (Geological Survey of Western Australia, 1980).

In the lower catchment, sediments are dominated by claypan dominant terrain, until the river delta, where beaches and coastal dunes are prevalent, consisting of light grey, unconsolidated and poorly consolidated quartzose calcarenite. Sediments of the Ashburton River body are alluvium, consisting of clay, silt, sand and gravel, partly calcreted (Geological Survey of Western Australia, 1982).

The proposed Ashburton North site comprises intertidal flats and mangrove swamps, beaches and coastal dunes, and residual sand plains and alluvium associated with the Ashburton River system. It is anticipated that the local stratigraphic profile would comprise of sandy Quaternary sediments overlying sandy to clayey alluvium with possible deposits of calcrete. Underlying these sediments is Tertiary sandstone and limestone which is potentially up to 50 m thick in the Survey Area. The deeper Cretaceous sediments are typically made up of shallow siltstone overlying coarse grained basal Birdrong Sandstone.

2.2 Landuse

The majority of the Pilbara region is utilised by mining and exploration leases, related mainly to the vast iron ore reserves in the Hamersley Basin, and pastoral land, particularly sheep and cattle grazing. Conservation areas also exist within the region.

2.3 Climate

The Project area is located in the Pilbara Region of Western Australia, around 10 km south west of Onslow. The region has a hot, semi-arid climate with an average annual rainfall varying between 200 mm and 350 mm. However, annual rainfalls of effectively between 0 mm and 1000 mm have been recorded which illustrates the extremely variable climate of the region. For most of the region, rainfall predominantly occurs during the summer months, with large events resulting from cyclonic activity and major storms. Annual rainfall in the region is highly variable both spatially and temporally, with stream flow being generated in response to large rainfall events. This variability in rainfall is predominantly due to the random nature of the tropical cyclones, monsoonal low pressure systems and localised thunderstorms passing through the region (Ruprecht & Ivanescu, 2000). A photograph showing the nearby Fortescue River under dry conditions and following Cyclone Dominic (January 2009), is provided in Appendix D.

Evaporation in the Pilbara region is very high with the mean annual evaporation in Onslow being 2,200 mm. Evaporation rates generally exceed the mean annual rainfall, keeping the landscape typically arid, except for areas along the alluvial river systems and other areas which obtain moisture from groundwater sources.

2 Data Review

Temperature variations can be extremely large, with average daily maximums for Onslow ranging from 24.8°C to 35.7°C (Ruprecht & Ivanescu, 2000).

The total monthly rainfall recorded at Onslow in January to April 2009 is presented in Table 2-1 and Chart 2-1, along with the long-term (1886-2009) average monthly rainfall volumes.

Table 2-1 Monthly Rainfall Recorded at Onslow in 2009

	2009 Rainfall (mm)	Long term average rainfall (1886-2009) (mm)
January	275	27.7
February	110	51.2
March	16	49.6
April	0	20.5
May	-	46.9
June	-	44.1
July	-	18.4
August	-	8.8
September	-	1.2
October	-	0.8
November	-	1.4
December	-	5.2
Total	-	277

Note: Data not available at the time of report for May-December 2009

Source: Bureau of Meteorology, station 5017

2 Data Review

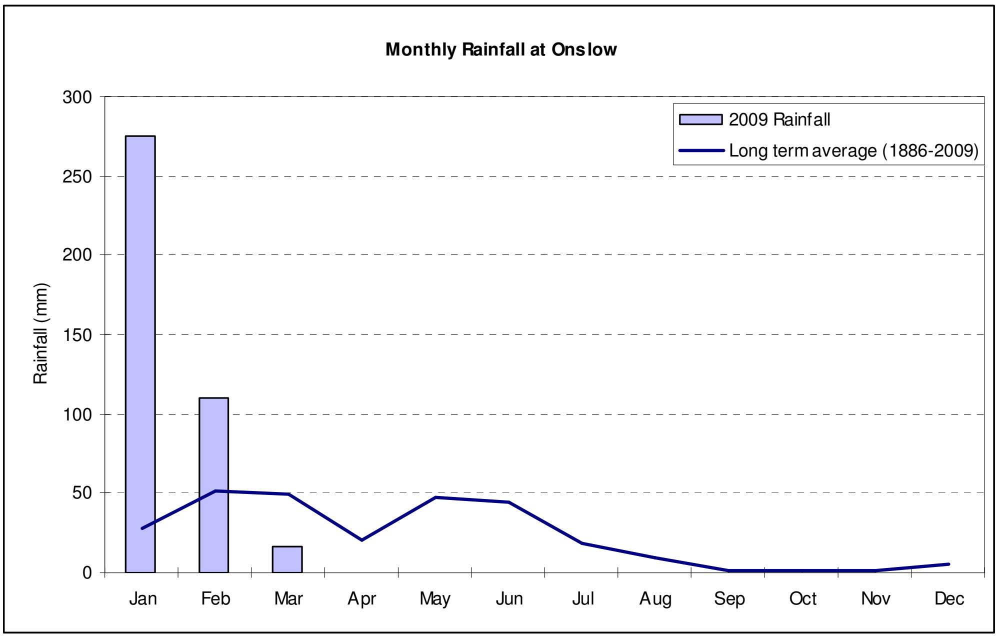

Chart 2-1 2009 and Long Term Average Monthly Rainfall at Onslow

The long-term average total annual rainfall recorded at Onslow is 277 mm. In January 2009, 275 mm of rainfall was recorded, almost equalling the long-term annual average over one month. This high rainfall was due to a tropical cyclone (cyclone Dominic) on January 27th where 238 mm of rainfall was recorded over a 24 hour period. This large storm event resulted in elevated stream-flows in the Ashburton River, and localised flooding.

Rainfall recorded during February was also above the long term monthly average, recording 110 mm during the month. This elevated rainfall volume is a result of a large localised storm, where around 106 mm of rain was recorded over four days from the 15th to the 18th of February. This rainfall event resulted in elevated river flow rates and localised flooding.

2.4 Water Quality

The Ashburton River is generally fresh, with salinity being around 133 mg/L TDS (Ruprecht & Ivanescu, 2000). This is similar to other rivers in the Pilbara region (range 50 – 1,000 mg/L). Salinity in the Ashburton River, and all Pilbara region rivers, generally decreases with increasing flow. It becomes more saline during times of low flow.

Total suspended solids (TSS) and turbidity in the Ashburton River are generally low, and generally increase with increasing flow. The turbidity for the Ashburton River ranges from less than 10 NTU over a range of flows, from 30 m^3/sec to 250 m^3/sec, to 3,300 NTU at a flow rate of around 250 m^3/sec. The flow weighted turbidity for Ashburton River is 1,705 NTU, which is higher than other Pilbara river sites, which range from 10 – 587 NTU (Ruprecht & Ivanescu, 2000).

There is a positive relationship between TSS and turbidity, which is site-specific and can be determined for each system. In general, both TSS and turbidity increase with increased flows. For average flow rates the turbidity levels in the Ashburton River are generally low, however in flood events extremely high levels have been observed.

2.5 Surface Water Hydrology

The Ashburton River is one of the largest rivers in the Pilbara and is the major feature of the Ashburton River Drainage Basin (Figure 1-1). The Ashburton River catchment area is approximately 78,777 km^2 (Haig, 2009) and is fed by numerous tributaries, namely Irregully Creek, Hardey River, Duck Creek and Henry River. These creeks are ephemeral and generally fill and flow only during large rainfall events.

Flows in the major tributaries exhibit a complex inter-relationship at a landscape scale between water course, location, floodplains, claypans and a suite of longitudinal and network sand dunes. In addition, due to the arid climate and very high evaporation rates, the occurrence of overland flow is rare and is usually only associated with tropical cyclone events. The hydrology of the region is one of extremes, experiencing both severe droughts and major floods.

The Ashburton River discharges over the coastal flats towards the Indian Ocean, just southwest of Onslow, often via wide and braided estuarine flowpaths. The discharge points are frequently a combination of direct ocean outlets, dispersal through marshy flats and groundwater seeps. The river also contributes significant recharge to groundwater resources on the coastal plains.

Stream flows in this region are mostly a direct response to rainfall which is highly seasonal and variable. Most runoff occurs during the period from January to March, with peak river flows consistently being recorded in February, usually as a result of major storms and cyclones.

The Ashburton River, like all watercourses in the Pilbara region is ephemeral, and flows only in response to rainfall events, being dry in the non-tidal reaches for some part of each year (Ruprecht & Ivanescu, 2000).

2.6 Existing Flow Sediment and Dissolved Nutrient Data

The Department of Water (DoW) commenced monitoring of total daily river flow volumes in the Ashburton River in 1972. The gauging station is located at Nanuturra Bridge around 100 km inland from the mouth of the Ashburton River. Monitoring of daily flow volumes has been undertaken since this time.

Suspended solid concentration data for the Ashburton River has been collected by the DoW since 1975 using various techniques. Only seven samples have been taken; several in 1975 and 1976 and then single samples taken in 2002, 2005 and 2006. In February 2009, URS commenced a field sampling program where an additional six samples were undertaken. All sampling events occurred during times of low flow due to flooding and subsequent site access constraints (see Section 4.1). As a result, very little suspended solid data for the Ashburton River currently exists.

The DoW also collected nitrogen (N) and phosphorus (P) concentration data for the Ashburton River between 1973 to 2008 These data were used to calculate a mean N and P concentration, which were multiplied by the daily river flow volumes (see above) to determine daily N and P discharges. The sum

2 Data Review

of daily N and P discharges were used to determine the total annual N and P loads discharged from the Ashburton River.

Despite the limited historic data available, the estimation procedure presented in this report provides a preliminary assessment of long term annual suspended sediment being discharged to the marine and coastal ecosystems from the Ashburton River.

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Field Investigation

3.1 Sampling Site Locations

3.1.1 Total Suspended Solids and Turbidity Sampling

Water samples were collected from three sites (Figure 1-1) between February and April 2009. On each sample date the samples were collected from three different depths where possible; 0 m, 1.5 m and 3.0 m. Sample sites were selected at the time of sampling, based on sample site access and river water levels. Sample sites were located at:

- Nanuturra Bridge: located approximately 100 km inland from the river mouth;
- Mouth of the Ashburton River; and
- Offshore: approximately 10 km offshore from the river mouth.

3.1.2 Flow Measurement

Flow measurement in the Ashburton River was located at the Department of Water (DoW) automated gauging station just upstream of the Nanuturra Bridge (station 706003). The station is located approximately 100 km inland from the river mouth.

3.2 Methodology

3.2.1 Sample Collection

All water samples were collected between February and April 2009 using a Niskin water sampler. Samples collected from the Nanuturra Bridge were collected by lowering the Niskin water sampler from the bridge into the river water below. Samples collected from the mouth of the Ashburton River, and offshore samples, were collected using a small boat. All samples were collected during times of relatively low flow.

All collected samples were frozen on site and transported to an analytical laboratory within 72 hours. Preservation methods followed Australian Standard 5667.1:1998.

3.2.2 Sample Analysis

All water samples were analysed for electrical conductivity (EC), Total Dissolved Solids (TDS), Turbidity and Total Suspended Solids (TSS) at ALS laboratory in Perth, using methods described in APHA 2005. Samples were also analysed for particle size distribution at Microns to Measure, a specialist laboratory in Victoria. Particle size analysis measurements were made using a Coulter LS230 instrument. The sample was dispersed in water using ultrasound to aid dispersion, and the distribution was calculated using a Mie Theory optical model (RI 1.55/0.1). A summary of the sampling program and analyses conducted is provided in Table 3-1. All laboratory results are provided in Appendix A and B, with Chain of Custody forms provided in Appendix C.

Table 3-1 Summary of the Ashburton River Sampling Program

Sample site	Date	Depth of sample (m)	Analyses
Nanuturra Bridge	08/02/09	0.0	EC, TDS, TSS, turbidity, particle size distribution
Ashburton River Mouth	10/02/2009	0.0	
		1.5	
		3.0	
Ashburton River Mouth	14/02/2009	0.0	
		1.5	
		3.0	
Nanuturra Bridge	24/03/09	0.0	
		1.5	
		3.0	
Off shore	31/03/09	0.0	
		1.5	
		3.0	
Nanuturra Bridge	02/04/09	0.0	
		1.5	
		3.0	

3.2.3 Ashburton River Flow Volumes

The DoW have measured daily flows at the Nanuturra Bridge gauging station since 1972. The daily flow data is collected and verified by the DoW every six months.

All flow volumes used in this report have been provided by the DoW. All flow data dated from 1972 to 2008 has been verified and checked. Flow data for 2009 has not been verified by the DoW, as the verified data was not available at the time of writing. Therefore, unverified flow data will be used for the period February to April 2009.

Frequency of Flooding

Daily flow rates for the Ashburton River between 1973 and 2008 were used to estimate the frequency of flooding in the area. Calculations of the probability of peak flows and the Average Recurrence Interval (ARI) or major flow events, were undertaken using the River Analysis Package software, and also based on formulas provided in Department of Environment (2003). Maximum flow rates for each year were determined and ranked from highest to lowest, and this ranking was used to determine the average recurrence interval for each of the major flow events for each year. The average recurrence interval for any storm or flow event is defined as how often a flow, river height, or rainfall event is likely to be exceeded (Department of Environment, 2003).

The probability of peak flow in a single year not being exceeded was calculated based on Eq.(1):

$$p = 1 - \frac{[Rank]}{(N+1)} \qquad \text{Eq.(1)}$$

Where:
p is the probability of peak flow in a single year not being exceeded
N is the number of years of data
[Rank] is the ranked number assigned to a sorted list of maximum flows for all years

The probability of peak flow being exceeded in a single year is then used to calculate the ARI, using Eq. (2).

$$ARI = \frac{1}{(1 - p)} \qquad \text{Eq. (2)}$$

Where:
ARI is the Average Recurrence Interval in years
p is the probability of the flood not being exceeded

These calculations were performed on Ashburton River maximum annual flow volumes to determine the flooding frequency of major flood events. Results of this analysis are discussed in Section 4.2.

3.2.4 Sediment Transport Curve

Sediment transport curves are prepared by plotting the flow rate in m^3/day (independent variable) against total suspended solids (dependent variable) on a logarithmic scale (Glysson, 1987). One significant limitation to this approach is the assumption that a water sample taken at a single spot in the river is representative of the entire cross section of the river. However, in the absence of multiple samples taken at one time across the river mouth, the use of a single sample represents a preliminary estimate of sediment discharge.

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Ashburton River Hydrology

4.1 Flow Volume

Total annual flow volumes of the Ashburton River have been highly variable since monitoring commenced in 1972 (Chart 4-1). Total annual flow volumes range from 3,200 ML/yr in 2007 when rainfall was minimal, to around 4,500,000 ML in 1997, as a result of a major storm event. The average annual river flow at Nanuturra Bridge gauging station is around 840,000 ML/yr. Above-average flows were recorded in 1980, 1995, 1997, 1999, 2000, 2004 and 2006, with the highest flow on record being recorded in 1997. The frequency of storms and large flows has increased since the mid-1990s, with the average flow from 1973-1994 being around 500,000 ML/yr, increasing to around 1,500,000 ML/yr from 1995-2008 (Chart 4-1).

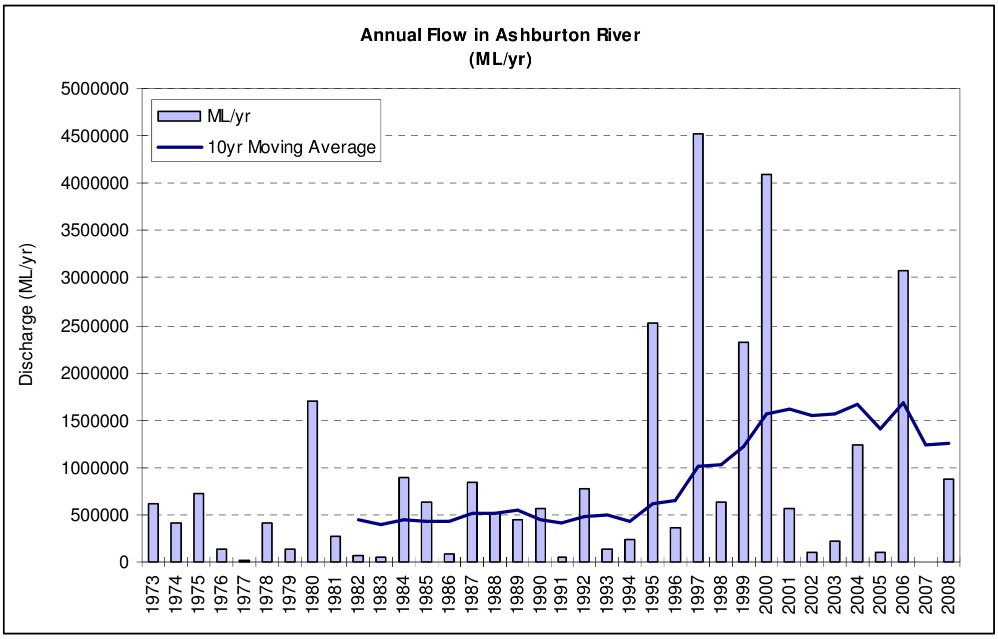

Chart 4-1 Annual Flow Volumes in the Ashburton River (1973-2008)

A major flood event occurred in 1997, when a slow-moving monsoonal low pressure system formed in the vicinity of Broome on the 28th January 1997. In 24hrs, 477 mm of rain was recorded at Onslow, with 415 mm being recorded over a 5hr time-span (Leighton & Mitchell, 1997). This extreme rainfall event caused the Ashburton River and its tributaries to flood. This was the largest flood event recorded at this site since monitoring began in 1972.

During the 2009 sampling program, a large rainfall event was recorded in Onslow, when around 106 mm of rain was recorded over four days from the 15th to the 18th of February. This rainfall event resulted in elevated river flow rates (Chart 4-2) and localised flooding, limiting sampling site access. Aerial photography of the Ashburton River mouth in February 2009 (Figure 4-1) shows significant sediment deposition into the ocean as a result of this storm and previous storms.

4 Ashburton River Hydrology

Samples of water were collected on either side of this high flow event, although no samples were able to be collected during the event, due to inaccessibility from flooding of roads. As a result, all samples were collected during times of relatively low flow.

Daily flow in the Ashburton River in January to March 2009, including sampling dates is presented in Table 4-1 and Chart 4-2.

Table 4-1 Ashburton River Daily Flow Volumes and Sampling Dates

Sample date	Flow (ML/day)
08/02/09	1,772
10/02/09	3,426
14/02/09	155
24/03/09	130
31/03/09	43
02/04/09	33

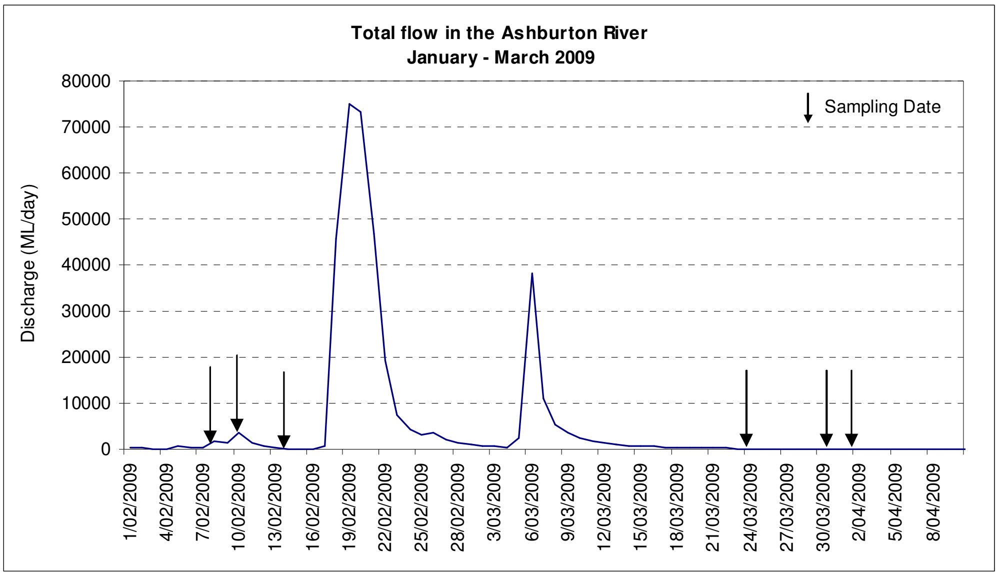

Chart 4-2 Total Daily Flow in the Ashburton River (January to April 2009)

4.2 Frequency of Flooding

The maximum flow was obtained for every year using the average daily maximum streamflow values. A Flood Frequency Analysis using Log-Pearson Type III Analysis was then performed to obtain the magnitude and frequency of floods (Chart 4-3).

The Average Recurrence Interval (ARI) is defined as how often a flow event is likely to be exceeded (Department of Environment, 2003). Based on the Flood Frequency Analysis, the major flood event recorded in 1997 has an ARI of 500 years, indicating that this flood is the probable maximum flood.

Other smaller flooding events recorded in above average flow years 2000 and 2006 could be expected to occur every 18 and 12 years respectively. Overall, an above average flow event could be expected to occur on average every seven years (excluding major flooding events). However, these calculations are based on long-term averages (1973-2008), and the frequency of high flow volumes has increased since the mid-1990s. When calculations are performed from 1994 to 2008, the ARI's are reduced, with the flow recorded in 2009 being a typical annual-biennial flow event. Based on these calculations, the typical annual flow would be around 170,000 ML/yr, increasing to around 820,000 ML/yr every second year.

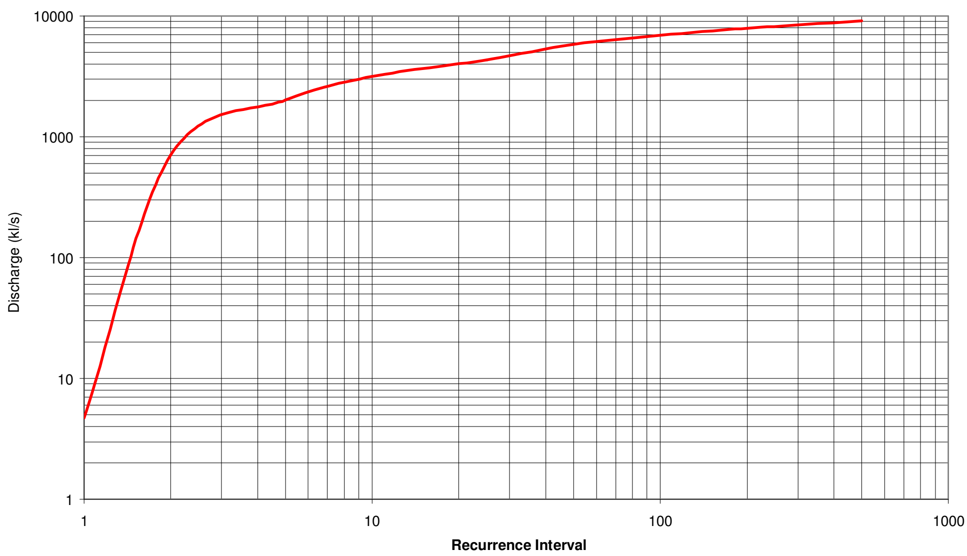

Chart 4-3 Flood Frequency Analysis for the Ashburton River

4.3 Flow Velocities

Flow velocities are expected to decline significantly over the Ashburton River delta due to the low gradients and open land surface. This reduced stream velocity means that sediment deposition will be maximised in this zone.

Dissolved Nutrients

5.1 Nitrogen and Phosphorus

Levels of total N discharged annually from the Ashburton River were highly variable (Chart 5-1) and closely reflect annual water flow volumes (Chart 4-1). Similarly, total P discharged annually were highly variable (Chart 5-2) and closely reflect annual flow volumes (Chart 4-1). The flow rates experienced between 1973 and 2008 cover a broad spectrum of annual discharges from the Ashburton River, therefore future discharges are likely to be within this range. Finally, the mean annual discharge N and P are calculated to be 405.1 tonnes/yr and 134.2 tonnes/yr respectively. These N and P values differ from the previously documented N and P values of 172 tonnes/yr and 26 tonnes/yr respectively in northern Western Australia (Lord and Associates, 2002), possibly due to the large river flows that occurred during the current study period. However, these data provide a useful background with which to compare future levels of N and P from the Ashburton River and surrounding coastal waters.

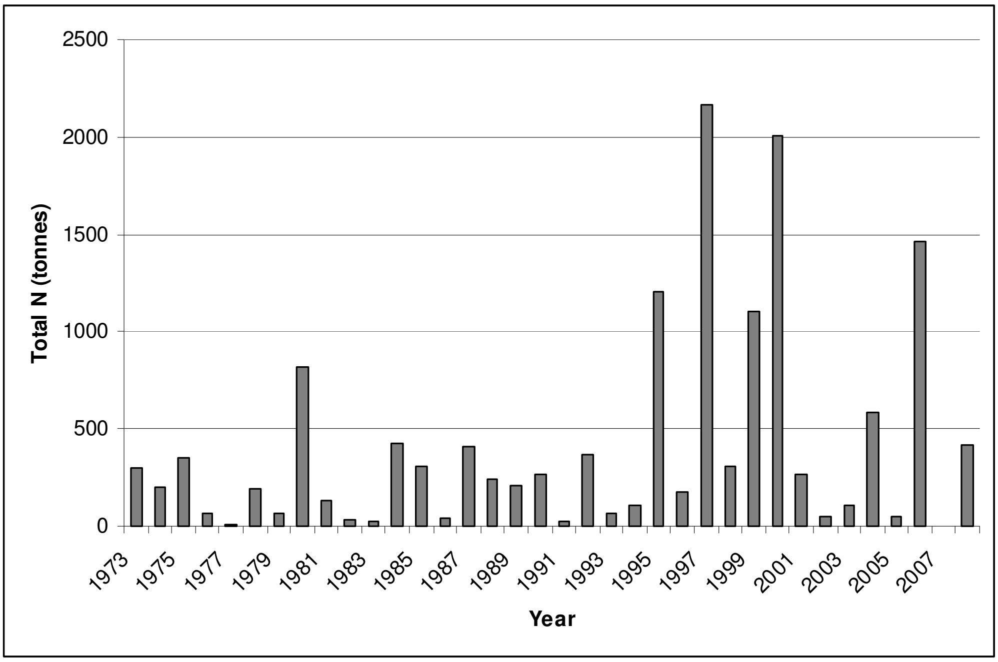

Chart 5-1 Relationship between total nitrogen levels and flow rates between 1973 and 2008 in the Ashburton River

5 Dissolved Nutrients

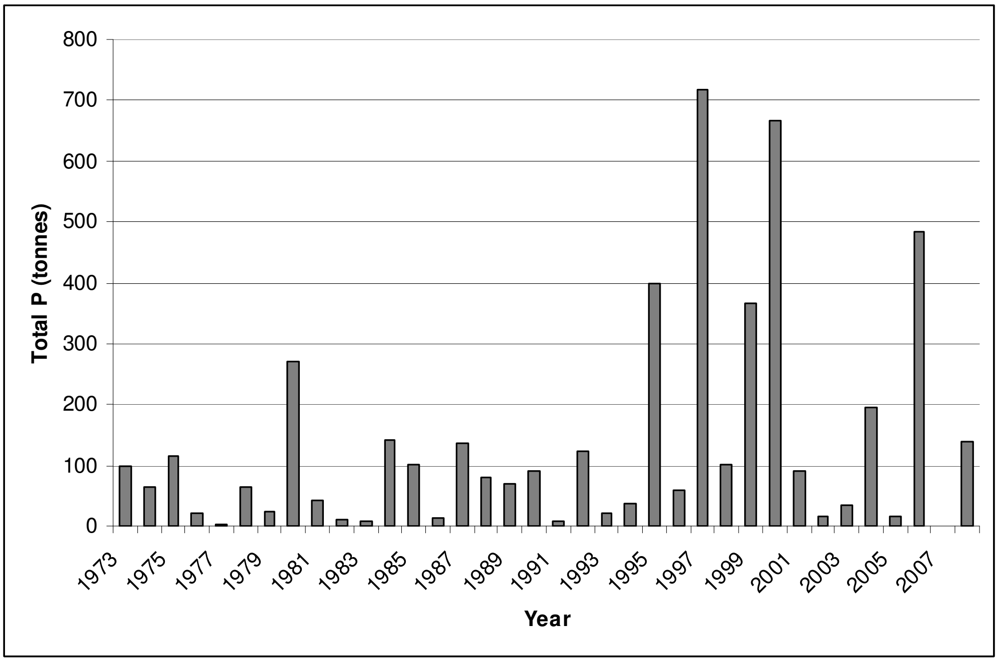

Chart 5-2 Relationship between phosphorus levels and flow rates between 1973 and 2008 in the Ashburton River

Table 5-1 Estimated Total Annual Nitrogen and Phosphorus Discharges from the Ashburton River – Based on Daily Flow Measurements

	Estimated Total Annual Nitrogen Load (tonnes/yr)	Estimated Total Annual Phosphorus Load (tonnes/yr)
Mean annual flow over all years	405.1	134.2

Sediment Transport

6.1 Suspended Solids

The concentration of Total Suspended Solids (TSS) in the Ashburton River at the time of sampling was relatively low and remained fairly stable across the six sampling events. TSS concentrations from the river at the Nanuturra Bridge and the River Mouth sites ranged from 35 mg/L to 121 mg/L (Table 6-1). Samples collected during the 2009 sampling program were collected during times of relatively low flow (Chart 4-2). Therefore the low TSS and turbidity values probably reflect typical levels associated with the beginning of a rising limb or at the end of a falling limb of a river flow peak in the Ashburton River following a rainfall event. Historic data shows elevated turbidity occurs during times of increased flow. Therefore, average annual sediment loads can be expected to be highly variable based on the variable nature of the rainfall in the region, and the subsequent river flow rates.

Table 6-1 Measured Total Suspended Solids and Turbidity in 2009

Sample Date	Sample site	Sample Depth (m)	TSS (mg/L)	Turbidity (NTU)
08/02/2009	Nanuturra bridge	0.0	48	21.2
10/02/2009	Mouth of Ashburton River	0.0	35	14.8
		1.5	86	39.0
		3.0	115	44.6
14/02/2009	Mouth of Ashburton River	0.0	81	13.3
		1.5	97	8.4
		3.0	121	21.5
24/03/2009	Nanuturra bridge	0.0	55	32.6
		1.5	55	25.2
		3.0	59	32.1
31/03/2009	Offshore	0.0	16	0.6
02/04/2009	Nanuturra bridge	0.0	37	32.3
		1.5	37	35.6
		3.0	36	30.1

6.2 Particle Size

The majority of the sediment sampled in 2009 consisted of particles with a diameter of less than 30 µm, with the average particle size having a diameter of 10 µm (across all sampling events). Samples collected in 2009 consisted of particles in which between 76-99% were below 30 µm in diameter (Table 6-2), with 91-100% of the particles being less than 63 µm in diameter. Particles less than 63 µm are classified as silts and clays. Particles greater than 30 µm in diameter constituted a very minor component of the total sediment load.

Table 6-2 Particle Size in 2009 Water Samples

Sample Date	Sample Site	Sample Depth (m)	Mean Particle Diameter (microns)	Particles less than 30 µm diameter (%)	Particles less than 63 µm diameter (%)
08/02/09	Nanuturra Bridge	0.0	6.6	92	98
10/02/09	Mouth of Ashburton River	0.0	6.3	93	98
		1.5	7.1	92	97
		3.0	6.6	93	97
14/02/09	Mouth of Ashburton River	0.0	0.9	99	100
		1.5	5.7	93	98
		3.0	IS*	94	98
24/03/09	Nanuturra Bridge	0.0	10.9	87	95
		1.5	20.7	76	91
		3.0	9.3	87	96
31/03/09	Offshore	0.0	IS*	IS	IS
02/04/09	Nanuturra Bridge	0.0	19.3	78	92
		1.5	11.6	87	95
		3.0	16.5	84	94

*Notes: IS – Insufficient sample to allow analysis

6.3 Transport Curve

The sediment transport curve for the Ashburton River shows a weak positive log-linear relationship between TSS and flow rate. This relationship is improved when previous TSS measurements made by the DoW are included, resulting in a stronger correlation (R^2=0.74). This regression equation combined with annual river water discharge data was used to estimate the long term annual sediment discharge of the Ashburton River for a period of 37 years from 1972 to 2009 at the Nanuturra site (Chart 6-1). However, as the sediment transport curve is based on samples with sediment particle size diameters of less than 63 µm, it primarily represents suspended sediment concentrations either at the beginning of the rising limb of river flow or at the end of the falling limb of river flow.

Glysson (1987) has shown that the logarithmic relationship should hold true for higher flow rates occurring in between the sampling dates. Mindful of the limitations of this approach, in that the points on the curve are from single samples taken from a large river mouth, the annual sediment discharge (or load) in Chart 6-2 represents preliminary estimates covering the period from 1972 to present.

6.4 Sediment Discharge at Nanuturra

Measured TSS concentrations from the Ashburton River at the Nanuturra Bridge and the Ashburton River Mouth were used to quantify the suspended sediment load for the Ashburton River water over time. The data included samples made between the 8^{th} February 2009 and 2^{nd} April 2009, the available data on TSS concentrations sourced from DoW, and their corresponding flow data extracted from the surface water database of the DoW from 1975 to 1981.

Historic TSS data was limited and as a result, TSS data from the DoW for the <63 µm range was included in calculations. This means that these calculations are based on suspended sediment loading of small (clays and silts) particles only. Logarithmic transformed data to base 10 of TSS concentrations were plotted as a function of logarithmic transformed data to base 10 of flow rate for the Ashburton River. A simple linear regression was produced and shown via Eq.(3):

$$Log\ (TSS) = 0.528\, Iog\ (Flow\ rate) - 1.05 \qquad \text{Eq. (3)}$$

Where:
TSS is measured in mg/L
Flow rate is measured in ML/year.

Using Eq. (3) and the daily river water discharge recorded by DoW, the daily and annual suspended sediment load in the Ashburton River was estimated for the period of 1972 – 2009. Results of this analysis are provided in Chart 6-2.

6 Sediment Transport

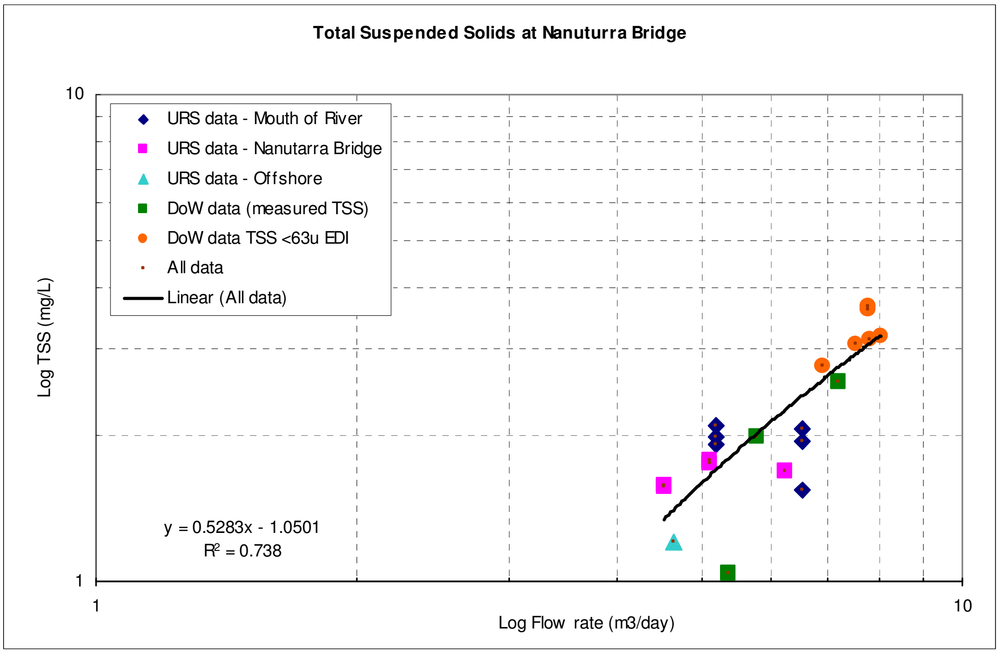

Chart 6-1 Concentration of Total Suspended Solids as a Function of Daily River Water Discharge in the Ashburton River at Nanuturra Bridge

The estimated annual sediment loads provided in these calculations are determined from the water quality samples collected at the Nanuturra Bridge gauging station, which is located around 100 km inland from the river mouth. Changes to sediment load between the Nanuturra Bridge site and the river mouth are likely to occur due to a number of factors including: the wide flat characteristics of the catchment between the gauging station and the ocean; changes in river velocity; and the backwater effect of the Nanuturra Bridge. The Nanuturra Bridge may cause the river to constrict, resulting in increased water levels upstream of the bridge and potentially increased erosion immediately downstream of the bridge.

Annual sediment load estimates are based on limited data, collected as one-off grab samples, with TSS concentrations at high flow rates being estimated from the existing relationship between TSS and flow at lower flow rates. The estimated sediment discharge is based on suspended solids only, which generally takes into account 80-90% of the total sediment load in a river (Bowyer, 1973). It does not take into account the total sediment load entering the ocean via bed load (i.e., coarser sediments rolling and bouncing over the river bed). Therefore, the final estimate of annual sediment load to the ocean may be underestimated by between 10-20%.

Total annual estimated sediment discharge from the Ashburton River at Nanuturra Bridge is provided in Chart 6-2.

6 Sediment Transport

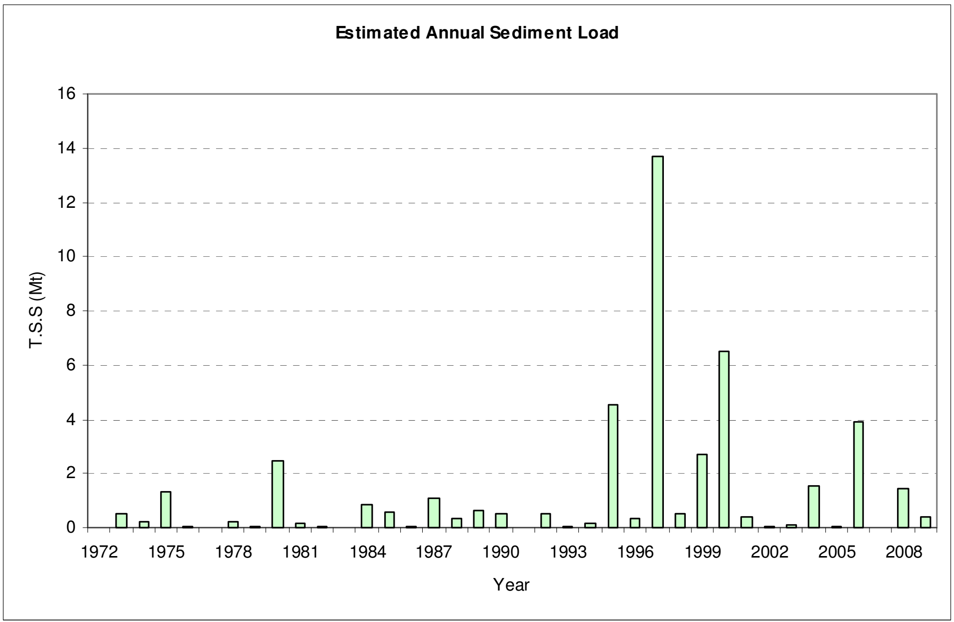

Chart 6-2 Estimated Annual Total Suspended Solids Load in the Ashburton River at Nanuturra Bridge over a 37 year period (based on daily flow)

The estimated average sediment load entering the ocean each year will continue to be highly variable. This is because sediment loading is dependent on river flow, which in turn is dependent on the intensity and duration of rainfall across the catchment area.

A comparison of turbidity measurement from this work with that published by Ruprecht and Ivanescu (2000) shows that low turbidity measurements (generally less than 200 NTU) are prevalent across a wide range of flow rates (Chart 6-3). This suggests that capturing the high turbidity measurements, and hence high suspended sediments, is not a common occurrence. Verification of the regression equation at higher flow rates would be a useful inclusion to future work.

6 Sediment Transport

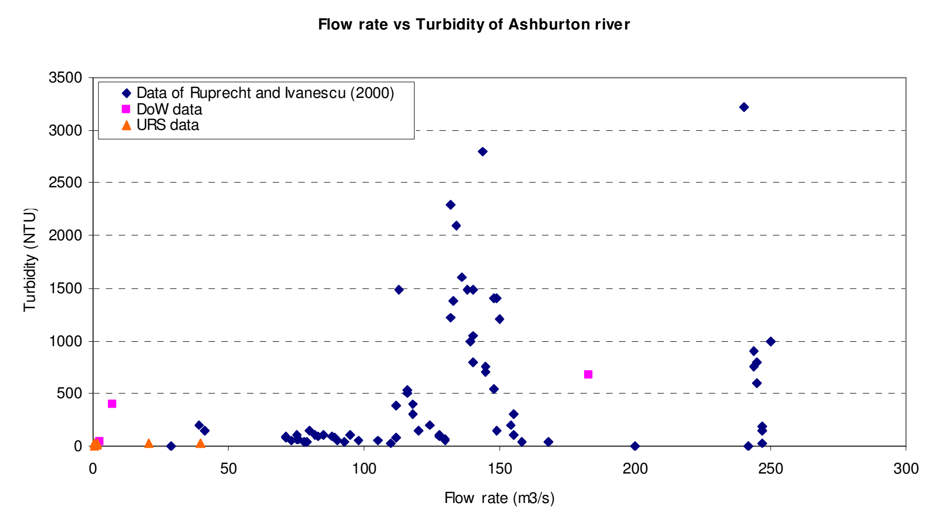

Chart 6-3 Comparison of Turbidity and Flow Rate in the Ashburton River

Chart 6-3 shows that at flow rates at or above around 120 m^3/s, turbidity in the Ashburton River increases and becomes more variable. At flow rates less than 120 m^3/sec, turbidity rates remain relatively stable and low (generally below 200 NTU). Flow rates at or above 120 m^3/s occur regularly in the Ashburton River, generally being recorded several times each year, resulting in elevated and highly variable turbidity (and hence suspended solid) values.

Average sediment load to the ocean via the Ashburton River has been estimated and is provided in Table 6-3. Overall, total annual average sediment load has been calculated to be around 1,300,000 t/yr, however this is highly variable from year to year depending on river flow. The total estimated annual sediment load between 1973 and 2008 ranged from 430 t/yr (in 2007, which was a year of low rainfall and low river flow) to 13,800,000 t/yr (in 1997, which was a year with a major flood event).

During a year with higher than average flow, it can be estimated that approximately 5,100,000 tonnes of sediment will be deposited into the ocean each year, while during an average flow year around 360,000 tonnes of sediment will be deposited.

Based on flood frequency calculations for period 1994 – 2009 provided in Section 4.2, it can be estimated that an above average flow event could be expected around every one to two years.

Table 6-3 Estimated Total Annual Sediment Load at Nanuturra Bridge (based on daily flow)

	Estimated Total Annual Sediment Load (t/yr)
Range between 1973-2008	430 – 13,800,000
Average flow year	360,000
Above average flow year	5,100,000
Average over all years	1,300,000

6.5 Sediment Discharge to Ocean

The Nanuturra Bridge gauging station is located around 100 km inland from the confluence of the Ashburton River with the ocean. Therefore it could be expected that the suspended load estimates provided in Table 6-3, which are based on concentrations and flows measured at the Nanuturra Bridge gauging station, may differ from the loads actually entering the ocean some 100 km away. TSS measurements were conducted by Australian Premium Iron Joint Venture (API) on 31st January and 6th February 2009 following a significant rainfall event measured at Onslow airport on 27th January of 238 mm. The results showed that coastal inshore waters adjacent to the Ashburton Delta reached a maximum of 41 mg/L TSS compared to 60 mg/L at the Nanuturra gauging station (see Appendix E).

The estimated sediment loads provided in Table 6-3 are at the upper limit of sediment discharging to the ocean for any given flow rate. Sediment discharge to the ocean in recent years has increased as a result of an increase in flooding frequency since 1994. The actual amount of sediment discharging into the ocean over the period of recorded flows at Nanuturra Bridge is expected to be lower than the amount estimated in this report. It is expected there would be losses due to sediment settling out as the flow velocities in the Ashburton River decline over the river delta, prior to the water entering the ocean.

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7

Conclusions and Recommendations

7.1 Conclusions

The average annual flow of the Ashburton River is around 840,000 ML, but is highly variable and typical of a pulsed tropical river system. Total nitrogen and phosphorus loads are generally variable, with a mean annual discharge of 405.1 t/yr of nitrogen and 134.2 t/yr of phosphorus. The average annual sediment load over all years was calculated to be around 1,300,000 t/yr. However annual loads are highly variable and dependent on river flow rates. The total estimated annual sediment load between 1973 and 2008 ranged from 430 t/yr (in 2007 which was a year of low rainfall and low river flow) to 13,800,000 t/yr (in 1997 which was a year with a major flood event).

During a year with higher than average flow, it can be estimated that approximately 5,100,000 t of sediment will be deposited into the ocean each year, while during an average flow year, around 360,000 t of sediment will be deposited. Above average flow events have become more frequent since the mid 1990s, with an above average flow event expected to occur around every one to two years.

The estimates of total annual sediment load provided in this report are based on average flow years or above average flow years. In general, particle size was small, with between 90-100% of all particles in the 2009 samples being classified as silts and clays (less than 63 µm diameter).

7.2 Limitations to Estimates of Total Suspended Solids Discharging from the Ashburton River

Sediment load calculations for the Ashburton River presented in this report include a series of assumptions and limitations, due mainly to the lack of suspended solid data collected during major flow events. Estimated sediment load concentrations may be underestimated and do not take into account the movement of larger particles during times of high flow. The final estimate of annual sediment load to the ocean may be underestimated by between 10-20%.

However, river velocities between the Nanuturra Bridge site and the river mouth are expected to decline as the water travels over the open, flat delta. This area is a sediment deposition site, and therefore many of the larger particles are expected to be dropped out of solution in this zone before entering the ocean.

Due to these limitations, it is recommended that a sediment sampling program continue, particularly during large flow events and around the river mouth, in order to more accurately determine annual sediment loads entering the ocean via the Ashburton River.

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Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Chevron Australia Pty Ltd and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 11/2/2009.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between February and September 2009 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

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A

Appendix A ALS Laboratory Results

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ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP0900898**	Page	: 1 of 4
Client	: **URS AUSTRALIA PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: ANDREW MCTAGGART	Contact	: Michael Sharp
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Facsimile	: +61 08 9221 1639	Facsimile	: +61-8-9209 7600
Project	: 42907170	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 18-FEB-2009
Sampler	: P.E & L.S	Issue Date	: 25-FEB-2009
Site	: ----		
		No. of samples received	: 7
Quote number	: EP-035-09	No. of samples analysed	: 7

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

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- Analytical Results

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Kaye Davies		Perth Admin

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Page	: 2 of 4
Work Order	: EP0900898
Client	: URS AUSTRALIA PTY LTD
Project	: 42907170

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key :
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Work Order : EP0900898
Client : URS AUSTRALIA PTY LTD
Project : 42907170

Analytical Results

Sub-Matrix: **SEAWATER**

Compound	CAS Number	LOR	Unit	1	2	3	4	5
			Client sampling date / time	08-FEB-2009 15:00	10-FEB-2009 15:00	10-FEB-2009 15:00	10-FEB-2009 15:00	14-FEB-2009 15:00
				EP0900898-001	**EP0900898-002**	**EP0900898-003**	**EP0900898-004**	**EP0900898-005**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**540**	**18400**	**40000**	**44600**	**44500**
EA016: Non Marine - Estimated TDS Salinity								
^ Total Dissolved Solids (est.)	----	1	mg/L	**351**	**12000**	**26000**	**29000**	**28900**
EA025: Suspended Solids								
^ Suspended Solids (SS)	----	1	mg/L	**48**	**35**	**86**	**115**	**81**
EA045: Turbidity								
Turbidity	----	0.1	NTU	**21.2**	**14.8**	**39.0**	**44.6**	**13.3**

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Page : 4 of 4
Work Order : EP0900898
Client : URS AUSTRALIA PTY LTD
Project : 42907170

Analytical Results

Sub-Matrix: **SEAWATER**

Compound	CAS Number	LOR	Unit	6	7	----	----	----
			Client sampling date / time	14-FEB-2009 15:00	14-FEB-2009 15:00	----	----	----
				EP0900898-006	**EP0900898-007**	**----**	**----**	**----**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**50800**	**54200**	----	----	----
EA016: Non Marine - Estimated TDS Salinity								
^ Total Dissolved Solids (est.)	----	1	mg/L	**33000**	**35200**	----	----	----
EA025: Suspended Solids								
^ Suspended Solids (SS)	----	1	mg/L	**97**	**121**	----	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	**8.4**	**21.5**	----	----	----

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ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP0901832**	Page	: 1 of 4
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Project	: 42907170	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 06-APR-2009
Sampler	: P.E/L.S	Issue Date	: 14-APR-2009
Site	: ----		
		No. of samples received	: 7
Quote number	: EP-035-09	No. of samples analysed	: 7

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

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Page	:	2 of 4
Work Order	:	EP0901832
Client	:	URS AUSTRALIA PTY LTD
Project	:	42907170

General Comments

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Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key :
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LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

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Work Order : EP0901832
Client : URS AUSTRALIA PTY LTD
Project : 42907170

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	1	2	3	4	5
			Client sampling date / time	24-MAR-2009 17:15	24-MAR-2009 17:17	24-MAR-2009 17:20	31-MAR-2009 09:43	14-FEB-2009 12:05
				EP0901832-001	**EP0901832-002**	**EP0901832-003**	**EP0901832-004**	**EP0901832-005**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**605**	**995**	**694**	**36600**	**764**
EA016: Non Marine - Estimated TDS Salinity								
^ Total Dissolved Solids (est.)	----	1	mg/L	**393**	**647**	**451**	**23800**	**497**
EA025: Suspended Solids								
^ Suspended Solids (SS)	----	1	mg/L	**55**	**55**	**59**	**16**	**37**
EA045: Turbidity								
Turbidity	----	0.1	NTU	**32.6**	**25.2**	**32.1**	**0.6**	**32.3**

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Page : 4 of 4
Work Order : EP0901832
Client : URS AUSTRALIA PTY LTD
Project : 42907170

Analytical Results

Sub-Matrix: **WATER**

			Client sample ID	6	7	----	----	----
			Client sampling date / time	14-FEB-2009 12:08	14-FEB-2009 12:10	----	----	----
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EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	695	872	----	----	----
EA016: Non Marine - Estimated TDS Salinity								
^ Total Dissolved Solids (est.)	----	1	mg/L	452	567	----	----	----
EA025: Suspended Solids								
^ Suspended Solids (SS)	----	1	mg/L	37	36	----	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	35.6	30.1	----	----	----

A Campbell Brothers Limited Company

B

Appendix B Particle Size Analysis Data

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MICRONS TO MEASURE

42 Ramsden Street, Clifton Hill
Post: PO Box 335 Clifton Hill, Victoria 3068, Australia
Phone & Fax: 03-9481 3451 **E-mail: pcresswe@bigpond.net.au**
International: +61-3-9481 3451 **www.micron2measure.com.au**
Mobile: 0419 396 049
(PEARSON CRESSWELL & ASSOCIATES P/L ABN 70 057 197 047)

ANALYSIS REPORT

Report No: 1143a Job No: B135

ALS Environmental
10 Hod Way
MALAGA WA 6090

Report Date: 15 May 2009
Samples Submitted: 24 February 2009

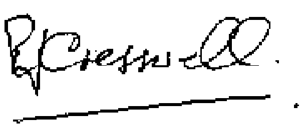
Sample ID: EP0900898

Report:

Our ID	Your ID	Mean microns	Median microns	% > 30 microns	% > 63 microns
B135-1	EP0900898-001	6.6	3.8	8.0	2.0
B135-2	EP0900898-002	6.3	3.6	7.3	2.2
B135-3	EP0900898-003	7.1	4.3	7.6	2.8
B135-4	EP0900898-004	6.6	4.0	7.3	2.6
B135-5	EP0900898-005*	0.9	0.5	1.5	0.4
B135-6	EP0900898-006*	5.7	3.7	7.1	2.2
B135-7	EP0900898-007#	Insufficient Sample			
B135- average		6.4	3.9	7.5	2.4

* These samples contained very low levels of particulates which may adversely affect the quality of the result. # This sample contained insufficient particulates to determine a distribution. Detailed reports for each sample are attached.

Comment on the Results: The particle size distributions for these samples appear to be very similar. Much of the difference at the coarser end of the distribution is probably attributable to differences in the concentrations of particulates (some of which were very low) which affects the availability of larger particles for measurement. An 'average' distribution based on the five best samples is also included.



Dr Pearson Cresswell

Notes: The measurements were made using a Coulter LS230 instrument. The sample was dispersed in water using ultrasound to aid dispersion. The distribution was calculated using a Mie Theory optical model (RI 1.55/0.1).

MICRONS TO MEASURE

42 Ramsden Street, Clifton Hill
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Phone & Fax: 03-9481 3451 **E-mail: pcresswe@bigpond.net.au**
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Mobile: 0419 396 049
(PEARSON CRESSWELL & ASSOCIATES P/L ABN 70 057 197 047)

ANALYSIS REPORT

Report No: 1158a Job No: B150

ALS Environmental
10 Hod Way
MALAGA WA 6090

Report Date: 15 May 2009
Samples Submitted: 8 April 2009

Sample ID: EP0901832

Report:

Our ID	Your ID	Mean microns	Median microns	% > 30 microns.	% > 63 microns
B150-1	1	10.9	7.5	13.4	4.9
B150-2	2	20.7	13.9	24.4	9.3
B150-3	3	9.3	6.6	11.4	4.4
B150-4	4#	Insufficient Sample			
B150-5	5	19.3	11.8	21.8	7.7
B150-6	6	11.6	7.5	12.9	5.1
B150-7	7	16.5	9.1	16.3	6.1

This sample contained insufficient particulates to determine a distribution.

Detailed reports for each sample are attached.

Dr Pearson Cresswell

Notes: The measurements were made using a Coulter LS230 instrument. The sample was dispersed in water using ultrasound to aid dispersion. The distribution was calculated using a Mie Theory optical model (RI 1.55/0.1).

C

Appendix C Chain of Custody Forms

URS

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CHAIN OF CUSTODY FORM

[illegible]

Lab Identification	Date	Time	Matrix	Sample Number	Comments
	[illegible]		Sea Water	[illegible]	
	[illegible]		Sea Water	[illegible]	
	[illegible]		Sea Water	[illegible]	
	[illegible]		Sea Water	[illegible]	
	[illegible]		Sea Water	[illegible]	
	[illegible]		Sea Water	[illegible]	[illegible]
	[illegible]		Sea Water	[illegible]	

Environmental Division Perth

Work Order

EP0900896

TOTAL

Remarks: [illegible]

NOTE: SAMPLES MAY CONTAIN DANGEROUS AND HAZARDOUS SUBSTANCES

Sheet 1 of 1

CHAIN OF CUSTODY FORM

Container Size, Type, Preservative and Analysis

Lab Identification	Date	Time	Matrix	Sample Number	Comments
1	[illegible]	[illegible]	Water		
2	[illegible]	[illegible]	Water		
3	[illegible]	[illegible]	Water		
4	[illegible]	[illegible]	Water		
5	[illegible]	[illegible]	Water		
6	[illegible]	[illegible]	Water		
7	[illegible]	[illegible]	Water		

Environmental Division Perth

Work Order

EP0901832

NOTE: SAMPLES MAY CONTAIN DANGEROUS AND HAZARDOUS SUBSTANCES

Appendix D Site Photographs

Plate D-1 Fortescue River during dry conditions, and in flood following a heavy rainfall event from Cyclone Dominic in January 2009

Plate D-2 Ashburton River at Nanuturra Bridge in May 2009 and February 2009.

Appendix D

Plate D-3 Ashburton River 5km upstream of Ashburton Delta

Plate D-4 Ashburton River Mouth/Estuary

Appendix E API Sampling

Nearshore coastal water from the west of Onslow was sampled by the Australian Premium Iron Joint Venture (API) to determine the TSS concentration in the water following major discharge events from the Ashburton River following Tropical Cyclone Dominic in January 2009 and a large inland rain event in February 2009 (see Plate E-1). Surface and bottom water were taken at 1 m from the surface and 1 m from the bottom respectively. TSS concentrations for January and February 2009 sampling are presented in Table E-1. Results indicate that the January 2009 TSS concentration in the surface and bottom coastal water was in the range of 11 – 27 mg/L and 11 – 32 mg/L respectively. The water in February 2009 was slightly more turbid with a surface and bottom TSS concentration ranging from 14 – 41 mg/L and 11 – 46 mg/L respectively. Plate E-2 and E-3 show the TSS concentration contour of surface and bottom waters in January and February 2009. URS detected an offshore TSS value of 16 mg/L in March 2009 (URS data).

In addition, one river water sample was also collected by API at the Nanuturra Bridge gauging station for TSS measurement. Unfortunately no flow data was recorded by API during this period. API detected a TSS concentration of 60 mg/L in the river water at the Nanuturra gauging station in February 2009 (API data). URS TSS data, ranged from 55 – 59 mg/L in March 2009, and 36 – 37 mg/L in April 2009 (URS data).

Table E-1 Total Suspended Solids Data from API Sampling during January and February 2009

Sites (Jan 09)	TSS (mg/L)	Sites (Feb 09)	TSS (mg/L)
LOR	<2	LOR	<2
31012009-1 Surface	26	06022009-1 Surface	41
31012009-1 Bottom	32	06022009-2 Surface	32
31012009-2 Surface	19	06022009-2 Bottom	21
31012009-2 Bottom	24	06022009-3 Surface	21
31012009-3 Surface	27	06022009-3 Bottom	29
31012009-3 Bottom	16	06022009-4 Surface	31
31012009-4 Surface	13	06022009-4 Bottom	25
31012009-4 Bottom	13	06022009-5 Surface	30
31012009-5 Surface	27	06022009-5 Bottom	11
31012009-5 Bottom	20	06022009-6 Surface	15
31012009-6 Surface	16	06022009-6 Bottom	22
31012009-6 Bottom	25	06022009-7 Surface	30
31012009-7 Surface	23	06022009-7 Bottom	31
31012009-7 Bottom	25	06022009-8 Surface	20
31012009-8 Surface	26	06022009-8 Bottom	19
31012009-8 Bottom	19	06022009-9 Surface	23
31012009-9 Surface	16	06022009-9 Bottom	33
31012009-9 Bottom	11	06022009-10 Surface	32
31012009-10 Surface	26	06022009-10 Bottom	19
31012009-10 Bottom	18	06022009-11 Surface	21
31012009-11 Surface	22	06022009-11 Bottom	22

Appendix E

Sites (Jan 09)	TSS (mg/L)	Sites (Feb 09)	TSS (mg/L)
LOR	**<2**	**LOR**	**<2**
31012009-11 Bottom	19	06022009-12 Surface	33
31012009-12 Surface	17	06022009-12 Bottom	39
31012009-12 Bottom	21	06022009-13 Surface	17
31012009-13 Surface	11	06022009-13 Bottom	14
31012009-13 Bottom	18	06022009-14 Surface	21
31012009-14 Surface	15	06022009-14 Bottom	24
31012009-14 Bottom	21	06022009-15 Surface	28
31012009-15 Surface	13	06022009-15 Bottom	14
31012009-15 Bottom	20	06022009-16 Surface	29
31012009-16 Surface	24	06022009-16 Bottom	13
31012009-16 Bottom	18	06022009-17 Surface	21
31012009-17 Surface	18	06022009-17 Bottom	38
31012009-17 Bottom	28	06022009-18 Surface	18
		06022009-18 Bottom	25
		06022009-19 Surface	31
		06022009-19 Bottom	46
		Gauging Station	60

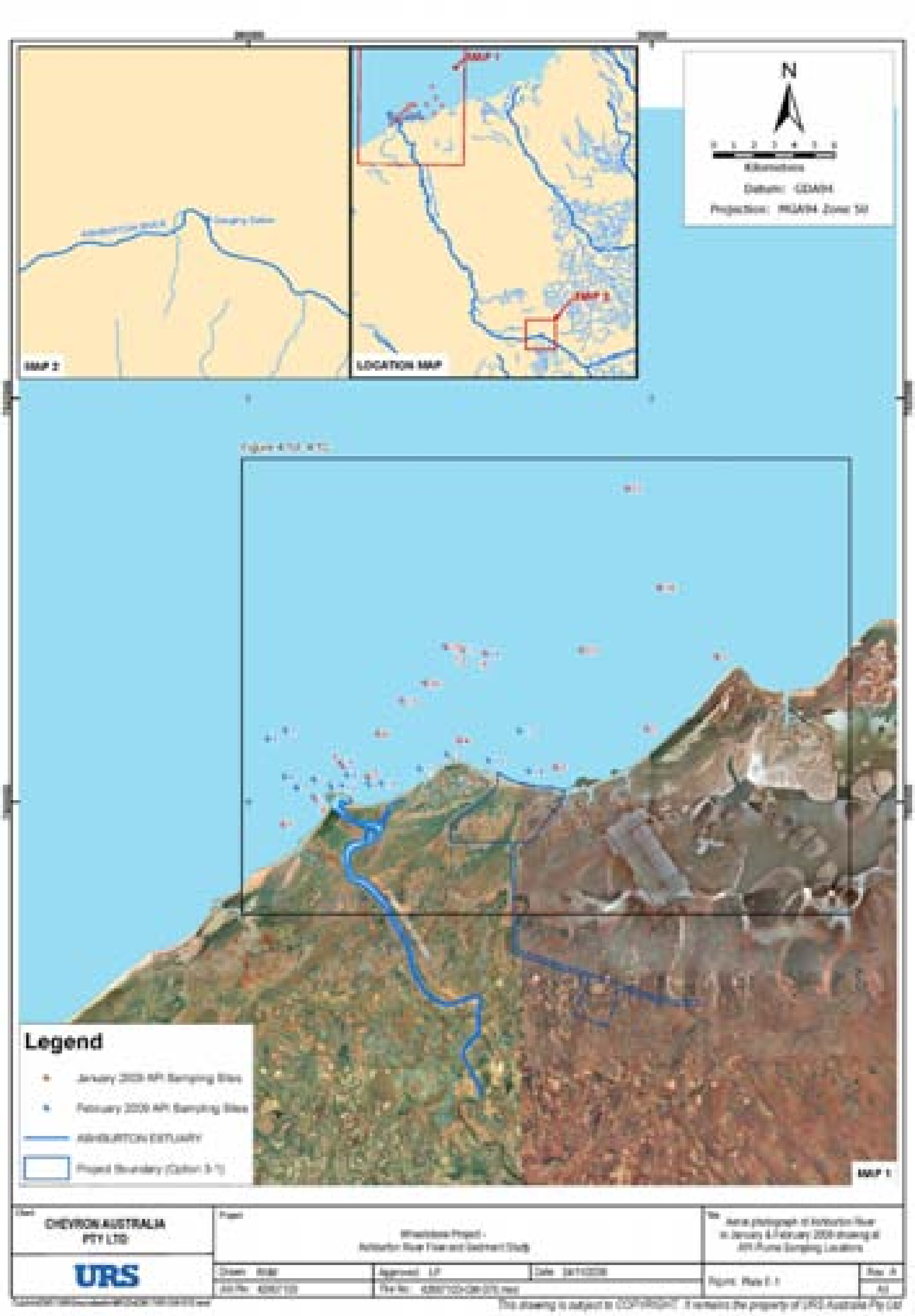

Plate E-1 Aerial photograph of Ashburton River in January & February 2009 showing all API Plume Sampling Locations

Appendix E

Plate E-2 Total Suspended Solids Concentration in Nearshore Waters January 2009

Plate E-3 Total Suspended Solids Concentration in Nearshore Waters February 2009

URS

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Appendix Q7

Baseline Water Quality Assessment Report

Tables

Figures

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MScience

WHEATSTONE LNG DEVELOPMENT

BASELINE WATER QUALITY ASSESSMENT REPORT NOVEMBER 2009

Report: MSA134R3

Report to:

URS Corporation
Level 3, 20 Terrace Rd, East
Perth WA 6004
Australia

MScience Pty Ltd,
239 Beaufort St, Perth, WA 6003, AUSTRALIA

Document Information

REPORT NO.	MSA134R3
TITLE	WHEATSTONE LNG DEVELOPMENT : BASELINE WATER QUALITY ASSESSMENT REPORT NOVEMBER 2009
DATE	17 November 2009
JOB	MSA134
CLIENT	URS Australia Pty. Ltd. Contract No. 213806 US
USAGE	This report presents an evaluation of the water quality baseline data. This data has been collected to provide background information for use in the assessment of potential dredging and operational impacts.
PRECIS	This report provides a summary of baseline marine water quality of the Onslow area. Data has been collected, analysed and summarised from five separate studies. The primary characteristics assessed include turbidity, light attenuation, total suspended solids, sedimentation, metals and nutrients. Where possible spatial and temporal variation have been characterised and described.
KEYWORDS	Water quality, sediments, baseline, Onslow Wheatstone

Version-Date	Released by	Purpose
V1.0 13 Nov 2009	DGM	Client review
V2.0 18 Jan 2010	DGM	Final
V3.0 4 Feb 2010	DGM	Final

1.0 INTRODUCTION

URS Australia Pty. Ltd. (URS) commissioned MScience Pty Ltd (MScience) to analyse baseline water quality studies and other available information in the Onslow region. The purpose of this review is to provide background information for environmental permitting and management of the Wheatstone Project.

Relevant data was obtained from five studies, these included:

- An intensive, boat-based sampling campaign undertaken to develop relationships between water quality characteristics and MODIS reflectance;
- Prediction of long-term water quality changes using historic interrogation of MODIS images
- Measurement of changes in turbidity and light attenuation using deployed instruments at two sensitive coral sites in the project area;
- Historical water quality studies as part of pre-feasibility monitoring for a port placement at Dampier. Carried out by AECOM Australia Pty Ltd and sub-consultants;
- Short term deployment of sediment traps for dredge plume modelling.

Table 1. Summary of information collected and analysed

Study	Dates	Information
Short term boat sampling	August and October 2009	Spatial differences in turbidity, light attenuation and total suspended solids. Relationships between water quality characteristic and MODIS reflectance
MODIS historic images	2006-2009	Predicted turbidity from MODIS reflectance
Deployed instruments	5th March – 10th September 2009	Turbidity, light attenuation and water temperature
Historical studies	2008-2009	Water quality during cyclonic influence, metals, nutrients, sedimentation
Short term sediment traps	May-June 2009	Sedimentation

2.0 AREA OF INTEREST

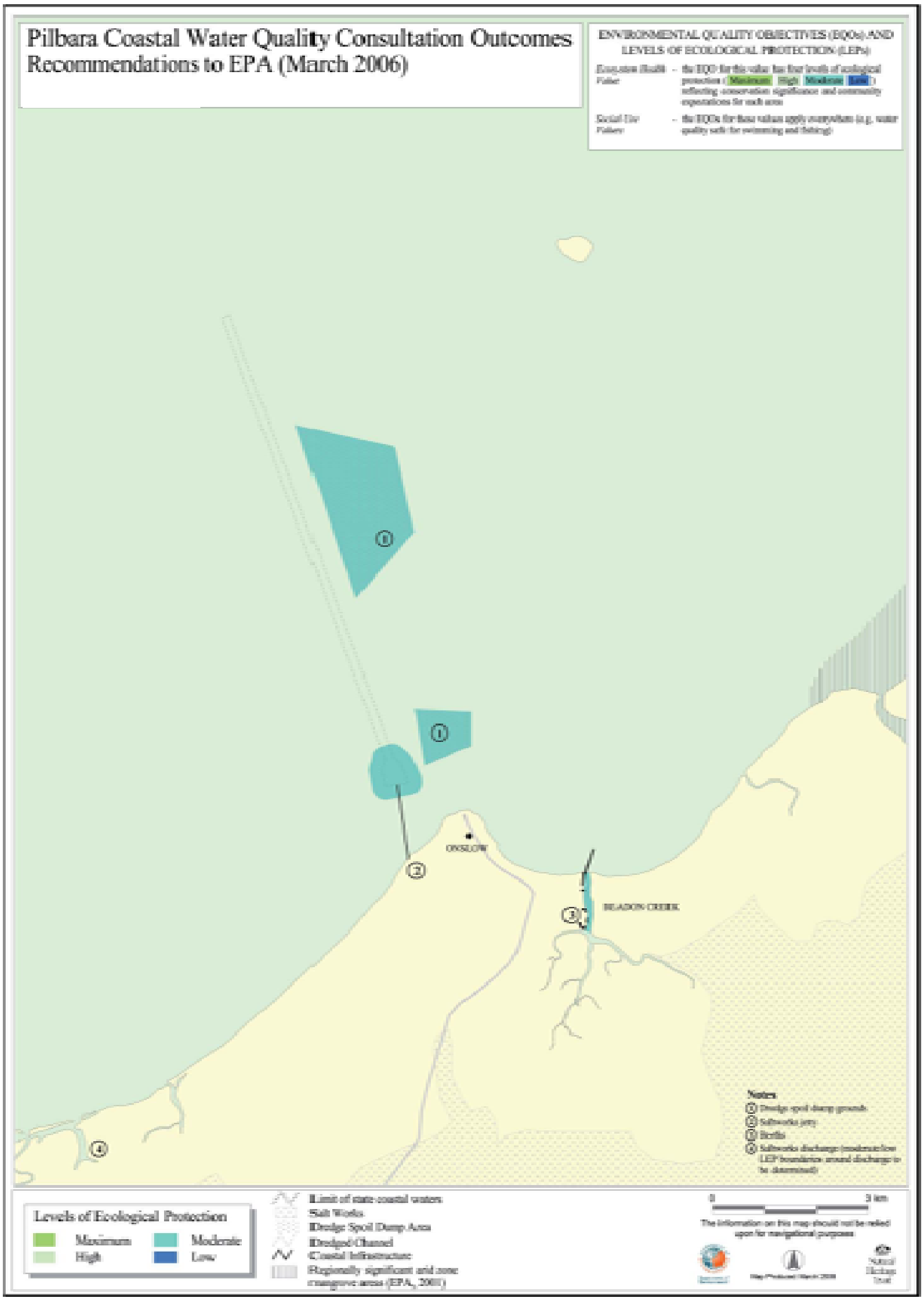
This review focuses on the marine environment adjacent to Onslow, Western Australia. According to the Pilbara Coastal Water Quality Consultation Outcomes document by the Western Australian Department of Environment (2006), most of this area should be afforded a high Level of Ecological Protection (LEP). Waters around the historic dredge spoil dump grounds, the saltworks jetty and berths have been allocated a moderate LEP. The saltworks discharge has been allocated a low to moderate LEP (Figure 1). Over the long term, areas of high protection are expected to have very low levels of contaminants and have no detectable change from natural variation in biological indicators (Department of Environment 2006) (Table 2).

Maximum levels of contaminants consistent with high ecological protection for waters of the North West Shelf have been published previously (Wenziker et al. 2006). Where specific guideline values have not been identified, natural variation is defined as being between long term 20th and 80th percentiles or between the 20th and 80th percentiles of relevant Reference sites (ANZECC & ARMCANZ 2000). Water quality characteristics reviewed in this report have been considered within the context of the Pilbara Coastal Water Quality Outcomes and the ANZECC & ARMCANZ guidelines.

Table 2. Expected Environmental Quality Objectives for the "Maintenance of Ecosystem Integrity' linked to Levels of Ecological Protection

Level of Ecological Protection	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

Figure 1. Levels of Ecological Protection in marine water around Onslow (Extracted from Department of Environment 2006).



3.0 BACKGROUND STUDIES

3.1 STUDY 1 - SHORT TERM BOAT BASED INVESTIGATIONS

3.1.1 METHODS AND LOCATIONS

Intensive short term studies were carried out under natural conditions to establish the relationships between turbidity, total suspended solids concentration (TSS) and light attenuation.

Turbidity, light and TSS were measured at three depths (surface, midwater and bottom) at 113 sites during two sampling trips (August 9-11, 2009 and October 5-6, 2009). Site locations are shown in Figure 2.

The measurements were also made at times selected to coincide with overpass of the MODIS satellite. This was to provide data for the calibration of turbidity, measured *in situ* with MODIS reflectance data (see Section 3.1.2).

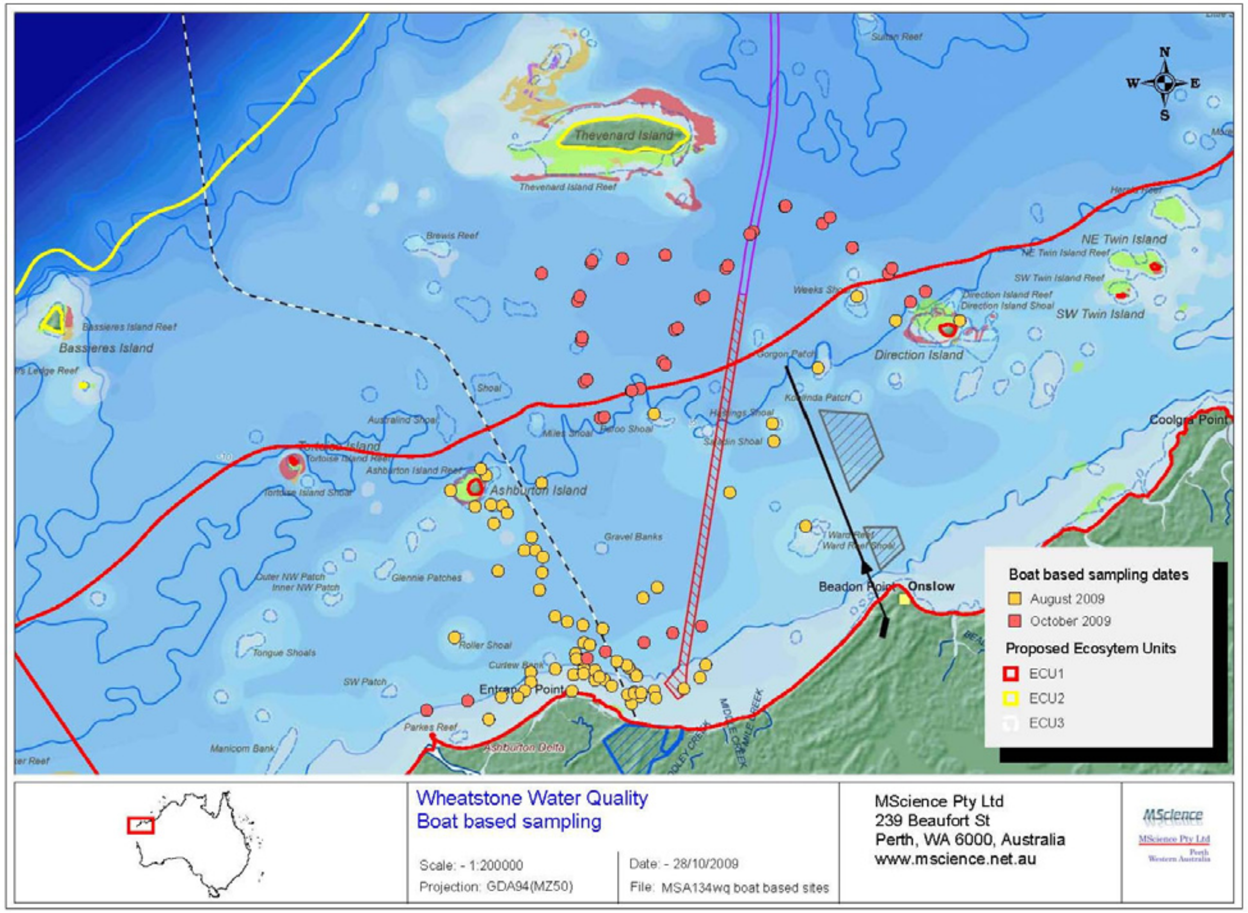
Turbidity was measured using an Analite NEP 260 turbidity probe (McVann Instruments, Pty Ltd, Melbourne) and light with a Li-Cor LI-1000 Data logger (connected to a Li-Cor Radiation Sensor). A hose was attached to both the instrument cable and to a pump at the surface. Depending on the level of turbidity, 1 to 2 litres of water were pumped from a hose inlet adjacent to the turbidity sensor each time a turbidity reading was taken. The water was filtered on site through a 1– 1.2 µm pore size, 47 mm diameter GF/C) filter paper (Whatman – Schleicher & Schuell and sent to a commercial laboratory (Marine and Freshwater Research Laboratory [MAFRL]) for gravimetric determination of total suspended solids (TSS).

Light attenuation was calculated as E (Kirk 1977), using the equation:

E = (log(irradiance at surface)-log (irradiance at depth))/distance between measurements

The relationships between turbidity and TSS and turbidity and light attenuation were established using linear regression.

Figure 2. Sampling sites for boat based measurement of turbidity, total suspended solids and light attenuation



3.1.2 Relationship between turbidity, total suspended solid concentrations and light attenuation

The boat based measurements indicated strong relationships between turbidity, TSS (Figure 3) and light attenuation (Figure 4). Light attenuation was more strongly related to turbidity than to TSS (Figure 5).

These relationships were used to derive historical baseline water quality statistics from analysis of MODIS images (see Section 3.2) and for prediction of turbidity from TSS in Section 3.4.

Figure 3. Relationship between turbidity and total suspended solids.

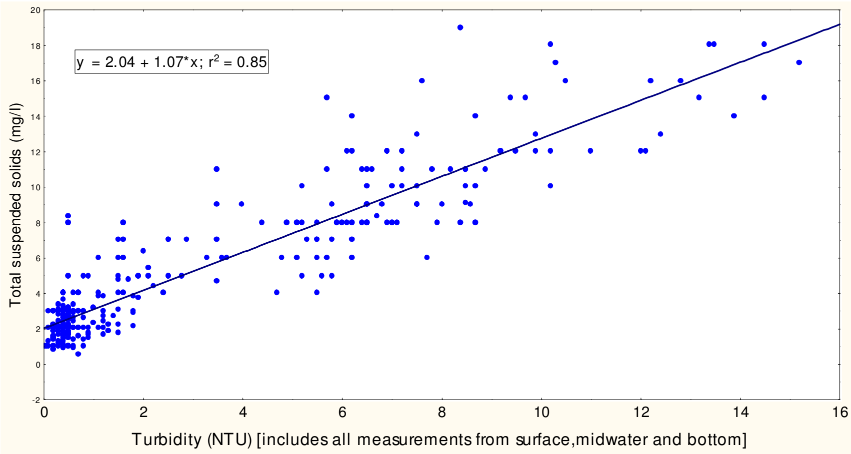


Figure 4. Relationship between turbidity and light attenuation (E).

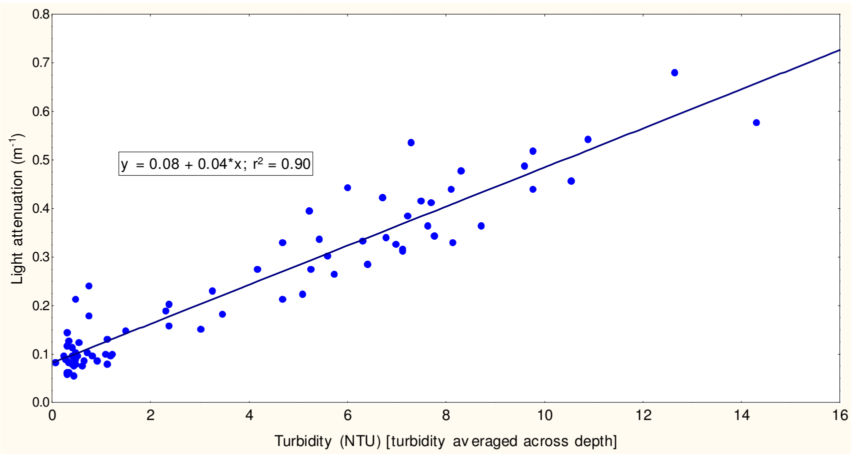
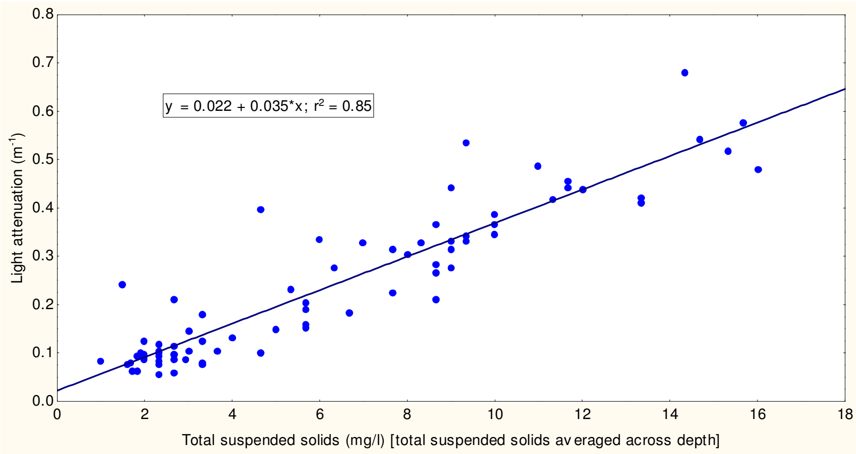


Figure 5. Relationship between total suspended solids and light attenuation (E).



3.2 Study 2 - Mapping of turbidity based on MODIS images

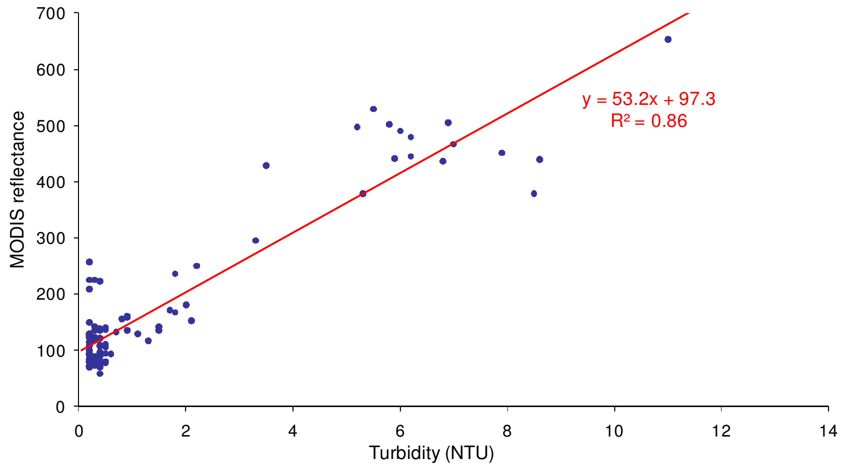
3.2.1 Procedures and calibration

Analysis of existing MODIS (or Moderate Resolution Imaging Spectroradiometer) images was used to provide a long term historical record of turbidity at 30 sites over three years in marine waters around Onslow. MODIS is a key instrument aboard the Terra and Aqua satellites. Terra's orbit around the Earth is timed to pass from north to south across the equator in the morning, while Aqua passes south to north over the equator in the afternoon. Terra MODIS and Aqua MODIS are viewing the entire Earth's surface every one to two days, acquiring data in 36 spectral bands, or groups of wavelengths.

MODIS imagery has been used previously to measure sediment plumes during dredging (Wang et al. 2008) and has been shown to provide a reasonable estimate of TSS changes in surface water (Islam et al. 2007).

Initially a calibration study between *in situ* measurement of turbidity (see Section 3.1) and MODIS reflectance was performed. This study related *in situ* turbidity to reflectance acquired by the MODIS Terra and Aqua sensors at a common time and location. Turbidity was related to the remotely sensed reflectance measured in the red part of the visible spectrum (620–670 nm for the MODIS band in 250 m resolution). The *in situ* turbidity was measured on 9th, 10th and 11th August plus 5th and 6th October 2009 for calibration points.

Figure 6. Relationship between turbidity and MODIS reflectance



After performing a quality check of the MODIS values it was clear that Terra data from the 9th and 11th August and the 6th October, together with Aqua data from 9th and most of the 10th August and 6th October was not suitable for calibration. This was due to problems with view angles, sun glint and clouds. Thus the regression was based on the following MODIS data:

- 10th August: Terra, plus few Aqua
- 11th August: Aqua
- 5th October: Aqua and Terra

This provided approximately 85 observation pairs. The resulting plot of these data pairs and the derived linear regression is shown on Figure 6.

A total of approximately 150 useful MODIS/Terra scenes from June 2006 to September 2009 were then chosen (see Figure 7). These images were selected after manual screening to avoid images compromised by sun glint, view angles and clouds. Following a review of the image options, it was clear that Terra images alone could be selected to cover the specified time interval (1 scene per 10 days), thus Aqua scenes were not used.

Table 3. Sites selected for MODIS image analysis over 4 years. Also shown on Figure 9.

Site number	Vicinity/location	Ecosystem Unit
1	Direction Island	1
2	End Shipping Channel	2
3	Glennie Patches	1
4	Gorgon Patch	1
5	Onslow Salt Shipping Channel	1
6	North West Ward Reef	1
7	Ward Reef	1
8	Ward Reef	1
9	Little Shoals	2
10	Roller Shoal	1
11	Saladin Shoal	1
12	Weeks Shoal	1
13	Ashburton Island	1
14	Tortoise Island	1
15	North East Twin Island	1
16	Coolgra Point	1
17	Coolgra Point	1
18	Glennie Patches	1
19	South West Twin Island	1
20	Inshore Pipeline route	1
21	Brewis Reef	2
22	Mangrove Islands	1
23	Thevenard Island	2
24	Direction Island	1
25	Thevenard Island	2
26	North East Saladin Shoal	1
27	Brewis Reef	2

28	Inshore Dredge	1
29	South of Bowers Ledge	2
30	South West Mangrove Is	1

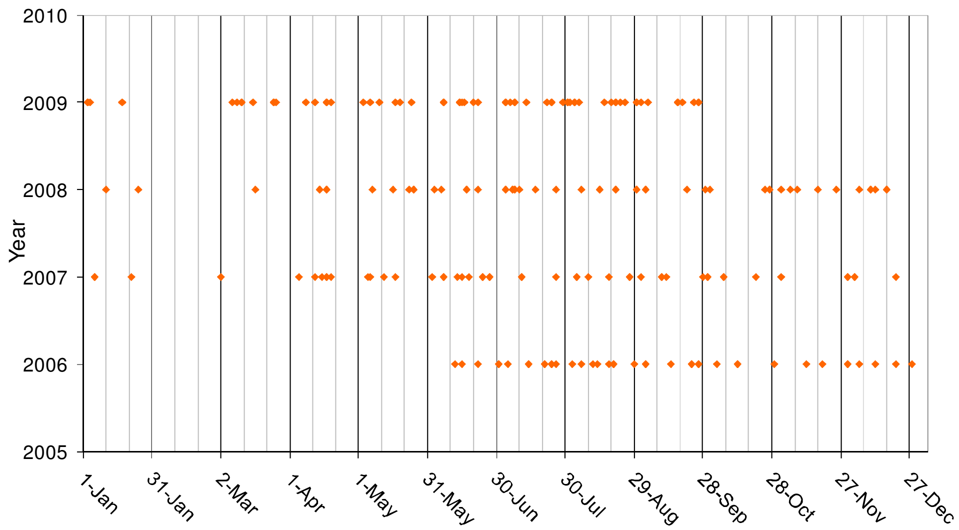
The selected images were systematically corrected, georectified and subset to cover the area of interest. The processing steps included removal of atmospheric effects to calculate the surface reflectance. These surface reflectance values were subsequently transformed to turbidity based on the regression formula presented above. The last step involved masking of clouds. Results were derived both as a calibrated image and in a tabular format.

For analytical purposes, the sites were allocated into one of three major ecosystem units (see Figure 2) defined as follows:

- ECU1 - Onslow nearshore, encompassing waters up to 10 m depth in relatively complex bathymetry covering mainly soft substrates but including a ridge of scattered patch shoals that support corals and sponges;
- ECU2 - Onslow offshore, encompassing waters between 10-20 m and most offshore islands and coral reefs and algal dominated shoals;
- ECU3 - Onslow inner Shelf, incorporating the relatively steep slope from the 20 m to the 70 m depth contour.

No sites in ECU3 were included in the MODIS analysis.

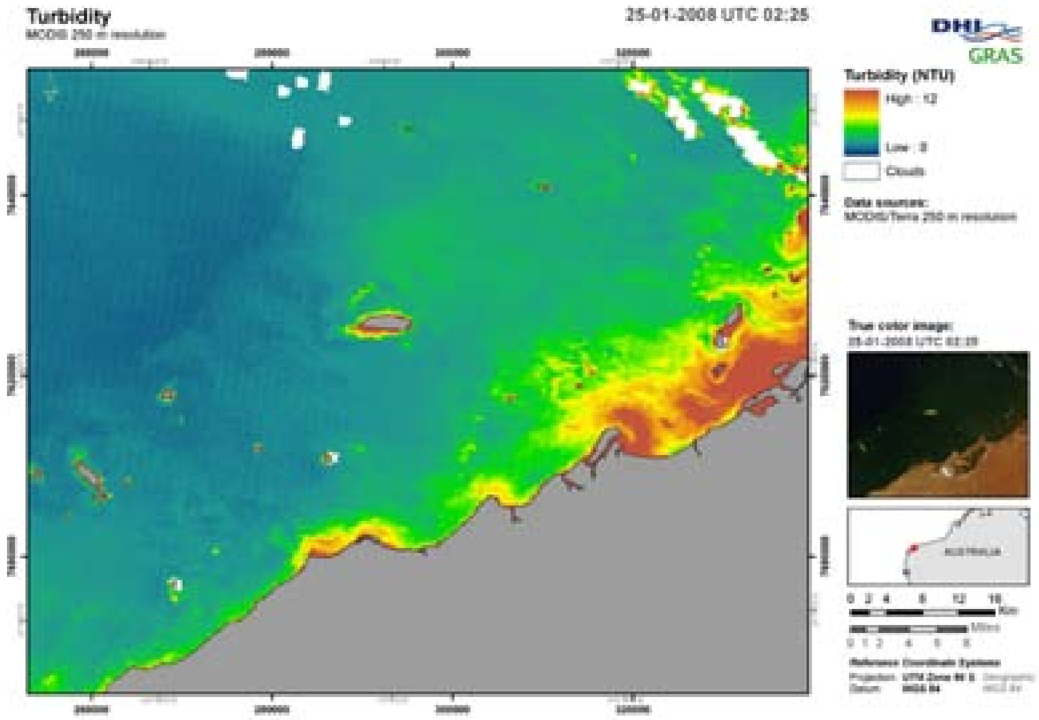
Figure 7. Dates of MODIS images selected for turbidity prediction



3.2.2 Turbidity based on MODIS images

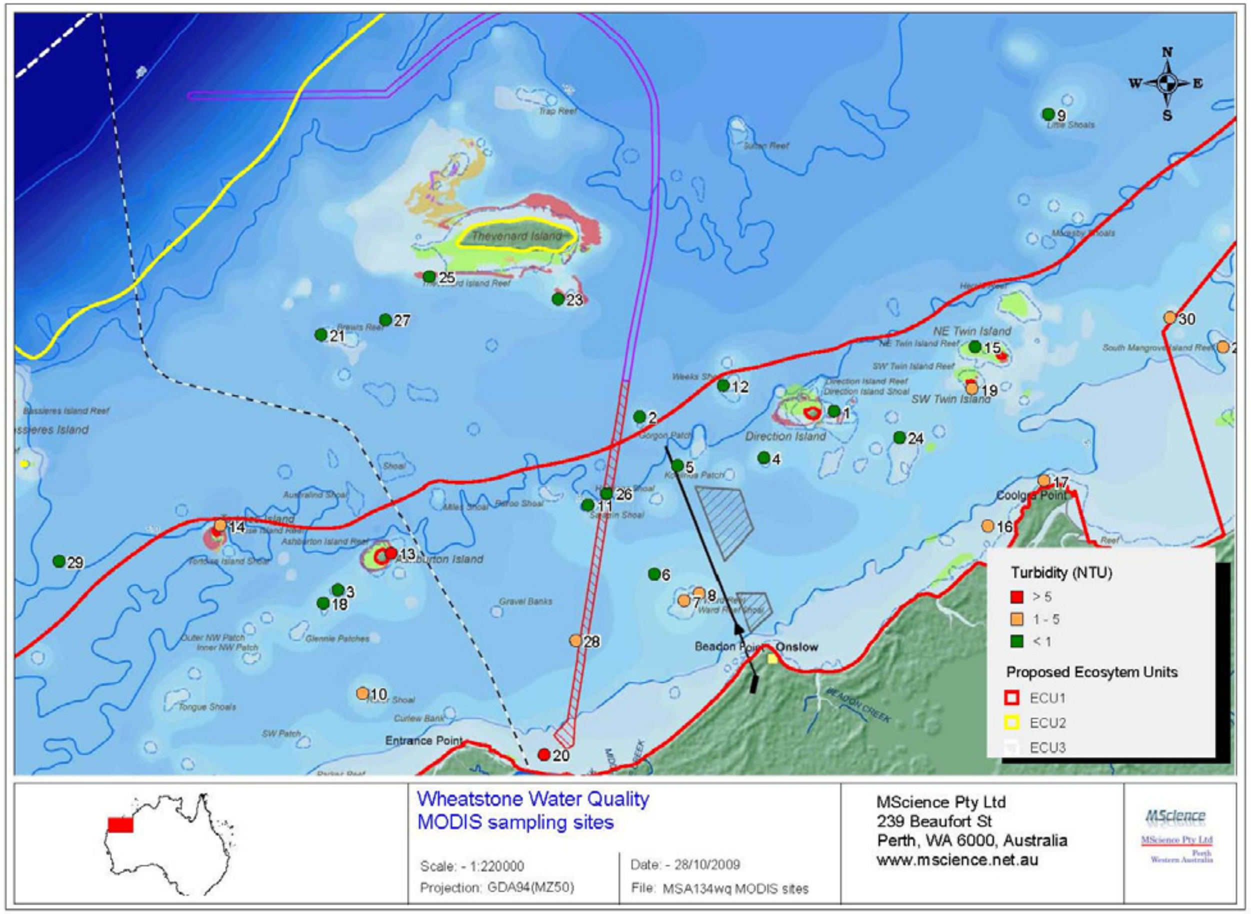
Analysis of MODIS images provided 4560 data points across 30 sites over four years. There were 152 data points for each site. The analysis did not include cyclonic conditions as reliable images were not available during these times. An example of an analysed image is shown in Figure 8.

Figure 8. Example of MODIS calibrated image



These data have been analysed to show long term mean, median, 80th percentile and 95th percentiles for turbidity, TSS and light attenuation (Table 4). TSS and light attenuation (E) were calculated from the relationships derived in Section 3.1.2. Medians are also shown together with sites locations on Figure 9.

Figure 9. Locations and median turbidity of MODIS sites analysed over 4 years



Overall, turbidity, light attenuation and TSS were all higher at the nearshore sites (ECU1) than the offshore sites (ECU2) and were higher in summer (November – April inclusive) than in winter (May – October inclusive).

Table 4. Descriptive water quality statistics determined MODIS image analysis

Location	N	Mean	Median	80th percentile	95th percentile
All sites					
Turbidity (NTU)					
Summer	1380	3.5	1.7	4.6	11.8
Winter	3180	1.8	0.3	2.2	8.8
Full year	4560	2.3	0.7	3.1	9.9
Total suspended solids (mg/l)					
Summer	1380	5.8	3.9	7.0	14.9
Winter	3180	4.0	2.4	4.4	11.6
Full year	4560	4.5	2.8	5.3	12.8
Light attenuation (E, m^{-1})					
Summer	1380	0.2	0.15	0.27	0.56
Winter	3180	0.2	0.09	0.17	0.44
Full year	4560	0.2	0.11	0.20	0.48
Ecosystem unit 1 (Nearshore)					
Turbidity (NTU)					
Summer	1012	4.4	2.4	5.6	14.4
Winter	2332	2.4	0.7	2.9	11.1
Full year	3344	3.0	1.1	4.2	12.2
Total suspended solids (mg/l)					
Summer	1012	6.8	4.6	8.1	17.6
Winter	2332	4.6	2.8	5.2	14.0
Full year	3344	5.3	3.2	6.6	15.3
Light attenuation (E, m^{-1})					
Summer	1012	0.26	0.18	0.31	0.66
Winter	2332	0.18	0.11	0.20	0.53
Full year	3344	0.20	0.13	0.25	0.57
Ecosystem unit 2 (Offshore)					
Turbidity (NTU)					
Summer	368	0.9	0.4	1.7	3.2
Winter	848	0.3	0.0	0.3	1.5
Full year	1216	0.5	0.0	0.8	2.4
Total suspended solids (mg/l)					
Summer	368	3.0	2.5	3.9	5.5
Winter	848	2.3	2.0	2.4	3.7
Full year	1216	2.5	2.0	2.9	4.6
Light attenuation (E, m^{-1})					
Summer	368	0.12	0.10	0.15	0.21
Winter	848	0.09	0.08	0.09	0.14
Full year	1216	0.10	0.08	0.11	0.18

The seasonal trends in turbidity are also shown on Figure 10 and differences between sampling sites on Figure 11. These figures indicate both temporal and spatial differences in both median turbidity and in the variation associated with each median. Higher turbidity (due to location or time) was usually associated with higher variation in turbidity. The consistently high values in Figure 11 for site 13 may indicate some land corrupting that pixel.

Figure 10. Median turbidity at each time calculated across sites. Bars represent 20th and 80th percentiles.

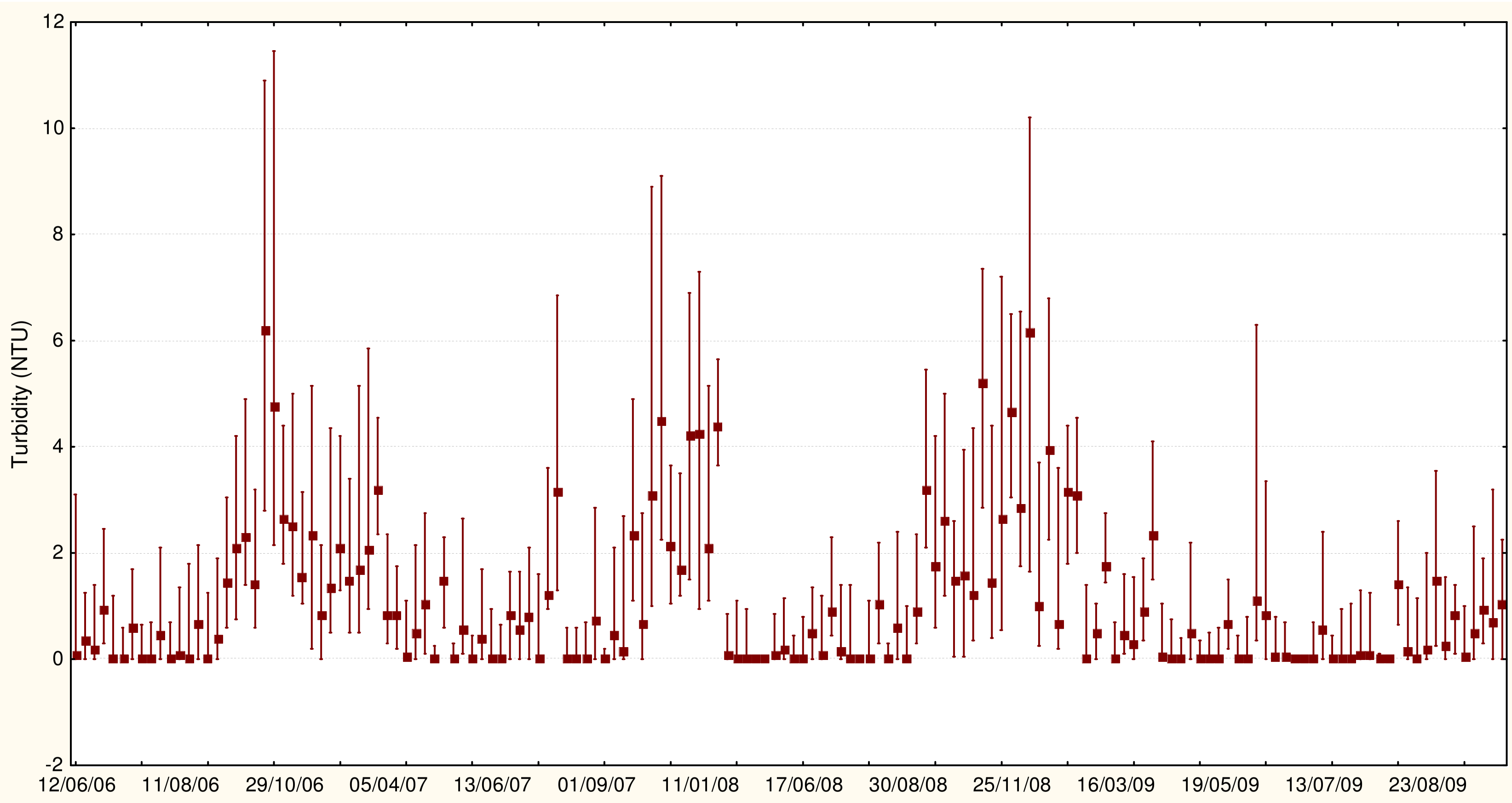
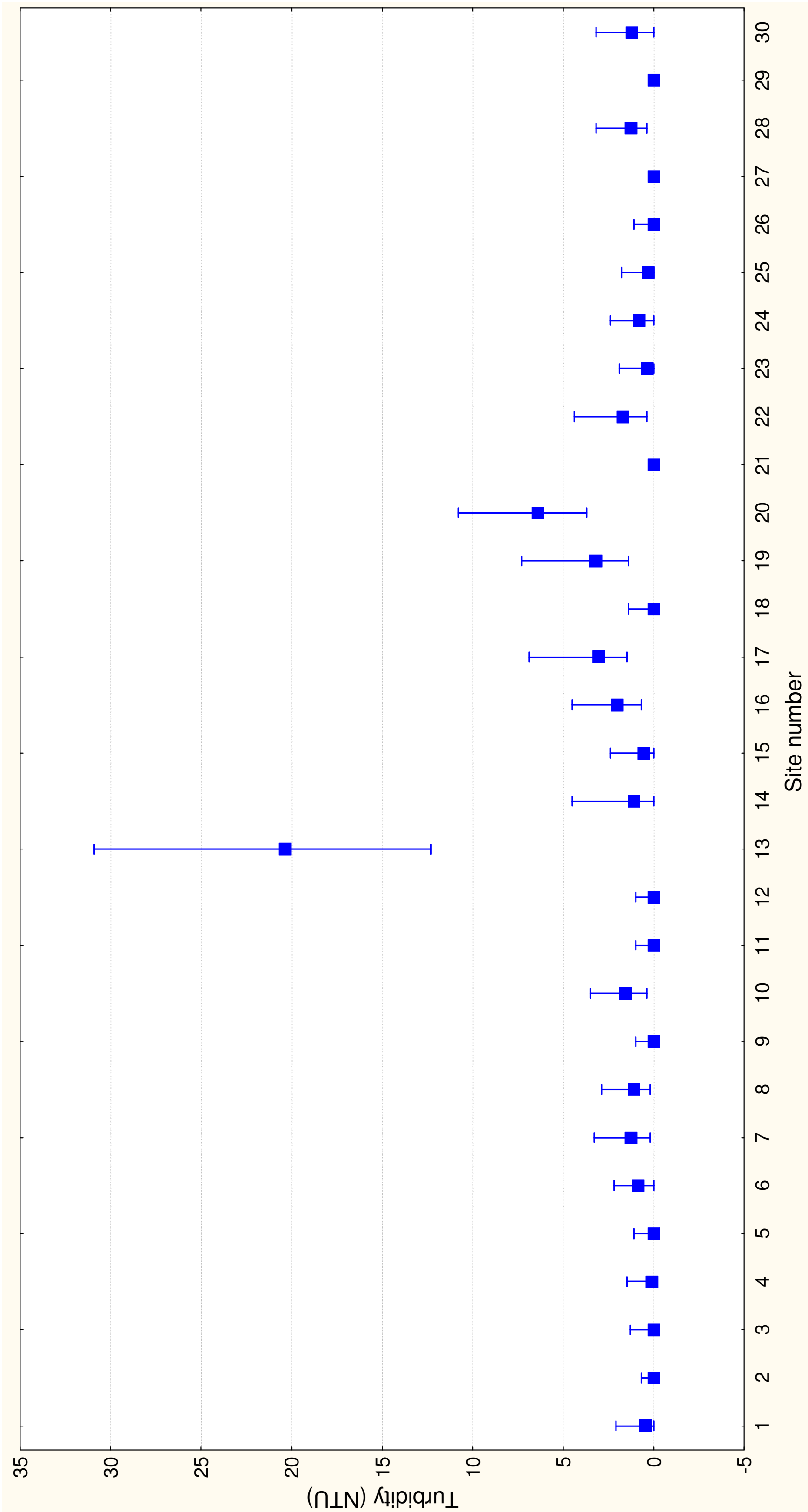


Figure 11. Median turbidity at each site calculated across time. Bars represent 20th and 80th percentiles.



3.3 Study 3 - Deployed turbidity, light, temperature and salinity sensors

From 3rd March 2009 until 9th September 2009, instrumentation for the assessment of water quality was deployed at two sensitive coral sites; one near Paroo Shoals and the other close to Direction Island. Instrument specifications and sensor configuration are described below and summarised in Table 5. In addition a surface Photosynthetically Active Radiation (PAR) sensor was deployed at the Onslow meteorological station.

3.3.1 Instrument specifications

A YSI 6600 V2 Sonde was used in this deployment. This is a multi-parameter water quality measurement and data collection system. Sensors measured PAR and included a wiping mechanism to extend maintenance interval and improve data reliability. PAR is the spectral range of solar light from 400 to 700 nanometres and is used by aquatic plants in photosynthesis.

A YSI 6136 Turbidity Sensor was also integrated with the YSI 6600 V2 Sonde for the measurement of turbidity. This also featured a mechanical self-wiping capability for long term deployment. Turbidity was measured in Nephelometric Turbidity Units (NTU).

All sensors were originally supplied calibrated by the manufacturer, and at each service a bench-check was performed against a known standard (distilled water, 0 NTU). Temperature and salinity sensors were also configured with the Sonde.

Instruments were programmed to take a measurement every 15 minutes.

3.3.2 Instrument configuration and moorings

The Direction Island (9 m LAT) mooring had a Sonde instrument located at 0.6 m ASB and at 3.0 m ASB, attached to a 360 kg anchor with transponder and tilt sensor. The 0.6 m ASB Sonde had a 0.5 m angled mounting arm that was used to secure two PAR sensors, at 0.6 m ASB and 1.0 m ASB, as well as a turbidity sensor at 0.6 m ASB. The 3.0 m ASB Sonde only had a turbidity sensor at 3.0 m ASB. The angled arm was designed to prevent the shading effects.

The Paroo Shoal (10 m LAT) mooring had a Sonde PAR and turbidity sensor located at 0.6 m ASB and a turbidity sensor at 4.0 m ASB, attached to a 360 kg anchor with transponder and tilt sensor. The 0.6 m ASB Sonde had a 0.5 m angled mounting arm that was used to secure two PAR sensors, at 0.6 m ASB and 1.0 m ASB, as well as a turbidity sensor at 0.6 m ASB. The 4.0 m ASB Sonde only had a turbidity sensor at 4.0 m ASB.

To minimise data loss and instrument failure, the following procedures were applied:

- Application of chemical anti-foul paints;
- Careful preparation and maintenance of instruments including re application of anti- seize grease on all moving parts at each service;
- External battery cases for extended deployments;
- Extra anodes mounted on areas susceptible to corrosion;
- Purpose-built mooring frames for instrument protection and ease of deployment;

- Deployment of 'Special Marks' buoys to deter fishing vessels from trawling moorings.

Table 5. Details of deployed instruments at Paroo Shoals and Direction Island

		Paroo Shoals	Direction Island
Instrument		YSI 6600 V2 Sonde	YSI 6600 V2 Sonde
Sensors	Light (PAR)	2 (0.6 and 1 m ASB)	2 (0.6 and 1 m ASB)
	Turbidity	2 (0.6 and 4 m ASB)	2 (0.6 and 3 m ASB)
	Salinity	2 (0.6 and 4 m ASB)	2 (0.6 and 3 m ASB)
	Temperature	2 (0.6 and 4 m ASB)	2 (0.6 and 3 m ASB)
Deployment dates		5^{th} March – 9^{th} September 2009	5^{th} March – 9^{th} September 2009
Service/download interval		6 weeks	6 weeks

3.3.3 Data Processing and Analysis

All turbidity and PAR data were passed through a thorough quality control (QC) procedure prior to final analysis. Procedures are summarised as follows:

Turbidity
Negative values were interpreted as the result of baseline drift causing a small zero point offset rather than a larger calibration error. Deployments where negative values were observed were corrected by adding (zero - 1^{st} percentile) to all results for that deployment. All individual results were checked and classified for reliability as follows:

1 Category 1 – unreliable data as demonstrated by:
- ◊ On retrieval, instrument observed to have fouling interfering with sensor function;
- ◊ On retrieval, instrument observed to have a mechanical malfunction (eg wiper obscuring sensor or operating outside of programmed parameters, physical damage to parts of the instrument, incorrect reading frequency, calibration failure etc).

  Data graphed to identify start of interference.

2 Category 2 – suspect data as demonstrated by:
- ◊ No direct evidence of sensor interference but anomalous data detected on inspection of check plots as demonstrated by.
  - A > 5 fold difference between the two sensors (suspect data for higher value). Applied when both instruments were functional and lower data of the two instruments appeared reliable and/or;
  - A >5 fold increase from baseline without a significant change in potential forcing factors (wind, swell, rainfall, tide) and/or;
  - Fouling adjacent to but not directly covering sensor on the instrument frame.

  Periods of potential elevation of turbidity due to increases in forcing factors were identified prior to data filtering.

3 Category 3 – reliable data as demonstrated by:
- ◊ No direct or indirect evidence of sensor interference.
- ◊ None of the conditions described above are applicable.

Light
Minor offsets to PAR data were needed to set night time PAR data to near "zero" and ensure instruments were synchronised. The offset is the representative (not the minimum spike) data recorded during the night. This offset was applied to all data.

All individual PAR results were then checked and classified for reliability as follows:

1 Category 1 – unreliable data as demonstrated by:
- ◊ On retrieval, instrument observed to have fouling interfering with sensor function;
- ◊ On retrieval, instrument observed to have a mechanical malfunction (eg wiper obscuring sensor or operating outside of programmed parameters, physical damage to parts of the instrument, calibration factors etc).

  Data graphed to identify start of interference.

2 Category 2 – suspect data as demonstrated by:
- ◊ No direct evidence of sensor interference but anomalous data detected on inspection of check plots as demonstrated by.
  - Suspected mooring interference where two or more sensors were deployed and there was a significant mismatch in data trends;
  - Fouling adjacent to but not directly covering sensor on the instrument frame

  Periods of potential elevation of PAR due to increases in forcing factors were identified prior to data filtering

3 Category 3 – reliable data as demonstrated by:
- ◊ No direct or indirect evidence of sensor interference.
- ◊ None of the conditions described above are applicable

Light attenuation was calculated directly from PAR measurements made at each site together with the surface irradiance measured at the meteorological station using the formula shown in Section 3.1. Use of land based surface irradiance to calculate light attenuation is consistent with published research elsewhere (Cooper et al. 2007). Analysis of light attenuation only included measurements made from 10.00 am to 14.00 pm (inclusive).

3.3.4 Turbidity and Light Attenuation

Instrument malfunction and interference resulted in the exclusion of a significant proportion of turbidity data collected at the Direction Island and Paroo Shoals between March and September 2009. A conservative approach was taken to suspect data as described in Section 3.3.3. Suspect and unreliable data was excluded from the analysis.

The available data indicates daily median turbidity at both sites ranged between 0 and 6 NTU with occasional higher readings (Figure 12 and Figure 13). There were no clear differences between the sensors located close to the seabed (0.6 m ASB) and the sensors located 3-4 m above the seabed (3 or 4 m ASB).

Figure 12. Turbidity at Direction Island during late summer and winter measured 0.6 and 3.0 m above the seabed. Daily medians, bars represent 20th and 80th percentiles

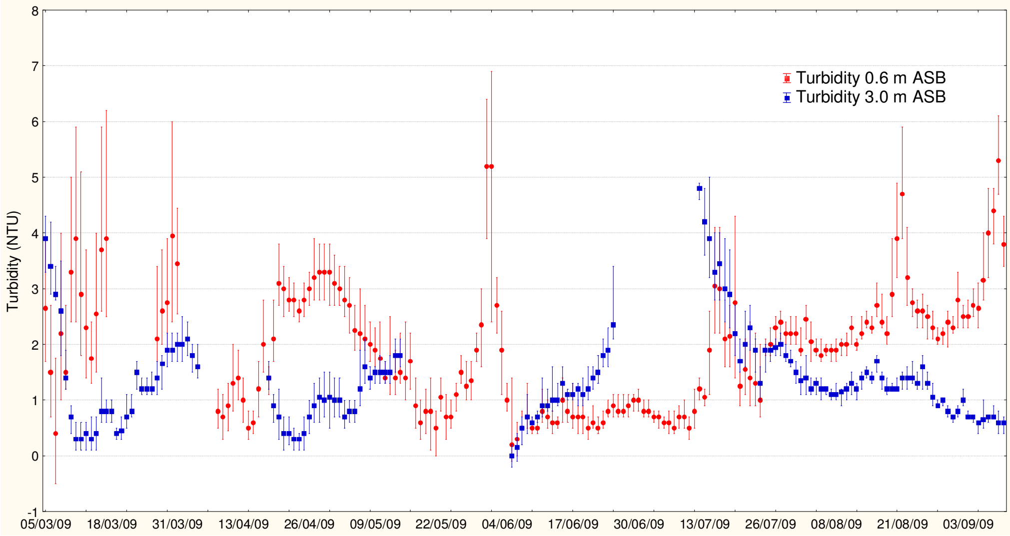
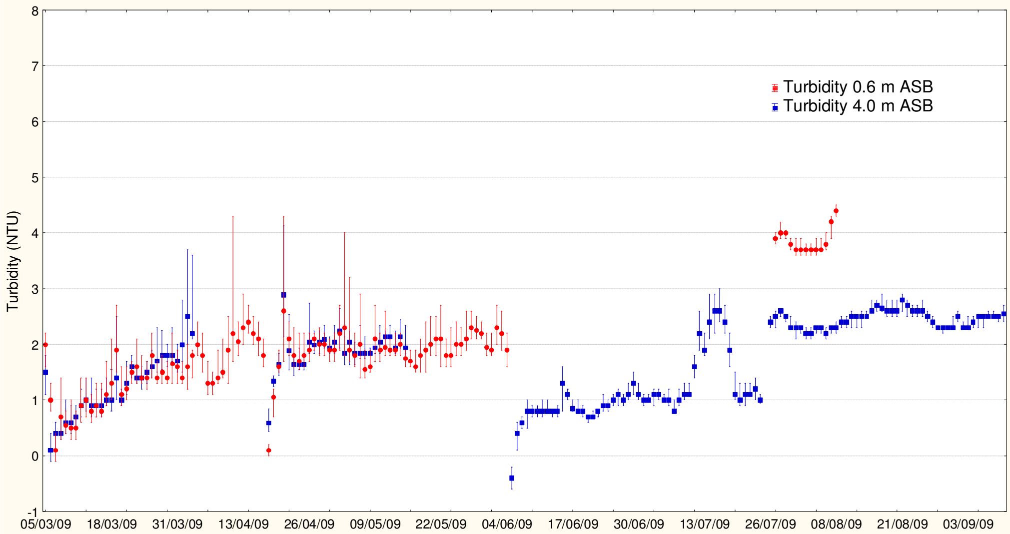
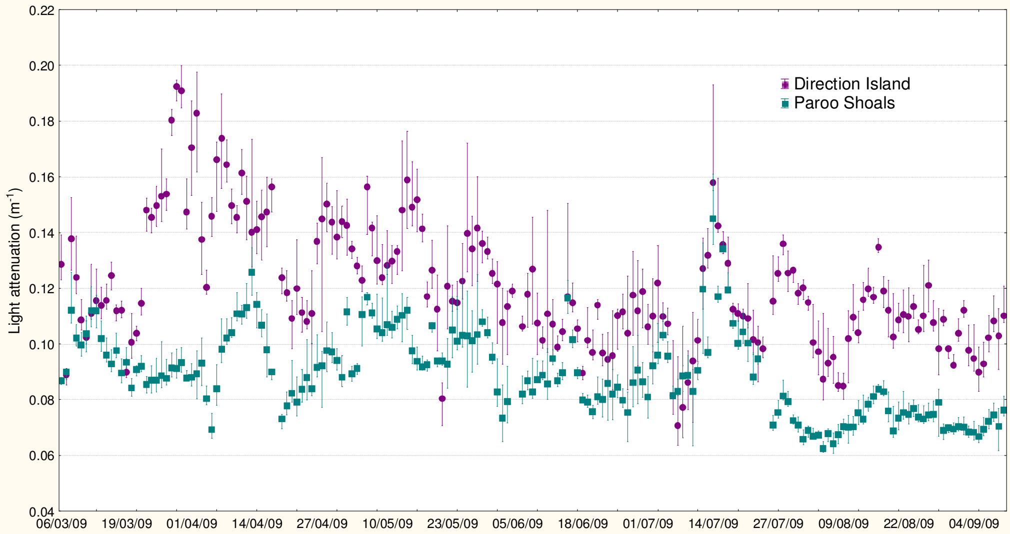


Figure 13. Turbidity at Paroo Shoals during late summer and winter measured 0.6 and 3.0 m above the seabed. Daily medians, bars represent 20th and 80th percentiles



The data indicates that daily median light attenuation at both sites ranged between 0.06 and 0.2 m^{-1} (Figure 14) during late summer and through winter 2009.

Figure 14. Light attenuation (E) over time at Direction Island and Paroo Shoals. Daily medians, bars represent 20th and 80th percentiles



Turbidity and light attenuation were low at both sites assessed with deployed instruments. Turbidity in winter (May-October inclusive) tended to be higher than turbidity in summer; however, summer was only represented by a short period after February 2009 and did not include any periods of cyclonic disturbance.

Light attenuation tended to be higher at Direction Island than Paroo Shoals and higher in summer than winter.

Table 6. Descriptive statistics of water quality as determined using deployed turbidity and light sensors

		N	Mean	Median	80th percentile	95th percentile
Turbidity (NTU)						
Summer	Direction Island	4059	1.21	1.00	1.80	3.10
Summer	Paroo Shoals	3883	1.57	1.50	2.00	3.10
Summer	Pooled sites	7942	1.39	1.30	1.94	3.10
Winter	Direction Island	8794	1.43	1.30	1.80	3.10
Winter	Paroo Shoals	10530	1.84	2.10	2.50	2.80
Winter	Pooled sites	19324	1.66	1.50	2.40	2.80
Light attenuation (E, m^{-1})						
Summer	Direction Island	1097	0.14	0.14	0.16	0.19
Summer	Paroo Shoals	1096	0.10	0.09	0.11	0.12

Summer	Pooled sites	2193	0.12	0.11	0.14	0.17
Winter	Direction Island	2602	0.11	0.11	0.13	0.15
Winter	Paroo Shoals	2580	0.09	0.09	0.10	0.12
Winter	Pooled sites	5182	0.10	0.10	0.12	0.14

3.3.5 Water Temperature

Water temperature showed a strong seasonal pattern ranging from 30°C in early March to approximately 20°C in July. Higher water temperatures are likely between December and March. Monitoring did not include early summer or any periods of cyclonic activity.

Figure 15. Seasonal changes in water temperature at Direction Island and Paroo Shoals

3.4 Study 4 - Historical Studies on Water Quality

Australian Premium Iron (API) engaged AECOM Australia Pty Ltd (AECOM) to characterise baseline marine water quality regimes within coastal waters west of Onslow in summer 2008/2009 and autumn 2009. Selected relevant information from this study is presented in this baseline report.

3.4.1 Water Quality Around Cyclonic and Flood Conditions

3.4.1.1 Procedures

To record the effect of a major runoff event on water quality in marine waters off Onslow, water samples were collected at the surface and bottom following the passage of Tropical

Cyclone (TC) Dominic in January 2009 and the subsequent large inland rainfall event in February 2009. Light measurements were also made.

Samples were collected as follows (Figure 16):
- 31^{st} January, 2009   17 marine sites
- 6^{th} February, 2009   19 marine sites

Sampling locations are shown on the colour coded figure (Figure 16).

Water samples tested for TSS were taken 1 m from the surface and 1 m from the bottom without any replication. TSS was measured by filtering a known volume of water (approx 500 ml) through a pre-weighed filter paper as described in Section 3.1. The filters were stored on ice in the dark and frozen at the end of the sampling day. Samples then sent to MAFRL and analysed for dry weight.

Light intensity in µmol/s.m was measured at 1 m increments through the water column. Light was measured using a Licor LI 192 Underwater Quantum Sensor attached to a LI-250A head unit. Attenuation was calculated as E as described previously.

Turbidity was not measured in this study but has been estimated from TSS using the equations derived in Section 3.1.

For the purposes of this report, both turbidity and TSS are reported as depth averages. Light attenuation was calculated in the top 5 m of water from light intensity measurements as described in Section 3.1.

3.4.1.2 Results

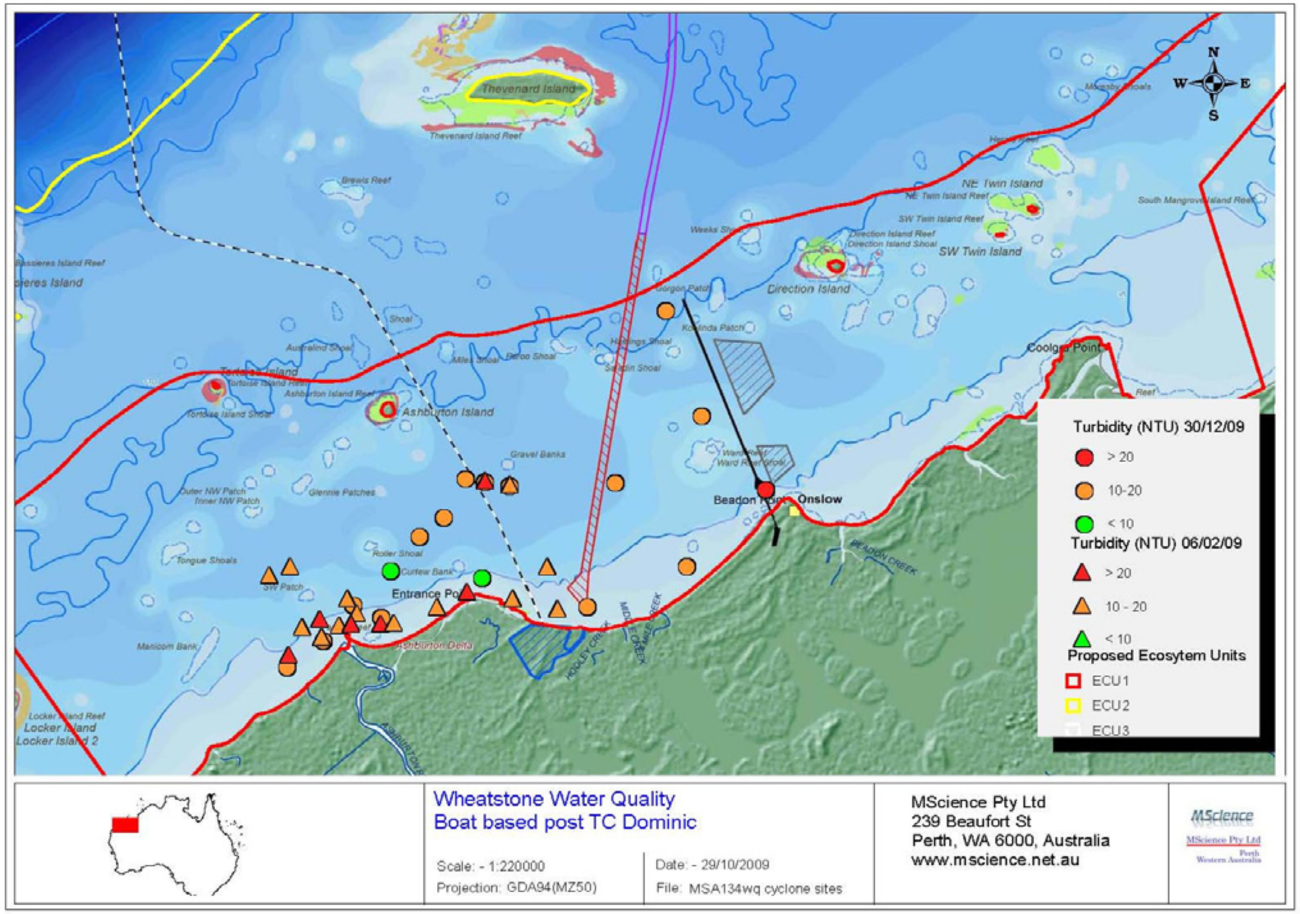
Turbidity, TSS and light attenuation (Table 7) were much higher in the 2 weeks following TC Dominic than during the non-cyclonic periods assessed using MODIS (Table 4). As with the MODIS data, these statistics are derived from a single measurement per site on each day across many sites.

Table 7. Descriptive statistics of water quality 4 and 10 days after TC Dominic

Date	N	Mean	Median	80^{th} percentile	95^{th} percentile
Turbidity (NTU)					
31/01/09	17	14.8	15.4	17.0	21.8
06/02/09	20	18.6	17.6	22.6	28.3
Pooled days	37	16.9	15.8	21.0	27.3
Total suspended solids (mg/l)					
31/01/09	17	20.2	21.0	23.0	29.0
06/02/09	18	24.9	23.8	29.5	38.5
Pooled days	35	22.6	21.5	27.3	36.0
Light attenuation (E, m^{-1})					
31/01/09	17	0.28	0.28	0.32	0.77
06/02/09	17	0.37	0.26	0.45	1.90
Pooled days	34	0.32	0.27	0.41	0.77

There was no clear spatial pattern of increased turbidity, TSS and light attenuation following TC Dominic. Sites close to the mouth of the Ashburton River were elevated, but so was turbidity at most other sites up to 20 km to the north and north-west (Figure 16).

Figure 16. Location of sampling sites and turbidity 4 and 10 days after TC Dominic



3.4.2 Turbidity during cyclonic conditions

3.4.2.1 Procedures

A single nephelometer was deployed at an inshore location approximately 5 kilometres off the coast, 20 kilometres west of Onslow at a depth of 8-9 m (Figure 18).

The nephelometer was deployed on 21st January 2009 and collected data until 30th January 2009, when the casing failed and the unit flooded. TC Dominic passed over Onslow on 27th January 2009.

The instrument used was an Analite NEP495 turbidity and temperature logger. This factory calibrated instrument was installed approximately 0.5 m above the sea bed and was set to record within the range of 0 – 400 NTU every hour.

Data was analysed to provide daily statistics prior to, during and after the passing of TC Dominic.

3.4.2.2 Results

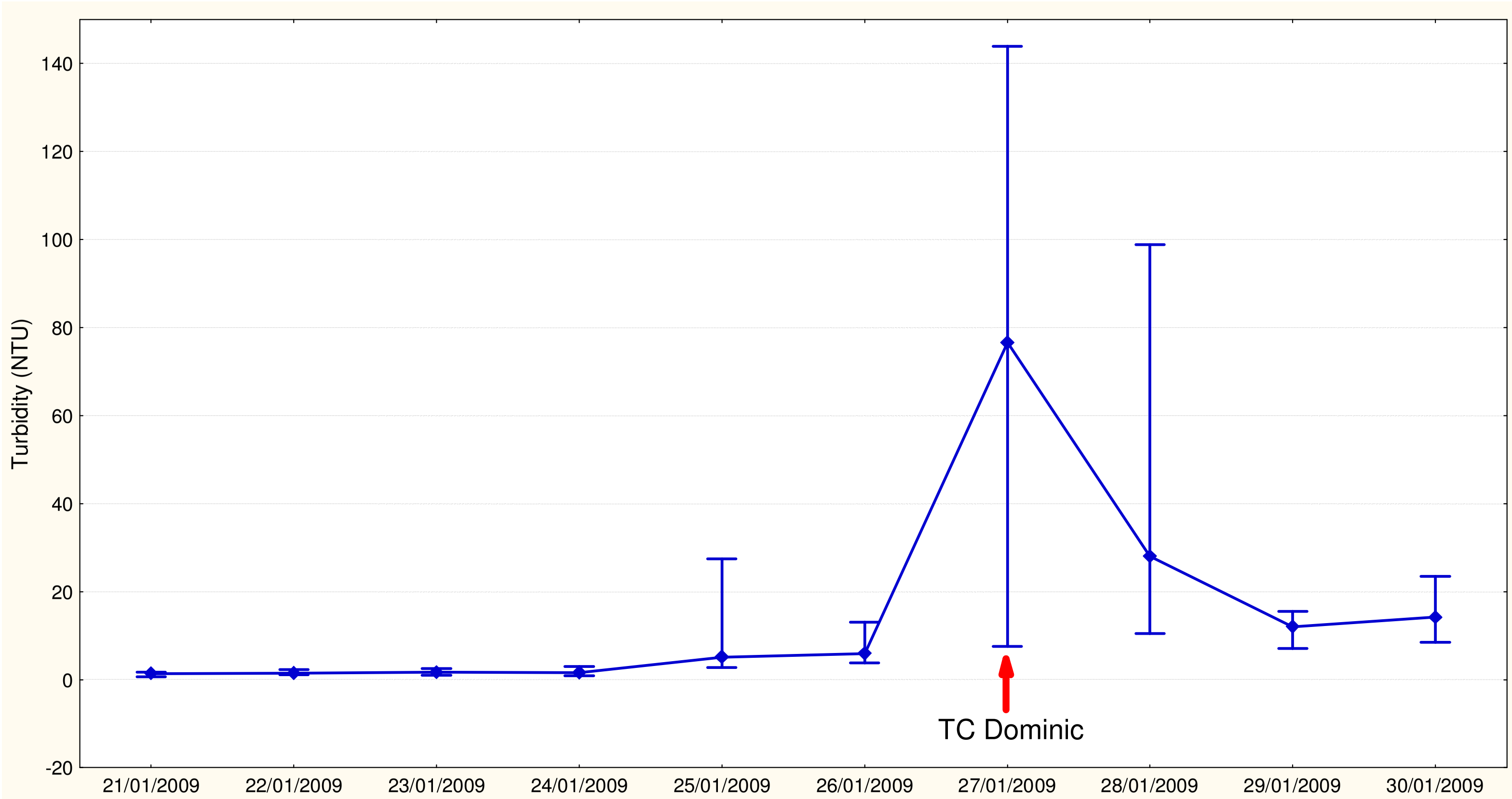
The data collected during cyclonic conditions is for one nearshore site only and the statistics calculated from 24 hourly readings on each of 10 days. Turbidity and variation in turbidity was elevated for 2 days prior to the cyclone and at least 3 days after the cyclone (Figure 17). In the days before cyclonic influence, turbidity at this site was similar to, or lower than, the long term statistics calculated from the MODIS images (see Table 4).

In the days after passage of the cyclone, turbidity was similar to that measured during boat based monitoring of nearshore areas around the same time (Table 7). The turbidity at this offshore site fell quickly after January 27th, corresponding with the rapid weakening of the cyclone as it crossed the coast.

Table 8. Descriptive statistics of turbidity measured with a deployed nephelometer at one site during the passage of after TC Dominic

Date	N	Mean	Median	80th percentile	95th percentile
21/1/09	10	1.3	1.4	1.8	1.9
22/1/09	24	2.2	1.5	2.3	2.7
23/1/09	24	1.8	1.7	2.5	3.4
24/1/09	24	2.0	1.6	3.0	3.6
25/1/09	24	14.1	5.2	27.4	55.7
26/1/09	24	7.6	6.0	13.1	15.3
27/1/09	24	77.8	76.6	143.9	175.5
28/1/09	24	49.8	28.0	98.8	145.6
29/1/09	24	13.3	12.1	15.5	30.6
30/1/09	21	16.9	14.2	23.5	36.7
All dates	223	19.8	5.7	23.5	98.8

Figure 17. Daily median turbidity (NTU) at one site during the passage of TC Dominic. Bars represent daily 20th and 80th percentiles.



3.4.3 Metals and nutrients

3.4.3.1 Procedures

Three replicate seawater samples were collected at each of 10 sites (Figure 18) from both surface (1 – 2m from water surface) and bottom (1 – 2m from bottom) at each site where there was adequate depth. Bottom samples were only taken if the site depth was greater than 12 metres. All samples for chemical analysis were collected by AECOM Australia Pty Ltd (AECOM) field team during December 2008 and March 2009.

Samples were collected (and filtered where relevant) into appropriate laboratory bottles, and transported in dark containers on ice. Samples were frozen prior to analysis. All samples were analysed by MAFRL.

Samples for metal analysis were collected using a Teflon coated Niskin bottle (6 l). This was lowered to the appropriate depth and then opened. Water samples were transferred into 50 ml HDPE tube and filtered in the field with an HDPE plunger through 0.45 µm cellulose acetate disposable filter into 10 ml vials.

All samples were analysed by ICP-AES for total metals in accordance with ISO 15587-1:2002 (Water quality - Digestion for the determination of selected elements in water).

For determination of total nitrogen (TN) and total phosphorus (TP), two unfiltered samples were collected and stored in 125 ml HDPE bottles. Two additional samples were collected and filtered in the field with an HDPE plunger through a 0.45 µm cellulose acetate disposable filter into 10 ml vials. These samples were analysed for nitrite and nitrate (NO_3+NO_2), ammonium (NH_4) and orthophosphate.

TN, TP, total nitrite and nitrate, ammonium and orthophosphate in water samples were analysed by using a Lachat Automated Flow Injection Analyser.

Chlorophyll *a* samples were collected by filtering (in the field) a measured volume of water (approx 2 l) through a Whatman GF/C filter (47 mm x 1.2 µm) using a filter tower and vacuum pump. The filters were protected with clean GF/C filter and stored on ice in the dark and frozen at the end of the sampling day. All samples were then sent to the laboratory and analysed for chlorophyll *a*.

3.4.3.2 Results

With the exception of zinc and aluminium, concentrations of most metals in water were similar to or below the ANZECC & ARMCANZ guideline values for marine waters (Table 9), or were below the limits of detection of the methods used.

Nutrients, particularly TP, TN and oxides of nitrogen (NO_2 + NO_3), were higher than the ANZECC & ARMCANZ guideline values for marine waters (Table 10). Nutrient concentrations tended to be higher at the nearshore sites (sites M5-M10) than at the outer sites.

Figure 18. API sampling sites for metals, nutrients, sedimentation and deployed nephelometer

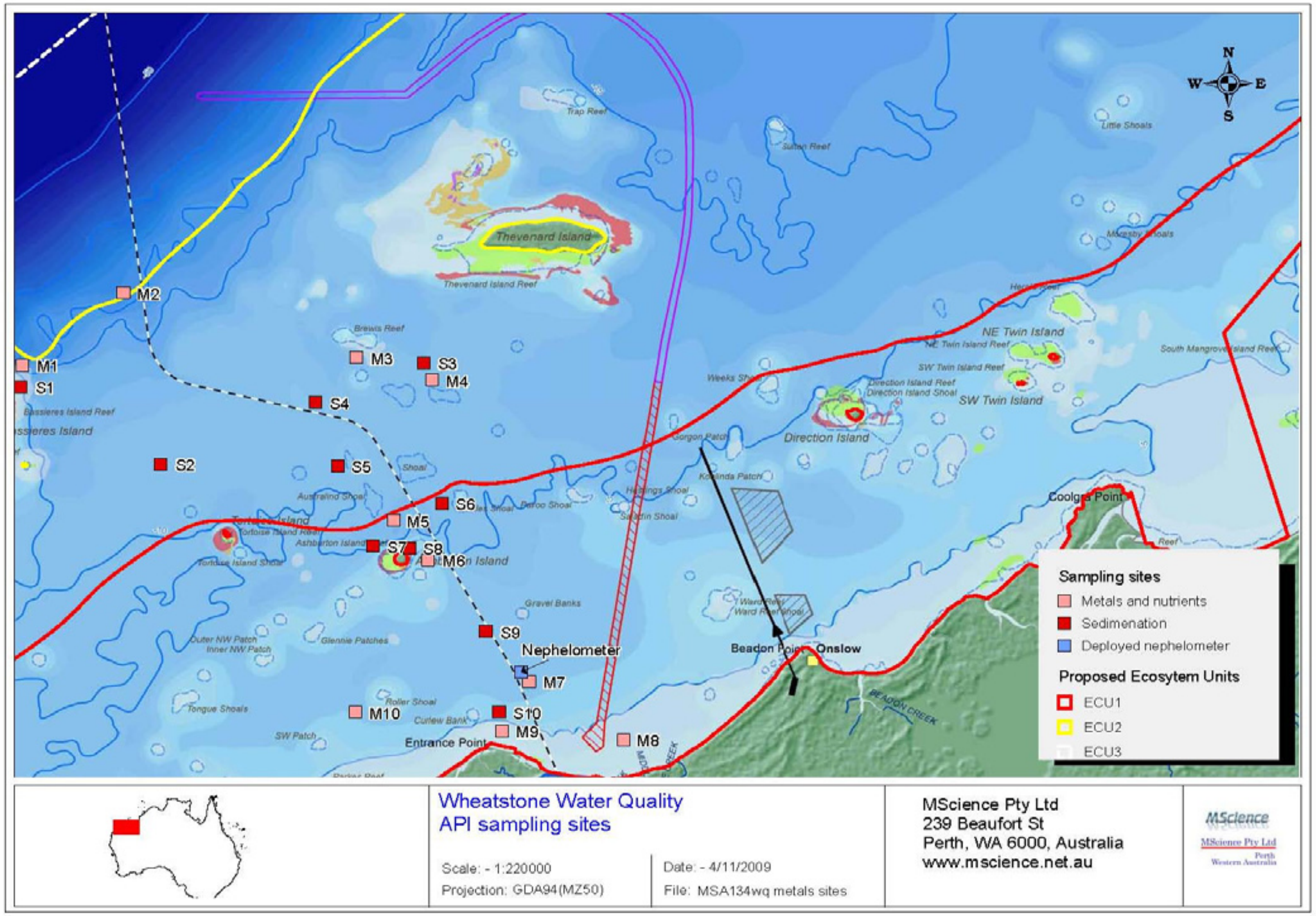


Table 9. Total metals in waters around Onslow (µg/l)

Parameters		Al	As	Cd	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	V	Zn	Hg
Site	**Location/Detection limits**	**<10***	**<10***	**<0.6***	**<1***	**<1***	**<2***	**<0.2***	**<4***	**<4***	**<10***	**<20***	**<1***	**<5***	**<0.1***
Guidelines - marine water***		0.5**	6.8**	0.7	31.8	1.3		80**	23**	7	4.4	6**	100	15	0.1
Samples collected December 14, 2008															
M1	Surface	13.3	<10	<0.6	<1	<1	21.7	0.8	<4	<4	<10	<20	<1	42.7	<0.1
M1	Bottom	23.3	<10	<0.6	<1	<1	15.3	0.8	<4	<4	<10	<20	<1	49.0	<0.1
M2	Surface	<10	<10	<0.6	<1	<1	6.7	0.5	<4	<4	<10	<20	<1	26.7	<0.1
M2	Bottom	16.7	<10	<0.6	<1	<1	6.3	0.6	<4	<4	<10	<20	<1	49.0	<0.1
M3	Surface	13.3	<10	<0.6	<1	<1	2.7	0.6	<4	<4	<10	<20	<1	21.3	<0.1
M4	Surface	15.0	<10	<0.6	<1	<1	4.0	0.7	<4	<4	<10	<20	<1	34.3	<0.1
M5	Surface	<10	<10	<0.6	<1	<1	<2	0.8	5.3	<4	<10	<20	<1	38.7	<0.1
M5	Bottom	<10	<10	<0.6	<1	<1	<2	0.8	5.0	<4	<10	<20	<1	57.7	<0.1
M6	Surface	<10	<10	<0.6	<1	<1	<2	0.8	5.0	<4	<10	<20	<1	94.0	<0.1
M7	Surface	<10	<10	<0.6	<1	<1	<2	1.3	5.3	<4	<10	<20	<1	44.7	<0.1
M8	Surface	<10	<10	<0.6	<1	<1	<2	1.3	5.3	<4	<10	<20	<1	14.3	<0.1
M9	Surface	<10	<10	<0.6	<1	<1	<2	2.6	5.3	<4	<10	<20	<1	38.0	<0.1
M10	Surface	<10	<10	<0.6	<1	<1	<2	1.6	5.3	<4	<10	<20	<1	38.3	<0.1
Samples collected March 28, 2009															
M1	Surface	<10	<10	<0.6	<1	<1	2.3	0.5	8.3	<4	<10	<20	<1	11.3	<0.1
M1	Bottom	<10	<10	<0.6	<1	<1	2.7	0.3	6.3	<4	<10	<20	<1	15.7	<0.1
M2	Surface	<10	<10	<0.6	<1	<1	<2	0.4	6.7	<4	<10	<20	<1	25.0	<0.1
M2	Bottom	<10	<10	<0.6	<1	<1	4.4	0.4	8.7	<4	<10	<20	<1	12.0	<0.1
M3	Surface	<10	<10	<0.6	<1	<1	<2	0.4	9.7	<4	<10	<20	<1	10.3	<0.1
M4	Surface	<10	<10	<0.6	<1	<1	<2	0.4	9.0	<4	<10	<20	<1	39.3	<0.1
M5	Surface	<10	<10	<0.6	<1	<1	<2	0.3	9.3	<4	<10	<20	<1	6.3	<0.1
M5	Bottom	15.0	<10	<0.6	<1	<1	2.0	0.3	10.3	<4	<10	<20	<1	7.7	<0.1

Parameters		Al	As	Cd	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	V	Zn	Hg
M6	Surface	10.0	<10	<0.6	<1	<1	<2	0.5	9.3	<4	<10	<20	<1	18.0	<0.1
M7	Surface	<10	<10	<0.6	<1	<1	3.3	1.5	8.7	<4	<10	<20	<1	49.0	<0.1
M8	Surface	36.7	<10	<0.6	<1	<1	4.0	4.2	9.0	<4	<10	<20	<1	12.7	<0.1
M9	Surface	<10	<10	<0.6	<1	<1	2.0	2.4	10.0	<4	<10	<20	<1	11.0	<0.1
M10	Surface	<10	<10	<0.6	<1	<1	2.7	1.2	8.7	<4	<10	<20	<1	10.3	<0.1

* limit of detection

** low reliability values no guideline triggers

*** (ANZECC & ARMCANZ 2000; Wenziker et al. 2006)

Table 10. Nutrients in waters around Onslow (µg/l)

Parameters		Ammonia	Ortho - P	NO_3+NO_2	Total P	Total N	Chlorophyll 'a'
Site	**Location**	**<3***	**<2***	**<2***	**<5***	**<50***	**<0.1***
Guidelines - marine water**		1-11		2-8	15	100	0.7-1.4
Samples collected December 14, 2008							
M1	Surface	6.3	3.3	10.0	9.7	96.7	0.5
M1	Bottom	4.3	3.3	6.0	9.7	130.0	0.5
M2	Surface	4.7	3.0	5.3	9.0	106.7	0.3
M2	Bottom	3.7	2.7	5.7	9.7	120.0	0.4
M3	Surface	5.7	2.0	3.3	9.7	130.0	0.5
M4	Surface	3.0	2.0	4.0	9.3	123.3	0.4
M5	Surface	3.0	2.0	6.3	9.3	103.3	0.3
M5	Bottom	4.3	2.7	12.7	11.0	140.0	0.2
M6	Surface	7.7	3.0	170.0	18.0	343.3	0.3
M7	Surface	5.7	2.7	14.7	13.0	173.3	0.3
M8	Surface	4.3	2.7	62.0	16.3	180.0	0.3
M9	Surface	5.0	2.0	82.7	16.3	256.7	0.4
M10	Surface	4.7	2.7	13.7	13.7	136.7	0.3
Samples collected March 28, 2009							
M1	Surface	9.7	4.0	5.0	11.7	173.3	0.9
M1	Bottom	<3	4.0	3.0	12.7	130.0	1.0
M2	Surface	4.3	3.0	4.7	11.7	136.7	1.6
M2	Bottom	<3	3.3	2.0	13.3	153.3	0.8
M3	Surface	5.3	3.3	2.5	11.7	146.7	0.5
M4	Surface	10.7	5.0	68.7	11.3	180.0	1.5
M5	Surface	3.0	2.0	3.3	9.3	140.0	0.9
M5	Bottom	8.8	2.0	6.7	12.0	166.7	0.9
M6	Surface	<3	2.0	4.0	10.7	173.3	1.4
M7	Surface	5.0	3.0	30.0	10.0	183.3	1.5
M8	Surface	11.0	3.3	6.0	12.3	246.7	0.8
M9	Surface	<3	2.0	10.7	13.0	196.7	1.5
M10	Surface	4.0	2.3	17.0	10.7	216.7	0.8

* limit of detection

** (ANZECC & ARMCANZ 2000; Wenziker et al. 2006)

3.4.4 Sediment traps

3.4.4.1 Procedures

Three cycles of sediment trap deployment and retrieval were undertaken, these deployments are presented in Table 11.

Table 11. Dates for sediment trap retrieval and deployment

Cycle Number	Deployment	Retrieval
1	21/01/09	14/03/09 - 16/03/09
2	14/03/09 - 16/03/09	18/04/09
3	18/04/09	07/06/09 – 08/06/09

Sediment trap stations were established at each location (Figure 18). Each sediment trap consisted of a cluster of three vertical PVC tubes (a, b and c) coated with antifouling paint. The tubes were approximately 5 cm in diameter and 15 cm high. They were sealed with a cap at the bottom and were open at the top. The tubes were held in place in stainless steel brackets approximately 0.5 m above the sea bed. A photograph of a typical deployed sediment trap is presented in Figure 19.

Upon retrieval, the individual tubes were capped *in situ* to retain sediment and delivered to the laboratory for processing as quickly as was practicable. Sediment was sent to ALS-Chemex (cycle 1) and Advanced Analytical (cycle 2 and cycle 3) to be processed for total dry weight.

ALS-Chemex analysis involved drying the sample in an oven at 110 ^{O}C until samples reached a constant weight (typically 6 to 12 hours depending on moisture content). Sediment samples were then transferred to a container of known weight and re-weighed on a certified scientific balance.

Advanced Analytical analysis involved transferring the sediment samples from sediment traps into plastic bottles. Traps were also rinsed with deionised water to ensure all the sediment samples were transferred. The samples were analysed for suspended solids using the APHA 2540D method while excess sand in samples was removed, washed of salt, dried and weighed. Total sample dry weight was the combined weight of suspended solids and sand.

3.4.4.2 Results

Sedimentation rates were higher during the January to March deployment than at other times. Sedimentation was also higher nearshore within ECU1 than offshore within ECU2 (Table 12).

The large differences between the first deployment period and the second 2 deployment periods may be due to seasonal changes however, the differences are large and are also associated with changes in methodology. For this reason the reliability of the values is uncertain.

Table 12. Sedimentation in water around Onslow (mg/cm^2.day)

	N	Mean	Minimum	Maximum
Ecosystem unit 1 (Nearshore)				
Jan-Mar 09	4	9.3	6.2	13.1
Mar-Apr 09	4	1.3	0.1	4.8
Apr-Jun 09	4	3.1	0.1	12.0
Ecosystem unit 2 (Offshore)				
Jan-Mar 09	4	7.3	6.2	10.1
Mar-Apr 09	5	0.1	0.1	0.3
Apr-Jun 09	5	0.3	0.0	1.1

3.5 SHORT TERM DEPLOYMENT OF SEDIMENT TRAPS

3.5.1 LOCATIONS AND METHODS

Additional sedimentation measurements were made as part of the Wheatstone Project baseline studies. PVC sediment trap tubes, (3 for each pair of frames) mounted on stainless steel sediment trap frames were used (Figure 19)

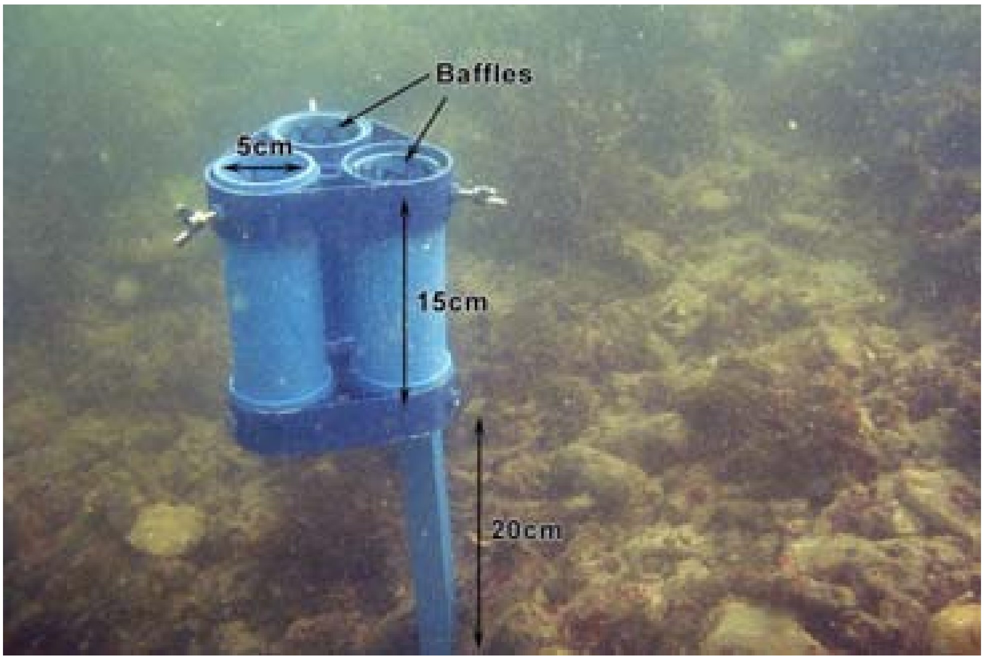
The sediment traps were deployed short term along the reef crest at a depth of 3 – 5 m CD, to target the depth of maximum coral abundance (Table 13). The areas selected were free of obstructions. Replicate sediment traps were placed approximately 1-5 m apart.

Table 13. Location and period of sedimentation measurement

Station	Replicates	Measurement dates	Depth (m LAT)
Ashburton Island	3	29/05/09 – 3/06/09	4
Jetty	3	29/05/09 – 3/06/09	5
Thevenard Island	3	29/05/09 – 4/06/09	3
Direction Island	3	29/05/09 – 5/06/09	3
Ward Reef	3	29/05/09 – 5/06/09	3

Deposition rate (mg/cm^2. day) was calculated from the dry mass in each tube, the cross-sectional area of the tube and the number of days deployed.

Figure 19. Deployed sediment traps



3.5.2 Short term sedimentation rates

This sedimentation data only covers a short period of time and provides the basis for a comparison between sites rather than information on temporal change.

Table 14. Sediment at selected sites during May and June 2009 (mg/cm^2.d).

Station	Sedimentation
Ashburton Island	3.1
Jetty	20.8
Thevenard	3.7
Direction Island	2.3
Ward Reef	6.9

Sedimentation rates were higher at the inshore sites (ECU1), particularly the jetty but with a slightly higher rate also at Ward Reef. Lowest sedimentation was at the offshore sites. The deployment in late May and early June was during a period of light to moderate winds and no other unusual metocean conditions.

4.0 INTERPRETATION AND DISCUSSION

4.1 TURBIDITY, TOTAL SUSPENDED SOLIDS AND LIGHT ATTENUATION

The various studies provide a broad range of information on turbidity, TSS and light attenuation across different seasons, locations and metocean conditions. While the methods used and sampling times vary across the different studies, the consistency between results provides confidence that baseline water quality for Onslow is well described on a regional and ecosystem unit scale from the synthesis of these data.

MODIS image analysis indicates turbidity is lowest in winter with a long term median of <1 NTU both nearshore and offshore. Variability is low as evidenced by the long term 80th percentile being <1 offshore and <3 NTU nearshore (Table 4). The nephelometers deployed at Direction Island and Paroo Shoals during 2009 indicated median turbidity between 1 and 2.1 NTU and 80th percentiles <3 NTU during winter and summer (Table 6). Similarly, median turbidity across a range of sites was <2 NTU in the days leading up to TC Dominic (Table 8).

In contrast, median turbidity across a range of sites increased to 77 NTU as the cyclone passed over, with the 80th percentile exceeding 143 NTU (Table 8). Turbidity remained above 20 NTU in excess of 10 days after the passage of TC Dominic as water and sediment discharged from the Ashburton River (Table 7).

MODIS image analysis also indicated spatial differences in turbidity (Figure 11). Site medians across the 4 years of analysis ranged from <1 to 20 NTU although all but 2 sites had a long term median <5 NTU. The margin between medians and 80th percentiles also varied between sites indicating both turbidity and turbidity variability were inconsistent among sites. Others have made similar observations on spatial variability and subsequently questioned the validity of using Reference/Impact comparisons for management or compliance purposes (Orpin et al. 2004).

The same temporal patterns of change were observed for TSS, with lower values offshore than nearshore (medians 2 vs 3.2 mg/l) and in winter (2-2.8 mg/l) than in summer (2.5-4.6 mg/l) (Table 4). Medians estimated from analysis across sites exceeded 20 mg/l shortly after TC Dominic. Based on turbidity measured during the passage of TC Dominic, TSS approaching 100 mg/l would have experienced.

These values, variability and seasonal changes in turbidity and TSS are consistent with those reported elsewhere on the North-West Shelf (Forde 1985; Stoddart and Anstee 2005) and in other clear tropical Australian marine waters during calm conditions (Orpin et al. 2004).

Light attenuation (E) estimated from turbidity (Table 4) was also lowest in winter with long term median < 0.12 m^{-1} both nearshore and offshore and long term 80th percentiles still <0.1 m^{-1} offshore and approximately 0.2 m^{-1} nearshore. In summer, long term 80th percentiles of E exceeded 0.3 m^{-1} at the nearshore sites. These predicted values were consistent with the shorter term direct measurements made at Direction Island and Paroo Shoals (Table 6). Light attenuation, was much higher when measured shortly after the passage of TC Dominic with across site medians exceeding 0.25 and 80th percentiles exceeding 0.3 m^{-1}.

The light attenuation coefficients were similar to those reported by Simpson (1988) and Pearce et al. (2003) for the North West Shelf. These authors also reported similar spatial and temporal variability

4.2 NUTRIENTS

Total nitrogen, total phosphorus and nitrate concentrations exceeded the guideline values specified by ANZECC & ARMCANZ (ANZECC & ARMCANZ 2000) for tropical waters at many of the sites sampled (Table 10). The nearshore sites tended to be much higher in nutrients. The waters of the North West Shelf region are oligotrophic with low availability of nitrogen limiting rates of primary production. Excessive nitrogen inputs to coastal environments can cause significant ecological changes (Gijzen and Mulder 2001) such as seagrass or coral loss, and 'blooms' of nuisance species of phytoplankton. Although baseline nitrogen concentrations were relatively high, ecological changes, such as those described above, have not been reported for this area.

Mean N:P ratios were approximately 12 for the offshore sites and ranged between 13 and 15 for the nearshore sites. At these ratios, nitrogen would be most limiting for phytoplankton growth (Pearce et al. 2003).

The high nutrient levels are consistent with high discharge of nitrogen and phosphorus from the Ashburton River. D.A. Lord and Associates (2002) reported nutrient load from the Ashburton River to the offshore environment is 172 t/year of nitrogen and 26 t/year of phosphorus, although these estimates may be an order of magnitude higher or lower, depending on the annual river flow. More recent estimates of nutrient loads since 1973, indicate average nitrogen discharge from the Ashburton River of 405 t/year and phosphorus of 134 t/year (URS 2009)

These results represent only a short period in time and indicate the need for a more comprehensive sampling program to establish appropriate Environmental Quality Criteria for this area.

4.3 METALS

Most of the metals analysed were below the recommended Environmental Quality Criteria specified for the protection of North West Shelf ecosystems (Wenziker et al. 2006). The exceptions were aluminium (low reliability value not a guideline) and zinc. A more comprehensive sampling program will determine the reliability of these values and to establish locally appropriate Environmental Quality Criteria.

4.4 SEDIMENTATION

The short term measurements of sedimentation indicate deposition rates in May and June 2009 of up to 20 mg/cm^2.day. The highest deposition rate was nearshore and close to the jetty. Further offshore deposition decreased to approximately 2 mg/cm^2.day (Table 14). Others have reported sedimentation rates in Mermaid Sound of 1-12 mg/cm^2.day (Simpson 1988). As would be expected, higher sedimentation rates have been reported at shallow nearshore sites particularly in the summer months when turbidity is increased.

These reported sedimentation rates are gross sedimentation, measured using tubular sedimentation traps. Under natural conditions, much of this sediment would be resuspended from flat or exposed seabed surfaces by tidal currents and wave energy. Net sedimentation, a more significant biological parameter, would be lower, but nevertheless related to gross sedimentation.

The sedimentation results derived from the API water quality investigations appear much less reliable with rates approaching zero between March and June.

4.5 ECOSYSTEM UNITS

The ecosystem units used to overlay water quality results in this report were useful in defining regional differences and they provide an opportunity to establish management and monitoring programs based on location. For example, all sites with long term turbidity medians >1 NTU were in ECU1 and all sites in ECU2 had long term median turbidity of <1 NTU. Median light attenuation was also 60% higher in ECU1 than ECU2 when compared over a full year. Similarly, higher nutrient concentrations were observed at the ECU1 sites than at the ECU2 sites.

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Appendix R1

Desktop Study of Marine Biosecurity in the Wheatstone Project Area

Tables

Figures

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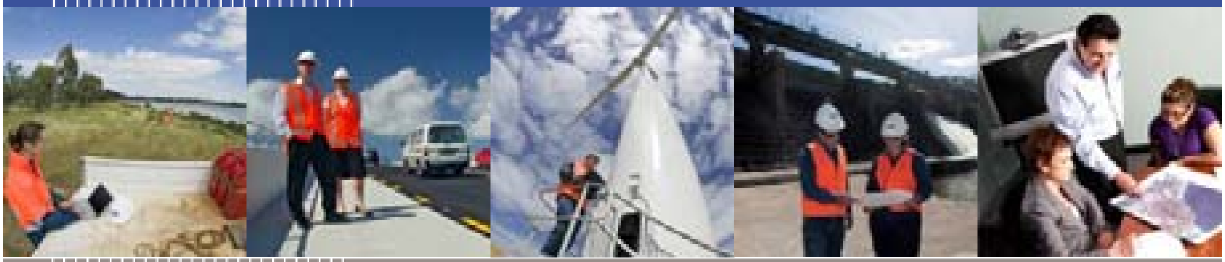

Report

Desktop Study of Marine Biosecurity in the Wheatstone Project Area

05 MAY 2010

Prepared for

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Executive Summary

Chevron Australia Pty Ltd proposes to construct and operate a multi-train Liquefied Natural Gas (LNG) and domestic gas (Domgas) plant 12 km south west of Onslow on the Pilbara Coast. The LNG and Domgas plant will initially process gas from fields located approximately 200 km offshore from Onslow in the West Carnarvon Basin and other yet-to-be determined gas fields. The project is referred to as the Wheatstone Project and "Ashburton North" is the proposed site for the LNG and Domgas plant. The Project will require the installation of gas gathering, export and processing facilities in Commonwealth and State Waters and on land. The LNG plant will have a maximum capacity of 25 Million Tonnes Per Annum (MTPA) of LNG.

The Wheatstone Project has been referred to the State Environmental Protection Authority (EPA) and the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA). The investigations outlined in this report have been conducted to support the environmental impact assessment process.

The issue of introduction of exotic marine species into the Australian marine environment can be divided into two major components:

- marine pest issues; and
- marine health issues.

While the two components are similar in that they relate to the introduction of exotic species into the Australian marine environment, the introduction mechanisms differ significantly, and the regulatory environment for the two components is also different.

Introduced marine pests

The introduction of exotic marine species into new environments has emerged as one of the most serious threats to marine ecosystems worldwide. Introduced species may exclude local species and/or cause major shifts in ecosystem structure, reduce biodiversity and cause diseases in native species, and even in humans. Several major marine pest incidents in eastern Australia and lesser incidents in Western Australia have heightened awareness of introduced marine pests.

The majority of marine introductions worldwide have been through vessel movements, primarily international shipping. Ballast water on large ships was originally thought to be the primary vector for distributing marine pests, but it is now known that 75% of species have been introduced through biofouling. This can occur on any immersed surface, but especially on areas where there is less water flow such as crevices and voids. Different types of vessels do not pose uniform risks. Ships to be used in the operational phase of the Project are likely to present low risks of introducing marine pests because they are likely to be well maintained with up-to-date antifouling protection, operating at high speeds and spending short periods in port. Mobile infrastructure such as dredges and barges used in the construction phase of the Project are likely to be high risk because they:

- undertake a broad range of activities;
- often travel for considerable distances between contracts;
- remain for extended periods in ports where marine pests are concentrated;
- are slow moving or stationary;
- may routinely leave equipment in the water for 24 hours or more; and
- are in close contact with the bottom..

Executive Summary

Only a small fraction of introduced marine species become marine pests. The National Introduced Marine Pests Coordination Group (NIMPCG) developed a list of 55 species of concern that could be, or have been, introduced into Australia; 14 are quarantinable pests.

Sixty introduced marine species are known to occur in Western Australia. Most (37) are temperate species that occur from Geraldton south, 6 are tropical species that occur from Shark Bay north, and 17 occur in both the southern and northern halves of Western Australia. Only four of these (the marine alga *Codium fragile fragile,* the dinoflagellate *Alexandrium minutum,* the bivalve *Musculista senhousia* and the polychaete worm *Sabella spallanzanii*) are on the NIMPCG list. All occur in the southwest of the state, from Fremantle and/or areas to the south. Twenty-four introduced marine species are known from the northwest (Gascoyne and Pilbara regions). A single species, the barnacle *Megabalanus tintinnabulum,* has been recorded from Onslow.

Management of introduced marine pests

The Department of Agriculture, Fisheries and Forestry (DAFF) is the lead Commonwealth agency responsible for developing management polices for marine pest issues. Through NIMPCG, DAFF is developing the 'National System for the Prevention and Management of Marine Pest Incursions' ('the National System'). The goal of the National System is to have a single set of regulations for marine pest management that is uniform throughout Australia. At present, procedures vary widely in different jurisdictions. The National System has three main components:

- Prevention systems and procedures to reduce the risk of introduction and translocation of marine pests in the first instance, with particular focus upon ballast water and biofouling.
- An emergency response framework, for coordination of appropriate responses to new marine pest incursions and translocations.
- Ongoing control and management arrangements, aimed at containing the risks of marine pests that have already been introduced into Australia.

Eighteen ports have been selected to provide the most cost effective marine pest monitoring strategy for Australia. Three Western Australian ports are on the national sampling program: Dampier, Port Hedland and Fremantle. The Western Australian Department of Fisheries (DoF) is responsible for ensuring that these ports are appropriately monitored. The Consultative Committee on Introduced Marine Pest Emergencies (CCIMPE) is the national coordinating body if a marine pest is detected. CCIMPE has developed a strategy for dealing with any emergency marine pest outbreak.

Australian ballast water requirements are similar to those of the *International Convention for the Management of Ships' Ballast Water and Sediments,* adopted in 2004, by the International Maritime Organization (IMO). Australia is a signatory to the Convention, but it has not yet come into force. The Australian Quarantine and inspection Service (AQIS) considers all salt water from ports and coastal areas outside Australia to be high risk. The current Australian requirement is that all ballast water from ports or coastal regions outside Australia must be exchanged at sea (beyond 12 nautical miles of shore) prior to arrival in Australia. Two ballast water exchange methods are approved:

- emptying the tank by 95% or more of its capacity and refilling the tank in the open sea, as far from land as possible.
- flow through in which the pumps are operated until at least 300% of the capacity of a tank has been replaced. It is expected that an exchange of this magnitude will ensure 95% or more dilution of the ballast water.

The AQIS requirements currently apply only to internationally sourced ballast water. There are currently no requirements for ballast water exchange for vessels entering Western Australia from interstate or for vessels moving from one part of WA to another. The National System will remove this anomaly, so all ballast water exchange is undertaken according to the same regulations.

There is a great deal of uncertainty over the future management of biofouling in Australia. DAFF is currently consulting with a range of sectors to develop the Australian Biofouling Management Requirements. The new requirements will constitute a targeted quarantine inspection regime that uses a risk based approach. The risk assessment criteria and the quarantine inspection regime include a hazard analysis of vessel classes, on-arrival biofouling risk assessments and in-water inspections if required by AQIS. Moderate and high hazard vessels classes (including petroleum production and exploration vessels) will be subject to an AQIS on-arrival biofouling risk assessment. If AQIS believes that a vessel is, or is highly likely to be, contaminated with any of the 14 species of quarantinable biofouling pests then an in-water inspection will be required. AQIS has authority to refuse entry to Australia for a vessel if a pest species of concern is found.

Until the National System is in place, the States and Northern Territory will continue to independently manage particular aspects of marine pest management. DoF is the lead agency for management of marine pest issues in Western Australia. DoF cooperates closely with the Department of Environment and Conservation, the Environmental Protection Authority (EPA), port authorities and other Commonwealth and State agencies.

Under the WA *Environmental Protection Act 1986*, the EPA assesses major projects being undertaken within the state. Following the assessment, the EPA makes a recommendation to the Minister for the Environment on whether to accept or reject the proposal. The EPA often suggests that specific Ministerial Conditions be attached to the Minister's approval. These conditions are legally binding. In recent years the Ministerial Conditions have stated that dredges and other high risk vessels must be inspected by a qualified marine scientist and certified to be clean of marine pests prior to the vessel's departure for Australia, or within 48 hours of arrival. The vessel must be re-inspected before moving to another location within Western Australia. Until the proposed Australian Biofouling Management Requirements are in place, the primary requirement for inspection of dredges and other construction vessels arriving into Western Australia from overseas will continue to be through the environmental assessment process.

The harbourmaster of each port has substantial powers to manage marine pests or suspected pests. The harbourmaster can order the departure or deny entry to any vessel that contains marine pests, is leaking oil or poses any other marine pollution risk to the harbour.

The WA *Biosecurity and Agricultural Management Act 2007* (BAM Act) was recently passed to provide a stronger legislative base for managing all aspects of biosecurity, including the marine environment. Regulations under the BAM Act are currently being developed, and are not yet public, so it is not possible to examine how they will potentially relate to the Project.

Introduced bacteria, viruses and parasites

As with marine pests, there are a number of potential transmission vectors for bacteria, viruses and parasites, but the mechanisms for introduction are more diverse. Most of the disease issues in the marine environment have been related to high density populations of species maintained in aquaculture.

Ballast water is known to present risks for introduction of bacteria, viruses and parasites. A major outbreak of cholera in South and Central America in 1991 and 1992 is thought to have been transmitted through contaminated ballast water.

Importation of food for human consumption, animal consumption or bait is a second source for bacteria, viruses and parasites. Regulations on the importation of unprocessed prawns were substantially tightened in 2007 to reduce the risk of introduction of exotic diseases into native marine prawn populations. Severe mortalities of pilchards across southern Australia in 1995 and 1998 and in abalone in Victoria in 2007 may have been due to introduction of disease via imported animal feed. Pilchards imported as feed for the South Australian tuna aquaculture industry may have introduced a disease into Australian pilchards. Similarly, imported food used in the Victorian abalone industry may have been contaminated with a disease vector.

Translocation is another possible vector for introducing bacteria, viruses and parasites. *Steinhausia mytilovum* may have been introduced into Cockburn Sound, Western Australia, in introduced mussels. The oyster “worm disease” was first recorded in oysters in New South Wales in about 1882 and caused substantial mortalities. The disease is caused by a parasitic spionid polychaete, *Polydora* sp.,that may have been introduced with oysters imported live from New Zealand in the early 1880s.

As with marine pests, there a variety of methods are used to combat the spread of bacteria, viruses and parasites. AQIS inspects goods shipped into Australia for their disease status. In addition to the AQIS requirements, individual jurisdictions may have their own requirements. Importation of “fish” into Western Australia or their translocation within the state is regulated by the DoF. There are strict protocols for the importation of live “fish” such as oysters for restaurants, etc. Advance permission and permits must be sought for importing species for aquaculture, and the organisms must be independently certified as being free of diseases.

The Consultative Committee on Exotic Animal Diseases (CCEAD) undertakes a coordination role similar to that done by CCIMPE for marine pests. There is no requirement that CCEAD be notified of a disease outbreak, but if it is notified, CCEAD can provide support from other jurisdictions in managing the outbreak.

Risks of the Wheatstone Project introducing marine pests and diseases

The risks of introducing marine pests into Western Australia via the Wheatstone Project are assessed as low for the following reasons:

- The north coast of Western Australia is part of the tropical Indo-West Pacific marine biogeographic region, and most of the species that could live in northwestern Australia already occur there naturally. There are some exceptions such as the Asian green mussel, *Perna viridis.* Species from other marine biogeographic regions (eastern Pacific, western Atlantic and eastern Atlantic) could potentially be brought directly to Western Australia from other marine biogeographic regions. Alternatively, introductions could occur in a stepping stone process where the species were first distributed to an Asian port and then brought into Australia from Asia. The black striped mussel, *Mytilopsis sallei*, is an example of such a species.
- Mega diverse tropical regions, such as the north coast of Western Australia, appear to have a natural resistance to introduced marine species becoming pests.
- Shipping movements in the Pilbara have been substantial for the last four decades, but no marine pests have been recorded as introduced to Pilbara ports.

Executive Summary

Most major marine disease outbreaks in aquaculture industries and wild caught fisheries in Australia are believed to have been caused by the introduction of contaminated bait or feed for aquaculture industries. The Project will not import bait or feed and therefore will not alter existing risks for this vector.

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1

Introduction

1.1 Background

Chevron Australia Pty Ltd proposes to construct and operate a multi-train Liquefied Natural Gas (LNG) and domestic gas (Domgas) plant 12 km south west of Onslow on the Pilbara Coast. The LNG and Domgas plant will initially process gas from fields located approximately 200 km offshore from Onslow in the West Carnarvon Basin and other yet-to-be determined gas fields. The project is referred to as the Wheatstone Project and "Ashburton North" is the proposed site for the LNG and Domgas plant. The Project will require the installation of gas gathering, export and processing facilities in Commonwealth and State Waters and on land. The LNG plant will have a maximum capacity of 25 Million Tonnes Per Annum (MTPA) of LNG.

The Wheatstone Project has been referred to the State Environmental Protection Authority (EPA) and the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA). The investigations outlined in this report have been conducted to support the environmental impact assessment process.

As scientific knowledge has increased in recent decades, the introduction of exotic marine species into new environments has emerged as one of the most serious threats to marine ecosystems worldwide (Padilla et al. 1996, Millennium Ecosystem Assessment 2005). Introduced species may become dominant in the new system, exclude local species and/or cause major shifts in ecosystem structure (Brenchley & Carlton 1983; Grosholz & Ruiz 1995). Marine biodiversity is often reduced in areas where introduced species have become established (Paesanti et al. 1991, Blanchard 1995, Blanchard 1997, Wyatt et al. 2005). The introductions can cause diseases in native marine species and even in humans. For example, some dinoflagellates produce toxins which accumulate in the tissues of shellfish that feed on the dinoflagellates (Hallegraeff et al. 1988). When affected shellfish are consumed by humans, the resulting paralytic shellfish poisoning is a serious illness that can result in death (Campbell 1994, Walters 1996).

Ruiz et al. (1997) noted a worldwide increase in toxic red tides, which can cause diseases in both native marine populations and humans, which they attributed to introductions of toxic dinoflagellates via ballast water. Matsuyama (2003) provided an excellent example of how an introduced species can affect the local marine environment. The dinoflagellate *Heterocapsa circularisquama* is a species that causes red tides. It was introduced to Japanese waters, where it was first recorded in 1988. The dinoflagellate spread rapidly, and by 2000 had caused 43 red tides. There are no records of *H. circularisquama* causing problems with fish populations in the wild or in aquaculture or other marine vertebrates and the dinoflagellate is not regarded as a public health hazard. However, *H. circularisquama* devastates bivalve populations. By the time of the 2003 paper, 18 of the red tides had affected fisheries for the Manila clam *Ruditapes philippinarum*, Pacific oyster *Crassostrea gigas*, pearl oyster *Pinctada fucata*, and the blue mussel *Mytilus galloprovincialis,* directly causing losses of at least 10 billion Yen. More recently Nagasaki et al. (2005) demonstrated that the causative agent of the losses is not *H. circularisquama* itself, but rather one of two types of viruses which occur commonly in the dinoflagellate.

1.2 Marine Pest Issues and Marine Health Issues

The introduction of exotic marine species into the Australian marine environment can be divided into two major aspects:

- marine pest issues; and

- marine health issues.

While the two components are similar in that they relate to the introduction of exotic species into the Australian marine environment, the introduction mechanisms differ significantly and the regulatory environment for the two aspects is also quite different. For these reasons, the two aspects are addressed separately in this document.

1.3 Scope of Work

The study will assess current knowledge of introduced marine species in the Onslow region with regards to marine pests and marine health.

1.3.1 Marine pests (macrobiota)

The study will consider the following in relation to marine pests:

- brief introduction to the marine pest issue;
- transmission vectors;
- species of concern to Australia;
- introduced marine species (including marine pest species) recorded in Western Australia; and
- introduced marine species (including marine pest species) recorded in the Gascoyne and Pilbara regions.

1.3.2 Marine health (viruses, bacteria and parasites)

The study will consider the following in relation to marine health

- marine bacteria, virus and parasite outbreaks in Australia;
- transmission vectors; and
- management of bacteria, viruses and parasites.

1.3.3 Actual impact

The study will assess the potential impact of the Project on environmental and social values (including the pearling industry) for both macrobiota and viruses, bacteria and parasites,

2

Marine Pest Issues

2.1 Introduction to the Marine Pest Issue

Australia is not immune to the threat posed by introduced marine pests. Several major introductions in the last 20 years have heightened awareness of the issue among regulators and in the public.

The first introduced marine pest to receive wide attention was the finding of the Northern Pacific seastar (*Asterias amurensis*) in the Derwent estuary at Hobart, Tasmania (Turner 1992). Serious concerns were immediately raised over the effects this species would have on shellfish populations, including commercially valuable abalone and scallops. While populations of the seastar appear to have decreased in recent years, at its peak the population was estimated at 30 million individuals. *A. amurensis* has since spread to other Tasmanian ports and to Port Philip Bay, Victoria (NIMPIS 2002, Aquanal 2002).

Similarly, a routine survey of Darwin Harbour for introduced marine pests was undertaken before the wet season in August 1998. Only six months later, in early 1999, a second post wet season survey found the black striped mussel (*Mytilopsis sallei*) coating virtually every hard surface in the Cullen Bay Marina. Populations were very dense, up to 23,650 individuals per square metre. Further examination found the species in two additional marinas (Tipperary Waters Marina and Frances Bay Marina) and on the hulls of three yachts in Darwin Harbour (all three yachts had been in Cullen Bay). A bamboo raft that had been brought into the harbour from Indonesia also had the mussel. The Northern Territory government reacted quickly by declaring an environmental emergency and establishing a whole of government approach to the outbreak. The Indonesian raft was taken ashore and burned. The three yachts were returned to Cullen Bay. All three marinas were closed and treated with chemicals (copper sulphate and chlorine) to kill the mussels. Yachts that had been in the harbour were tracked down and inspected wherever they were found. Fortunately, the eradication was successful (Russell & Hewitt 2000, Willan et al. 2000). It succeeded because the black striped mussel had only colonised artificial marinas with locks at their entrance, allowing them to be readily sealed off. As they were artificial, the marinas were considered to be of low environmental value, allowing them to be poisoned, and were discrete habitats. If the mussels had spread to the open harbour it is very unlikely that they would have been eliminated.

The Asian green mussel, *Perna viridis,* is a hardy species that is widely farmed in Southeast Asia. In fact it is one of the largest aquaculture species in the world in terms of tonnage. Unfortunately, the Asian green mussel is also an invasive species that readily develops large populations where it has been introduced. In another serious marine pest incident, the foreign fishing vessel *MV Wing Sang 108* was found illegally operating in Australian waters. It was taken to Cairns where it was anchored for a year in Trinity Inlet. During this period the vessel became heavily fouled with the Caribbean tubeworm *Hydroides sanctaecrucis.* When it was cleaned in August 2001, the hull of the *MV Wing Sang 108* was found to have dense clusters of *P. viridis*. A survey of the area was conducted and a small number of *P. viridis* were found (Neil et al. 2005). It is believed that small breeding population of Asian green mussel has been established in Cairns (Stafford et al. 2007), but the long-term effects of this are not yet known.

In Western Australia, the dredge *Leonardo da Vinci* was chartered to undertake a significant upgrade of Geraldton Harbour. The vessel arrived in October 2002 from Jamaica having travelled in warm waters over the entire journey of over a month. When it arrived in Geraldton, the stern, ladder and ladder recesses of the *Leonardo da Vinci* were found to be heavily fouled with a variety of organisms. A cursory inspection found approximately 20 species in a wide group of plants and animals. Only molluscs and barnacles could be fully identified in a brief period, but these included potential pest species. Emergency meetings were held and it was agreed that the dredge would be cleaned by divers in Geraldton Harbour. Several techniques were employed to reduce the chances of pest species being introduced. Barnacles above the water level were scraped off and taken to an approved land disposal site. Plastic tarpaulins were inserted between the vessel and the jetty to try and prevent species from moving onto the jetty piles. Divers scraped the external hull clean and as far as possible placed the scraped material into bags which were disposed of in the terrestrial landfill. The ladder and ladder recesses near the stern held 60 cubic metres of seawater. These areas were sealed off and a 5% solution of detergent was added (3 tonnes were used). Local snails of species related to those found in the sea chest were used as sentinels. After 24 hours in the detergent solution all of the sentinels were dead and the water was putrid. After an additional 24 hours the water was pumped out to a land reclamation area. Following the clean-up, the dredge was moved forward to another berth without starting its engines. Two smaller dredges were then used to clean the bottom where the *Leonardo da Vinci* had been. A survey five years after the incident did not detect any of the species of concern, but it is possible that there are small populations remaining that are still increasing (Wells et al. 2009).

In a second incident, the dredge *Volvox Asia* was found to be fouled with the Asian green mussel when it arrived in Dampier in 2006. The vessel was denied entry to Dampier and was taken to Singapore where it was cleaned before being allowed to enter Australian waters (URS 2007).

2.2 Transmission Vectors

There are a number of vectors by which introduced marine pest species may be introduced into Western Australia. The major ones are:

- shipping;
- construction and marine plant or vessels;
- commercial fishing operations;
- recreational vessels;
- aquaculture; and
- ornamental fish.

It should also be recognised that species distribution among the world's oceans can change naturally. Changes in the temperature or currents of the oceans, as well as self introduction via floating objects, all affect species distributions. For example, Wells & Kilburn (1986) recorded four South African species of molluscs in the extreme southwest of Western Australia. The species had apparently survived the transoceanic journey and settled to the bottom to become juveniles. However, they did not establish populations in Western Australia. It is the human induced introductions that are of concern here.

2.2.1 Shipping

The great majority of marine introductions worldwide have been through vessel movements, primarily international shipping. McDonald (2008) undertook a risk analysis of vessel movements at 15 Western Australian ports introducing marine pests to the ports using data from 2006. The analysis updated an earlier study by the National Introduced Marine Pests Coordination Group (NIMPCG 2006a) to determine whether risk profiles had changed as a result of the resources boom in the state. Both analyses used a variety of factors to calculate relative risk, for example: tonnage and source of ballast water; size of the vessel (as an indication of the risk of biofouling); and types of vessels. The results were similar indicating there had been little change.

Dampier was ranked as the highest risk port in Western Australia, and one of the highest in Australia (Table 2-1) (McDonald 2008). Fremantle ranked second and Port Hedland was third in the analysis. Dampier had 3,278 vessel visits, or 37% of the Western Australian total. Of these visits 2,188 vessels had an Australian last port of call and 1,090 were international. A total of 42,406,279 tonnes of ballast water was discharged into Dampier in 2006, 99.5% of which was of international origin. By comparison, the other ports in the western Pilbara had relatively little vessel traffic: 193 vessel visits at Varanus Island, 186 at Barrow Island and six at Exmouth. Ballast water discharges were also relatively small, ranging from zero at Exmouth to 254,827 tonnes at Barrow Island.

Table 2-1 Vessel visits and ballast water discharges in ports in the west Pilbara, Western Australia in 2006 (after McDonald 2008).

Port	Vessel visits			Ballast water discharged (tonnes)		
	Domestic	International	Total	Domestic	International	Total
Dampier	2,188	1,090	3,278	203,966	42,202,312	42,406,279
Barrow Island	180	6	186	135,873	118,954	254,827
Exmouth	5	1	6	0	0	0
Varanus Island	190	3	193	176,202	0	176,202
Total WA	4,909	3,967	8,876	6,615,859	116,805,503	123,421,361

Several factors were used to assess the risks of marine pests being introduced by different vessel types (McDonald 2008):

- time vessels spend in port or in coastal waters;
- distances between ports;
- variety of niches where species could be entrained;
- number of these niches;
- presence of a foul coating and its rate of deterioration;
- speed of the vessel; and
- other criteria.

Vessels were categorised as low, medium or high risk. Of the 3,279 vessels that entered the port of Dampier, 1,205 were considered to be low risk and 2,068 were medium or high risk (six could not be determined).

Ballast water

Vessels are designed to move through the ocean at a specified depth to maintain a proper balance and trim. If a vessel is lightly loaded, it will float higher in the water than it should, this can create problems with voyage management. The solution is to build ballast water tanks into the vessel into which water may be pumped. The increased weight lowers the vessel in the water until the proper depth is achieved. The ballast water is discharged when the vessel is loaded, with the cargo weight replacing the ballast water. Ballast water is used on large cargo ships, with volumes reaching tens of thousands of cubic metres each for the largest vessels. Ballast water is also used to 'balance' loads used in ships to reduce hull stresses. Smaller vessels and non-trading vessels that do not offload substantial amounts of cargo do not use ballast water. In total, over 123 million tonnes of ballast water were discharged into Western Australian ports in 2006, nearly 117 million tonnes of which was from international sources.

When the ballast water is taken on board a vessel, material in the water column is also drawn into the ballast water tanks. This material includes plants and animals living in the water column as well as sediment particles. Over time, a layer of mud develops in the bottom of the tanks as the sediment settles from the water. A variety of habitats are created: the soft sediment layer, the hard bottom of the tank walls and the water column itself. Species that can live in the absence of light can survive in the ballast water tank and there are few large predators. When the ballast water is released into a new harbour, the entrained species may be introduced. They may survive and develop populations If conditions are suitable.

Biofouling

As many as 75% of the marine species that have been introduced to Australia are thought to have been introduced through biofouling (Cranfield et al. 1998, Thresher et al. 1999, Thresher et al. 2000, Hewitt et al. 1999, Hewitt et al. 2004, Gollasch 2002, Bax et al. 2003). Unlike ballast water, biofouling can occur on vessels of any size. The term “hull fouling” is often used for biofouling but this is misleading because biofouling can occur on any immersed surface. Three phases of biofouling are recognised (Table 2-2):

- **Primary**. In the earliest stages of biofouling, biochemical and bacterial conditioning occurs on the newly exposed surface. A thin layer of microalgae then develops, with filamentous algae growing to a length of 5 mm.
- **Secondary**. The primary biofouling rapidly becomes secondary as the first animals begin to settle and grow on the surface, including barnacles, bryozoans, hydroids and worms. As the secondary fouling becomes thicker, mobile amphipods begin to occur.
- **Tertiary**. In the tertiary stage of biofouling, the community has become fully developed with sponges, ascidians, bivalve molluscs (mussels, oysters, and clams), sea anemones, worms, etc. The biofouling is now three dimensional, with numerous nooks and crannies where mobile faunal species can seek shelter. These include starfish, gastropods, crustaceans, bryozoans and tunicates.

The distribution of biofouling on a vessel is not uniform. Smooth, open surfaces are subjected to the greatest water flow when the vessel is underway, so it is more difficult for biofouling species to obtain and maintain purchase. Crevices and voids have less water flow, and are easier for species to adhere. Biofouling can develop on any immersed surface, including internal seawater piping.

Table 2-2 General temporal or biotic succession of biofouling colonisation and accumulation

	Primary	Secondary	Tertiary	
	Biochemical/bacterial conditioning	Acorn barnacles	Sponges	
	Microalgae (<1 mm)	Gooseneck barnacles	Ascidians	
	Filamentous algae (<5 mm)	Bryozoans	Mussels	
Immersion of vessel (e.g. release from drydock)				**Removal of vessel (e.g. drydocking)**
		Hydroids	Oysters	
		Serpulid worms	Clams	
		Spirorbid worms	Gastropods	
		Algal tufts	Crabs, shrimps	
		Coralline algae	Seastars	
		Amphipods	Sabellid worms	
			Sea anemones	
			Macroalgae	

Coutts et al. (2003) and URS (2006) contended that sea chests are often overlooked when biofouling issues are considered. Sea chests are voids open to the sea into which seawater can flow freely. There are typically gratings or other structures that prevent large objects from entering the sea chests. Often sea chests are inaccessible, so they are difficult to inspect. Coutts & Dodgshun (2007) inspected the sea chests of 42 vessels in New Zealand, finding 150 species of marine organisms, 15% of which did not occur naturally in New Zealand.

2.2.2 Construction and marine plant or vessels

Mobile infrastructure such as dredges, oil rigs, floating drydocks, etc are considered to be of high risk for the introduction of marine pests for a number of reasons (Kinloch et al. 2003), they:

- undertake a broad range of activities;
- often travel for considerable distances between contracts;
- remain for extended periods in ports where marine pests are concentrated;
- are slow moving or stationary;
- may routinely leave equipment in the water for 24 hours or more; and
- are in close contact with the bottom.

The Australian incidents with the *Leonardo da Vinci* in Geraldton and the *Volvox Asia* in Dampier were discussed in Section 2.1 (Wells et al. 2009). Internationally, a floating drydock introduced two species of sponges and one mollusc into Hawaii (Eldredge & Smith 2001). Similarly, Foster & Willan (1979) reported barnacles were introduced into New Zealand by a floating oil platform.

2.2.3 Commercial fishing operations

The risks of commercial fishing activities introducing or translocating marine pests from one area to another are high for the same reasons as mobile infrastructure. Summerson & Curran (2005) analysed these risks in detail in 15 Australian commercial fisheries, and briefly surveyed an additional 132 fisheries. The Kimberley prawn fishery was assessed in detail and 46 other Western Australian Department of Fisheries (DoF) managed fisheries were considered briefly. The study assessed four scenarios:

1. organism entrained in port and translocated to fishing ground;
2. organism present in one fishing ground and translocated to another fishing ground;
3. organism present in fishing ground and translocated back to port or to another port; and
4. organism entrained in one port and translocated to another port.

Wells (2008) followed up on the study with an analysis of the 50 or so fisheries managed by the DoF by looking at actual fishing boat operations. Movement of a vessel form one area to another, such as when a new fishing boat is bought out of state and brought into Western Australia to start fishing, was excluded as this was considered to be a shipping movement rather than a fishing operation.

Overall, there is a low risk of a Western Australian commercial fishery introducing a marine pest internationally as none of the fishing boats operate outside the country. The risks of an introduction from interstate were also low, as almost all of the fisheries operate entirely within Western Australia. Four fisheries (pearl industry, Northern Prawn Fishery, Kimberley trap fishery and one boat operating in the mackerel fishery) operate in the Kimberley, with some of the boats visiting Darwin for logistical support. However, at present, there are no species on the NIMPCG target list in Darwin (NIMPCG 2006a; NIMPCG 2006b). Of the ten NIMPCG target species in south eastern Australia, four are already in southern Western Australia. As with the north coast, there is little movement of Western Australian fishing vessels into the south eastern areas where the introduced pests occur.

However, if a pest species was introduced into Western Australian commercial fisheries, then operations could readily translocate it to other areas within the state. Such translocation could occur before the DoF became aware that the species was in fact in Western Australia. For this reason, Wells (2008) recommended that the fishing industry adopt the marine pest management policies advocated by Summerson & Curran (2005).

2.2.4 Recreational vessels

Cruising yachts up to 25 m in length are considered to be high risk for several reasons:

- they may spend extended periods in harbours where marine pests may be present;
- speeds in open water are typically slow;
- they may travel long distances across marine biogeographic regions;
- there are no international requirements or guidelines; and
- the owner often has little incentive to reduce drag.

In fact, it is thought that a cruising yacht was the vector for the outbreak of black striped mussels in Darwin Harbour in 1999.

Under Australian law, a vessel arriving from an international location must travel directly to an approved boarding station to undertake customs and immigration formalities before it travels to other areas such as a marine park (Australian Customs Service 2008). There are three approved boarding stations in the Gascoyne and Pilbara regions: Port Hedland; Dampier; and Carnarvon.

URS (2007) undertook a national assessment of the risks of cruising yachts introducing marine pest species to Australia. They analysed Australian Quarantine and inspection Service (AQIS) records on 4,620 yachts entering Australia in the six years from 2000 to 2005. Arrivals occurred in 58 ports across Australia but 87% of the arrivals occurred in only nine ports: Brisbane (965), Bundaberg (819), Cairns (641), Darwin (379), Port Jackson (Sydney) (309), Thursday Island (293), Mackay (216), Coffs Harbour (210), and Townsville (194). All of these major ports, except Darwin, are on the east coast; none is in Western Australia. During the six years there were a total of 117 arrivals in Western Australia; Fremantle (48) had the most arrivals.

It should be noted that the scope of the URS (2007) assessment only included international arrivals. There are no data available on the number of arrivals into Western Australia of domestic yachts. However, the few introduced marine pest species in the eastern states (Section 2.2.3) is again noted.

Aquaculture

Aquaculture is also a source of introduced marine species. Most of the marine species introductions into Australia through aquaculture have occurred in the eastern states, especially Tasmania. From the 1890s to the 1930s the New Zealand oyster, *Ostrea lutraria,* was imported into Hobart for the restaurant trade. The oysters were held in the harbour until sold. The New Zealand oysters have not survived in Tasmania, but 11 associated species are believed to have been introduced through this mechanism. Two freshwater species of trout, brown trout *Salmo trutta* (introduced in 1864) and rainbow trout *Oncorhynchus mykiss* (introduced in 1898), were introduced in the 19th century as freshwater angling species. Both species have seasonal marine runs in some areas. In the 1980s, aquaculture of the related Atlantic salmon (*Salmo salar*) was initiated in Tasmania and is now a major industry. Some escaped individuals have been found, but they are usually in poor condition. None of the three species is known to be having any measurable effect on the Tasmanian marine environment (Aquanal 2002, NIMPIS 2002).

After World War II, the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) made two attempts to introduce the Pacific oyster (*Crassostrea gigas*) into Australia for aquaculture. In 1947 a shipment of broodstock was sent from Japan by sea and introduced into Western Australia and Tasmania. After the extended sea voyage the animals were in poor condition and died. A second attempt was later made with the broodstock being transported by air. This introduction was only to Tasmania, where the species established a successful aquaculture industry (Thomson 1952, 1959). Wild oyster populations have since become established. In addition to Tasmania, the Pacific oyster now occurs along the east coast of Australia from New South Wales to South Australia.

With improvements in our knowledge of the risks of introducing species through aquaculture, the DoF now enforces stringent protocols for translocating marine and freshwater species into Western Australia. None of the 60 marine species known to have been introduced into Western Australia have arrived via aquaculture (Huisman et al. 2008).

2.2.5 Ornamental fish

Corfield et al. (2008) undertook an analysis of the introduction of exotic species into Australian freshwater environments. A total of 41 species have been introduced, 30 of which are believed to have come from freshwater aquaria and outdoor ponds. Many of these species have become substantial pests. Overall, about 12-14% of Australians maintain freshwater aquaria or outdoor ponds. In addition, freshwater plants and animals such as snails have also been introduced. The introductions most often occur when the aquarist releases fish into nearby freshwater habitats or when outdoor ponds are flooded by heavy rainfall. Morgan et al. (2004) undertook a study in Western Australia, and reported that ten freshwater fish species have been released in the State. Some of these were introduced decades ago for recreational fisheries, but others were through aquaria releases. Since the Morgan (2004) paper was published, the South American cichlid *Geophagus brasiliensis* has been found in the Bennett Brook and Whiteman Park area. Attempts to remove the species were unsuccessful and it is now spreading. Freshwater yabbies (*Cherax albidus* and *C. destructor*) were introduced in the 1930s (DoF 2008).

Marine aquaria are much more difficult to maintain than freshwater aquaria, and there are relatively few marine aquaria in Western Australia. Additionally, there are few pet shops selling marine fish. Many marine aquarists catch their own fish locally, so the risk of marine introductions through aquaria is small, but still present. None of the 60 marine species recorded as being introduced into Western Australia by Huisman et al. (2008) are thought to have been introduced through marine aquaria.

2.3 Species of Concern to Australia (Marine Pests)

When introduced into a new area, each species must become established in a new suite of environmental parameters. The new arrival has complex interactions with the existing biota and habitat of the new locality. Whether a new arrival will become a pest is difficult to predict as a single species may be a pest in one region where it has been introduced but not in other regions. There have been a number of attempts to develop lists of marine pests and potential marine pests of concern to Australia. During the 1990s and early 2000s, the CSIRO Centre for Research into Introduced Marine Pests (CRIMP) developed methods for surveying the marine environment for introduced pest species (Hewitt & Martin 2001). These were broad scale surveys that developed a national database of information on both the native biota of the area and introduced species.

The National Introduced Marine Pests Coordination Group (NIMPCG) is the national body developing an Australia-wide system for managing the marine pest issue. It includes representatives from all jurisdictions, industry, conservation stakeholders and scientific support. NIMPCG contracted CRIMP to undertake a wide ranging compilation of species that had been documented as being introduced marine pests in Australia or other parts of the world. Extensive literature reviews were conducted, and a database was developed on 1,582 marine and estuarine species (Hayes et al. 2002, Hayes & Sliwa 2003, Hayes et al. 2005). A national target list of species of concern was determined using risk analysis (Table 2-3). It should be recognised that the list is only a guide, and any survey for introduced marine pests should be designed to incorporate other species that have invasive characteristics in the study area. The NIMPCG list is currently being revised.

Table 2-3 is divided into species that could be introduced through ballast water and those most likely to be introduced through biofouling. The Pacific oyster, *C. gigas,* is the only species on the NIMPCG list to have been introduced via aquaculture (Thomson 1959). No marine species have been introduced into Western Australia for aquaculture (Wells 2008).

Table 2-3 Target species of introduced and potentially introduced marine species on the national monitoring program (NIMPCG 2006).

Group	Species		Group	Species
BALLAST WATER ONLY				
Dinoflagellates	*Alexandrium catenella*		Diatoms	*Chaetoceros convolutus*
	Alexandrium minutum			*Chaetoceros concavicornis*
	Alexandrium monilatum			*Pseudo-nitzschia seriata*
	Alexandrium tamarense		Ctenophorans	*Beroe ovata*
	Dinophysis norvegica			*Mnemiopsis leidyi*
	Gymnodinium catenatum		Copepods	*Acartia tonsa*
	Pfiesteria piscicida			*Pseudodiaptomus marinus*
				Tortanus dextrilobatus
BIOFOULING				
Algae	*Bonnemaisonia hamifera*		Cnidarians	*Blackfordia virginica*
	Caulerpa racemosa		Polychaetes	*Sabella spallanzanii*
	Caulerpa taxifolia			*Hydroides dianthus*
	Codium fragile spp. *fragile/ tomentosoides*			*Marenzelleria* spp.
	Grateloupia turuturu		Barnacles	*Balanus eburneus*
	Sargassum muticum			*Balanus improvisus*
	Undaria pinnatifida		Crabs	*Callinectes sapidus*
	Womersleyella setacea			*Carcinus maenas*
Bivalves	*Corbula amurensis*			*Charybdis japonica*
	Ensis directus			*Eriocheir sinensis*
	Limnoperna fortunei			*Hemigrapsus sanguineus*
	Mya arenaria			*Hemigrapsus takanoi/ penicillatus*
	Varicorbula gibba			*Rhithropanopeus harrisii*
	Musculista senhousia		Ascidians	*Didemnum vexillum*
	Mytilopsis sallei		Starfish	*Asterias amurensis*
	Perna perna		Fish	*Neogobius melanostomus*
	Perna viridis			*Siganus luridus*
	Crassostrea gigas			*Siganus rivulatus*
Gastropods	*Crepidula fornicata*			*Tridentiger barbatus*
	Rapana venosa			*Tridentiger bifasciatus*

2.4 Introduced Marine Species in Western Australia

2.4.1 Marine biogeography of Western Australia

The shallow water marine environment of Western Australia (<200 m) can be divided into three marine biogeographic regions (Wells 1980, Wilson & Allen 1987):

- A tropical north coast that extends from North West Cape north-eastwards to the Northern Territory border and across northern Australia to the southern part of the Great Barrier Reef. This tropical Australian region is part of the vast Indo-West Pacific Region that extends from the east coast of Africa through the tropical parts of the Indian and Pacific oceans to Hawaii. Many species are widely distributed across the entire region. Almost all of the species on the north coast of Australia also occur in countries to the north such as Papua New Guinea, Indonesia, the Philippines and others.
- A temperate south coast that extends eastwards from Cape Leeuwin to southern New South Wales has a warm temperate biota.
- The west coast of Western Australia, between Cape Leeuwin and North West Cape, is a region of marine biogeographic overlap, with tropical species dominating in the north and temperate species in the south. About 10% of the shallow water marine faunal species are endemic to Western Australia; most of these have at least part of their distribution on the west coast.

The Western Australian Museum conducted a detailed survey of marine species diversity in the Montebello Islands northeast of Onslow (Berry & Wells 2000). The survey found a wide variety of animals including corals, crustaceans, echinoderms, molluscs and fish. Almost all of the species recorded in the Montebello Islands were tropical, but there was a small component of Western Australian endemic species. The distributions of 217 species of molluscs were examined in detail: 206 were tropical; ten were endemic to Western Australia; and there was a single temperate species.

2.4.2 Introduced marine species in Western Australia

The National Introduced Marine Pest Information System (NIMPIS) was developed by CSIRO in 2002 (NIMPIS 2002). Although it is now out of date, the system has information on more than 250 species introduced into Australian waters. Sixty of these species occur in Western Australia (Huisman et al. 2008). Most of the species are apparently innocuous, being recorded by scientists but causing no known effects in the marine environment. A small minority of introduced marine species, estimated at between one in 10 and one in six, are estimated to become marine pests.

Huisman et al. (2008) recently compiled all available records of introduced marine species in Western Australia, including published and grey literature, and anecdotal records. The validity of each record was assessed, in particular whether there was voucher material in the Western Australian Museum or Western Australian Herbarium. A total of 102 species were considered with the following results:

- 60 species were considered to have been introduced to Western Australia through human activity and are living in the state;
- 7 species (including 4 natural introductions) were introduced but are not presently living in Western Australia;
- 26 species were regarded as cryptogenic (original distribution cannot be determined) or native; and
- 9 species records were questionable or rejected.

2 Marine Pest Issues

The geographic distribution of the 60 introduced marine species was investigated. Most (37) are temperate species that occur south of Geraldton, six are tropical species that occur from Shark Bay north, and 17 occur in both the southern and northern halves of Western Australia. This is consistent with other studies (e.g. NIMPIS 2002, Hewitt 2000) that demonstrate that there are more introduced species in temperate localities than in tropical areas.

The question of why there are more introduced marine species in temperate waters has been a subject of debate among scientists. One hypothesis is that there are simply more scientists and institutions in temperate areas, so there have been more studies in temperate waters than in the tropics. In Australia, for example, all of the capital cities are located either in temperate regions or, in the case of Brisbane, near the northern limit of the tropical-temperate overlap zone. Hewitt (2002) examined this question by analysing eight of the port surveys undertaken by the CRIMP, four in tropical ports and four in temperate ports. The number of surveys was the same in the two areas and the survey methods were as similar as possible, but more introduced species were found in the temperate ports surveyed.

A second hypothesis is that marine species compositions in temperate environments are better understood because there are fewer species. In the mega diverse tropics, particularly coral reefs, species diversity is much greater and the taxonomy is not as well established. It may be easier in these areas for introduced species to go unrecognised. However, even in groups that have been the most thoroughly examined by taxonomists, there are still more introduced species in temperate environments. A third suggestion is that the greater diversity in the tropics means niche sizes are smaller, providing less ecological space for an invading species to occupy.

In general, relatively few introduced species have been recorded in tropical areas, but there is a lack of data for coral reefs (Coles & Eldredge 2002). The exception is the Hawaiian Islands, where 343 introduced marine and estuarine species have been recorded (DeFelice et. al. 2001). The large number of introduced species in Hawaii may be due to the considerable amount of shipping in the area, but Hutchings et al. (2002) suggest that the combination of Hawaii's biogeographically isolated position at the margins of the Indo-West Pacific and its less diverse marine communities have made the islands more susceptible to invading species. Zahin & Hadfield (2002) demonstrated that there is no interaction in Hawaii between the introduced Caribbean barnacle, *Chthamalus proteus,* and the native barnacle, *Nesochthamalus intertextus*. Species introduced into the Hawaiian marine environment are concentrated in Pearl Harbour and other estuarine areas of Oahu rather than on open coral reef environments. Coles et al. (2002) undertook a rapid assessment of Hawaiian coral reefs and found only 26 introduced species of a total of 486 identified species, most of which (17) were limited to only one or two of the 41 sites surveyed. Half of the sites (21) had three or fewer introduced species.

Closer to the mega diverse coral reefs, Paulay et al. (2002) showed that there are >5,500 marine species recorded in Guam, but only 85 species are classified as introduced or cryptogenic. Only 23% of the introduced species recorded in Guam have been found outside the harbour of Apra. One of these was the trochus shell, *Trochus niloticus*, which was deliberately introduced as a fishery species.

2.4.3 Introduced marine pests in Western Australia

Only four of the 60 introduced species living in Western Australia are on the NIMPCG (2006) list (Table 2-4). Huisman et al. (2008) listed three of these. The fourth, the marine alga *Codium fragile fragile,* was subsequently found in Albany (McDonald et al. 2008). None of the four species on the NIMPCG list occurs in the Pilbara region.

Table 2-4 NIMPCG (2006) target species recorded in Western Australian marine areas

Group	Species	Areas inhabited	Source
Marine alga	*Codium fragile fragile*	Albany	McDonald et al. (2008)
Dinoflagellate	*Alexandrium minutum*	Fremantle, Bunbury	Huisman et al. (2008)
Mollusc	*Musculista senhousia*	Fremantle	Huisman et al. (2008)
Polychaete	*Sabella spallanzanii*	Fremantle to Esperance	Huisman et al. (2008)

Zeidler (1978) recorded the European shore crab, *Carcinus maenas,* in Western Australia using a single specimen collected at Blackwall Reach in the Swan River. Subsequent compilations of introduced species in Western Australia listed this pest species. However, it was not found by the CRIMP (2000) survey of the Fremantle marine area, and Huisman et al. (2008) concluded that *C. maenas* is not currently living in the Swan River. More recently, a major survey of the Fremantle marine area, including sites in the Swan River, Canning River, Fremantle Inner Harbour, Rous Head, Success Bank and Cockburn Sound failed to find the species (McDonald and Wells 2008; Wells et al. in press).

The Asian date mussel, *Musculista senhousia,* was first recorded in the Swan River in 1985 (Slack-Smith and Brearley 1987). The species was very abundant in many areas of the river, reaching densities as high as 2,600 per square metre, and was well established in the river. The species occurred in shallow areas <4 m deep. In the summer of 2000, the largest single day summer rainfall event in Perth's history occurred, with 179 mm falling. Salinities in the upper part of the water column immediately dropped and temperatures were reduced. This rapid change in environmental conditions apparently killed most or all of the *M. senhousia* at a time during the yearly cycle when populations were already reduced. The rainfall was followed by an intense bloom of toxic algae which apparently killed off any remaining mussels. A survey of the Fremantle marine area in September-October 2007 failed to find a single individual (McDonald & Wells in press).

2.5 Introduced Marine Species in the Pilbara

2.5.1 Introduced marine species in the Pilbara

There have been no surveys for introduced marine species in the Onslow region. The barnacle, *Megabalanus tintinnabulum,* is the only introduced species known from Onslow (Huisman et al. 2008). It is not a species on the NIMPCG (2006) target list.

In nearby regions, CSIRO (1999) surveyed Port Hedland for introduced species and recorded a total of 12 species (Table 2-5): seven bryozoans, four barnacles, and a hydroid. Dampier has not been specifically surveyed for introduced marine species, but extensive studies by the Western Australian Museum (Wells et al. 2003, Jones 2004, 2008) have recorded six species: five barnacles and a bryozoan. Two barnacles have been recorded each at Useless Loop and Carnarvon (a total of three species). Wyatt et al. (2005) reported on introduced marine species in Shark Bay, recording eight bryozoans, one tunicate and one hydroid.

Altogether 24 marine species have been introduced to the Gascoyne and Pilbara. As all of these areas are near Onslow and are tropical, any of the species could potentially be in the Onslow area. However, Huisman et al. (2008) reported that all 60 of the species introduced to Western Australia have been recorded in harbours near major ports; only 26 are known to have extended their ranges onto the surrounding open coast. While there has been no survey, it is likely that few of the 24 species actually occur near Onslow. Introduced marine species living in the Pilbara and Gascoyne regions are not considered to pose translocation risks to Onslow as none of them are potential marine pests on the NIMPCG target list of species (NIMPCG 2006a, NIMPCG 2006b).

2 Marine Pest Issues

Table 2-5 Introduced marine species recorded in the Gascoyne and Pilbara regions.

Species	Gascoyne	Pilbara	Useless Loop	Carnarvon	Onslow	Barrow I.	Dampier	Port Hedland
Bryozoans								
Amathia distans		X						X
Amathia vidovici		X						X
Bowerbankia gracilis		X						X
Bugula neritina	X	X					X	X
Bugula stolonifera	X	X						X
Conopeum seurati	X							
Savignyella lafontii	X	X				X		X
Schizoporella errata	X							
Tricellaria occidentalis						X		
Watersipora subtorquata	X							
Zoobotryon verticillatum	X	X						X
Tunicate								
Styela plicata	X							
Crustaceans								
Amphibalanus amphitrite	X	X		X			X	X
Amphibalanus reticulate		X				X	X	X
Paracerceis sculpta	X							
Megabalanus ajax	X	X	X			X	X	
Megabalanus rosa	X	X				X	X	X
Megabalanus tintinnabulum	X	X	X	X	X	X	X	X
Hydroids								
Antenella secundaria	X	X						X
Halecium delicatulum	X							
Obelia dichotoma	X							
Sarsia eximia	X							
Ascidians								
Botryllus schlosseri	X	X						
Styela plicata	X	X						
Totals	**18**	**15**	**2**	**2**	**1**	**6**	**6**	**12**

2.5.2 Introduced marine pests in the Pilbara

There are fewer introduced marine species in tropical than in temperate Western Australian areas and none of those present in the Gascoyne and Pilbara are on the NIMPCG list. However, this does not mean that a marine pest issue in the Pilbara could not exist.

Hallegraeff & Bolch (1991) recorded viable cysts of toxic species of dinoflagellates in the ballast water of ships in Port Hedland Harbour. Fortunately, the dinoflagellates did not establish populations in the area, but the possibility exists that such species could be introduced and survive.

Two bivalve species are of particular concern to Western Australia: the black striped mussel, *M. sallei* that was eradicated from Darwin Harbour in 1999 and the Asian green mussel, *P. viridis* that has apparently established a small population in Cairns (Section 2.1). The black striped mussel has been found on Indonesian fishing boats intercepted off the Pilbara coast. The vessels were considered to be unseaworthy, so their crews were taken on board Australian vessels, and the fishing boats destroyed at sea. In another incident, an arrival inspection showed that the dredge *Volvox Asia* had the Asian green mussel on its hull when it arrived in Dampier in late 2006. The vessel was denied entry to the port. It went to Singapore, where it was cleaned and was allowed to enter Australian waters (URS 2008). In a separate incident, a barge entered Dampier and was found to be extensively fouled. It returned to the offshore 200 m contour, where it was cleaned at sea before returning to Port Hedland. Thus, both the black striped and Asian green mussels have been detected in vessels entering Pilbara waters. Neither has apparently established populations, and continued vigilance is required to ensure they are not introduced.

2.6 Management of Marine Pest Issues

Management of marine pest issues is a complex problem that is being addressed at a wide range of levels: international, Australian, within Western Australia, and by individual ports, companies and private organisations. As approaches and regulations are in a state of considerable flux, the present section can only summarise the current status. Readers should be aware that there could be considerable changes in a relatively short period of time.

2.6.1 Management in Australia

At a federal level, the Department of Agriculture, Fisheries and Forestry (DAFF) is the lead agency responsible for developing management polices for marine pest issues. Within DAFF, the Invasive Marine Pest Species Program both coordinates the development and implementation of the marine pest management strategies, and services the NIMPCG. A 'National Taskforce on the Prevention and Management of Marine Pest Incursions' was established in 1999 which evolved into the beginnings of the 'National System for the Prevention and Management of Marine Pest Incursions' ('the National System'). The National System is still under development. An Intergovernmental Agreement (IGA) was signed by the Australian, State (except New South Wales) and Northern Territory governments to develop the National System. The NIMPCG has been charged with developing and coordinating the National System. The goal of the National System is to have a single set of regulations for handling marine pest management that is uniform throughout Australia.

The National System has three main components:

- Prevention systems and procedures to reduce the risk of introduction and translocation of marine pests in the first instance, with particular focus upon ballast water and biofouling.
- An emergency response framework, for coordinating appropriate responses to new marine pest incursions and translocations.
- Ongoing control and management arrangements, aimed at containing the risks of marine pests that have already been introduced into Australia.

Within DAFF, the Australian Quarantine and inspection Service (AQIS) is the agency responsible for implementing marine pest management policies. This is achieved primarily through the Commonwealth *Quarantine Act 1908,* which was modified by the *Quarantine Amendment Act 1999*, which defines ballast water as 'goods'.

2.6.2 National monitoring protocols

NIMPCG is developing a nationwide marine pest monitoring program for the target species list (Table 2-3) (NIMPCG 2006a, NIMPCG 2006b). The documentation clearly states that in addition to the target list, monitoring should always be undertaken with the clear understanding that other species may become invasive, and this should be considered in developing any monitoring program. The NIMPCG methodology was trialled in several locations, including Albany in Western Australia (McDonald et al. 2008), and is currently being revised. Eighteen ports were selected; providing a cost effective monitoring strategy that included both those areas at greatest risk and concurrently incorporating all of the marine biogeographic regions within Australia. Three Western Australian ports are on the national sampling program: Dampier, Port Hedland and Fremantle. DoF is responsible for ensuring that these ports are appropriately monitored.

2.6.3 Consultative Committee on Introduced Marine Pest Emergencies

The Consultative Committee on Introduced Marine Pest Emergencies (CCIMPE) is the coordinating body if a marine pest is detected. CCIMPE has developed a strategy for dealing with any emergency marine pest outbreak (CCIMPE 2006).

The plan has four stages:

- investigation;
- alert;
- operation; and
- stand-down.

A key to CCIMPE management is a common funding pool developed by the Commonwealth, States and Northern Territory that can be used to share the costs of combating a marine pest outbreak.

Western Australia is represented on CCIMPE by the State's lead agency for marine pest management, the DoF. If a marine pest is detected in Western Australia, then DoF is the organisation responsible for managing the outbreak. If DoF determines that the outbreak is of sufficient significance to notify CCIMPE, then it can draw on the national resource pool. DoF still remains in control of local management efforts.

The CCIMPE protocols can be activated if a single individual of a target species is located. This happened in Albany in June 2008, when a one specimen of the marine alga *Codium fragile fragile* was identified from material collected at the town jetty (McDonald et al. 2008). Following consultation with

CCIMPE, a survey was conducted of Princess Royal Harbour and adjacent areas where the species was likely to be found. No additional plants were found, but the Albany Port Authority subsequently reported two plants in the port area and their identity was confirmed. Other individuals have since been found in King George Sound, and it is unlikely that the species can be eradicated.

2.6.4 Ballast water

Ballast water was originally thought to be the primary vector for the dispersal of marine pests around the world (Carlton 1985, Thresher 1999, Eldredge & Carlton 2002). Because of this, the early development of marine pest policies centred on reducing the risk of introducing marine pest species through ballast water. As early as 1991, the Australian Government developed voluntary guidelines for ballast water management; these became mandatory in 2001.

The Australian ballast water requirements are similar to those of the transitional requirements of the *International Convention for the Management of Ships' Ballast Water and Sediments*. The text of the Convention was adopted by the International Maritime Organization (IMO) at a Diplomatic Conference in February 2004. The Convention provides for consistent ballast water management requirements to be implemented worldwide. Australia signed the Convention subject to ratification in May 2005. The convention will come into effect 12 months after it has been ratified by 30 states representing 35% of the worlds shipping tonnage. At 30 April 2009, the convention had been signed by 18 states representing 15.36% (IMO 2009).

AQIS initially developed a Ballast Water Decision Support System (DSS) to allow vessel masters to assess the risk of marine pest introduction through a ship's (international) ballast water. The DSS was based on a number of factors including marine species present at origin and destination ports, journey duration, ballast water exchange history and species survivability. However, the rules have subsequently been changed and the DSS is no longer used. AQIS now considers all salt water from ports and coastal areas outside Australia to be high risk. The current Australian requirement is that all ballast water from ports or coastal regions outside Australia must be exchanged at sea (outside 12 nautical miles of shore) prior to arrival in Australia . The exchange should preferably occur outside the 200 m depth contour. Ninety five per cent or more of the ballast water must be exchanged. This requirement acknowledges the fact that potential introduced marine pest species live in coastal environments, and have few larvae in the open ocean. Two exchange methods are approved (AQIS 2008a):

- emptying the tank by 95% or more of its capacity and refilling the tank in the open sea;
- flow through in which the pumps are operated until at least 300% of the capacity of a tank has been replaced. It is expected that an exchange of this magnitude will ensure 95% or more dilution of the ballast water.

AQIS (2008a) also suggests that it is desirable to discharge all other ballast tanks to allow for changes in operational requirements in port, when it may become necessary or desirable to empty ballast water tanks other than those originally planned. There are provisions for exchange not occurring in the open ocean if it would endanger the vessel or crew. In such circumstances, advance written approval is required from AQIS before the water is discharged in Australian coastal waters. During a vessel's arrival pratique, AQIS officers check the ballast water exchange records of the vessel including the GPS positions of the ship at the time of the exchange and pump operational records to ensure the exchange has in fact occurred.

The AQIS arrival pratique checks currently apply only to internationally sourced ballast water. There are currently no requirements for ballast water exchange for vessels entering Western Australia from interstate or for vessels moving from one part of Western Australia to another. This can create regulatory anomalies for example where ballast water in one tank may be international, while that in the adjacent tank on the same vessel is domestic. The National System will remove this anomaly, so all ballast water exchange is undertaken according to the same regulations.

2.6.5 Biofouling management of vessels arriving from overseas

There is a great deal of uncertainty over the management of biofouling in Australia.

Cruising yachts and other vessels <25 m in length are considered to be high risk for introducing marine pests through biofouling. AQIS introduced a voluntary system for these vessels on 1 October 2005. The goal was to make the requirements mandatory from 1 July 2008 following review and improvements (AQIS 2008b). However, legal advice was subsequently received by DAFF that such regulations could not be enforced based simply on the size of a particular vessel, but rather had to be uniform across all vessels.

DAFF is currently consulting with a range of sectors including non-trading, petroleum, commercial shipping and yachting to develop the proposed Australian Biofouling Management Requirements. The new requirements will constitute a targeted quarantine inspection regime that uses a risk based approach (DAFF 2008); a general description of the biofouling issue was recently released by DAFF (2009). The risk assessment criteria and the quarantine inspection regime include a hazard analysis of vessel classes, on-arrival biofouling risk assessments and in-water inspections if required by AQIS. The proposed Australian Biofouling Management Requirements will include a hazard analysis for vessel classes to assess their relative risk of translocating quarantinable biofouling pests (Table 2-3) into Australian ports and waters. Moderate and high hazard vessels classes (including some types of petroleum production and exploration vessels) will likely be subject to an AQIS biofouling risk assessment upon arrival to Australia. If AQIS believes that a vessel is, or is highly likely to be, contaminated with any of the 14 species of quarantinable biofouling pests then an in-water inspection will be required. The cost of an in-water inspection will be borne by the vessel operator. Further management actions may be required depending on the outcomes of the risk assessment and inspection.

2.6.6 Western Australian management practices for marine pests

As stated in Section 2.6, the goal of the National System is to have uniform regulations across Australia for managing the issues of introduced marine pests. Until the National System is in place, the States and Northern Territory will continue to independently manage particular aspects of marine biosecurity.

Department of Fisheries

DoF is lead agency for management of marine pest issues in the Western Australian State Government. While the DoF operates under several acts, the primary legislative tool is the Western Australia *Fish Resources Management Act 1994*. The Act prohibits the importation of a live “fish” not endemic to the State or its translocation within the State to an area where it is not endemic. Note that "fish" in this sense is defined as: "an aquatic organism of any species (whether alive or dead) and includes:

a) the eggs, spat, seeds, spawn, spores, fry, larva or other source of reproduction or offspring of an aquatic organism; and
b) a part only of an aquatic organism (including the shell or tail), but does not include aquatic mammals, aquatic reptiles, aquatic birds, amphibians or (except in relation to Part 3 and Division 1 of Part 11) pearl oysters."

Thus, the restriction is on a broad range of plants and animals, and not just fish. Pearl oysters are managed by DoF under an act specific to the pearling industry. Vertebrates other than fish are managed by the Department of Environment and Conservation (DEC). In managing marine pest issues, DoF cooperates closely with DEC, the Environmental Protection Authority (EPA), port authorities and other Commonwealth and State agencies.

Environmental Protection Authority

Under the Western Australia *Environmental Protection Act 1986*, the EPA assesses major development projects being undertaken within the State. The EPA has a range of options for establishing the level of assessment. If the proposal is determined to pose only local impacts that can be effectively managed, then the assessment can be undertaken without public comment. Major projects, such as the Wheatstone Project, require a full assessment with an extended period for public comment. Following the assessment, the EPA makes a recommendation to the Minister for the Environment on whether the proposal should be accepted or rejected. The EPA often suggests that specific Ministerial Conditions be attached to the Minister's approval. These conditions are legally binding. Following the incident with *Leonardo da Vinci*, the Ministerial Conditions have stated that dredges and other high risk vessels must be inspected by a qualified marine scientist and certified to be clean of marine pests prior to the vessel's departure for Australia, or within 48 hours of arrival. A second inspection is required at the completion of dredging if the vessel is moving to another location within Western Australia.

It is important to note that the EPA *recommends* a course of action to the Minister; the EPA does not approve or reject proposals. It is the Minister who makes the final decision. In making its recommendations, the EPA is bound by the EP Act (WA) to consider only environmental aspects of the proposal. The Ministerial decision is based on a broader range of considerations, including the social value of the project, in addition to environmental issues. DoF advises the EPA/DEC of compliance but is not the regulatory agency under the Ministerial Conditions.

Until the proposed Australian Biofouling Management Requirements are in place, the primary requirement for inspection of dredges and other construction vessels arriving into Western Australia from overseas will continue to be through the environmental assessment process. Even after these regulations are in place, management of vessels coming from interstate or being moved within Western Australia may continue to be through environmental assessments.

Port authorities

Under the *Western Australian Port Authorities Act 1999* and its associated *Port Authorities Regulations 2001,* the Harbourmaster of each port has substantial powers to manage marine pests or suspected pests. The Harbourmaster can deny entry or order the departure of any vessel that contains marine pests, is leaking oil, or poses any other marine pollution risk to the harbour.

2.6.7 Biosecurity and Agricultural Management Act 2007

The Western Australian Parliament recently passed the *Biosecurity and Agricultural Management Act 2007* (BAM Act) to provide a stronger legislative base for managing all aspects of biosecurity including the marine environment. Regulations under the BAM Act are currently under development and are not yet public, so it is not possible to examine how they will relate to the management of marine pest issues.

3

Introduced Bacteria, Viruses and Parasites (Marine Health)

3.1 Introduction to the Marine Health Issue

A major limitation in assessing whether diseases have been introduced and how the introductions may have occurred is the paucity of information available on diseases that occur naturally in the Western Australian marine environment. Diseases in molluscs are relatively well known because of their economic importance: pearl oysters, rock oysters, scallops and abalone are all commercially important species. Jones & Creeper (2006) surveyed existing information and reported a number of potential disease causing organisms in molluscs in Western Australia. They emphasised that even in this relatively well known group, very little is actually known about the diseases. *Vibrio* spp. were isolated from pearl oysters in the 1980s, and caused substantial mortalities (Section 3.3.4). Several other diseases have been found in pearl oysters, but their effects are unknown. The pathogenic haplosporidean protozoan *Haplosporidium* sp. was found in rock oysters (*Saccostrea*) on a number of Pilbara Islands near the Project area. One natural outbreak caused mortality of up to 80% in oysters on Airlie Island, northeast of Thevenard Island (Jones & Creeper 2006). Other outbreaks of the same or other diseases may have gone unrecognised.

In recent years there have been a number of widely publicised disease outbreaks that have heightened public awareness of the possibility of marine diseases being introduced into the Australian marine environment. Working on the outbreak of a virus in abalone farms in Victoria, Day & Prince (2007) highlighted the disease problems that can occur in aquaculture. The risks are similar to those that occur in terrestrial crop and animal husbandry but are not as well known. The worst cases of disease in terrestrial animals have occurred because the disease has crossed from one species to another. The original host has developed resistance to the disease but the new host has not. As a result, the disease effects are far more devastating in the new population. Over a period of time, the new host species may develop resistance to the disease.

The same phenomenon occurs in aquaculture and may be heightened if the disease can be transmitted through the water. In an aquaculture setting the animals are in close proximity to each other, meaning a disease can rapidly spread from one individual to another. Even in the best aquaculture venture the animals can be stressed from their close proximity to each other, the artificial environment, and possibly other factors. This can lower their disease resistance which makes them more susceptible to a disease outbreak.

Day & Prince (2007) reported that there have been many examples of wild stocks being affected by diseases introduced through aquaculture. Three possible effects can occur:

- introduction of new pathogens from exotic sources;
- transfer of pathogens between species; and
- amplification of indigenous pathogens and their transfer into wild stocks.

The sections below provide information on recent disease issues in Australian aquaculture environments. The pearl oyster and prawn issues are most relevant to the Project as both occur in the region in which the project will be developed.

3.2 Transmission Vectors

As with marine pest species, there are a number of transmission vectors for bacteria, viruses and parasites.

3.2.1 Ballast water

A key driver for the development of the *International Convention for the Control and Management of Ships' Ballast Water and Sediments* was recognition, as early as the 1980s, that ballast water could transmit both unwanted species and human pathogens (IMO 2009), in particular cholera. Some, but not all, strains of *Vibrio cholerae* produce the disease. Cholera is endemic to areas of Africa, Asia and central Europe. It can occur naturally in estuaries and brackish waters. Cholera is transmitted by eating contaminated food or drinking contaminated water, but outbreaks are usually water borne. In 1991 and 1992, a major outbreak of cholera occurred in Central and South America. During those two years, over 700,000 people became ill, with 6,323 dying. The outbreak was believed to have been spread via ballast water from country to country, with several ships arriving in Alabama, USA with ballast water contaminated by cholera (Ruiz et al. 1997).

3.2.2 Importation of food for human or animal consumption

Another possible vector for marine diseases is the importation of unprocessed materials to be used for human food, animal food, or bait. That the disease organisms can survive in fresh fish and shellfish is not surprising, but at least some can also survive in frozen products that have not been heat treated through cooking or other processes.

3.2.3 Translocation

Bacteria, viruses and parasites are readily translocated from one area to another in their hosts. For example, Jones & Creeper (2006) reported *Steinhausia mytilovum* in Cockburn Sound but not in other mussel growing areas of Western Australia, and suggested it could be transported in the mussels.

3.3 Marine Bacteria, Virus and Parasite Outbreaks in Australia

3.3.1 Pilchard deaths in southern Australia

Pilchards (*Sardinops sagax*) are a small (up to 15 cm) pelagic fish that form schools near the surface of waters in the open ocean. As the waters off Australia are nutrient poor compared to other oceans, pilchard populations are relatively low. Even so, there are thousands of tonnes caught over the range of the species, which extends from the Kalbarri Cliffs, Western Australia to Noosa Heads, Queensland.

In March 1995, quantities of dead adult pilchards started washing up on beaches along the eastern shores of the Great Australian Bight in South Australia. The deaths spread rapidly east and west at a rate of up to 30 km/day. By early May, dead pilchards extended from Albany, Western Australia to Bass Strait, Victoria. By the end of June the entire 6,700 km range of the species was affected. In early June a similar phenomenon started in northern New Zealand.

The pattern was similar in all populations, with adults in the range of 10-13 cm being killed; juveniles were apparently unaffected. Other organisms, both predators and scavengers, which ate the pilchards were also not affected. Once mortality spread through an area the deaths stopped, but the rate of spread and mortalities at the margins continued unabated. Overall, 10-15% of pilchard stocks were killed.

Detailed scientific studies, undertaken to isolate the cause of the deaths, determined that a *Herpesvirus* was responsible. The pilchards had apparently not been exposed to the virus in the past, and therefore had no immunity to the disease. It was concluded that the virus had been introduced into Australia. No direct evidence was obtained to determine the possible vector for the introduction (Fletcher et al. 1997), but there have been claims that frozen pilchards imported from overseas and used in the South Australian tuna farming industry may have been the source (Australian Democrats 1998; Day & Prince 2007). Between 10,000 and 16,000 tonnes of imported frozen pilchards were used as fish food in the South Australian tuna industry in 1995 (Day & Prince 2007). Whittington et al. (1997) reported that frozen Western Australian pilchards that had been infected with the virus were exported to New Zealand as fish food for an aquaculture venture, resulting in the inadvertent spread of the infection to the New Zealand population.

A second mass mortality occurred from October 1998 to May 1999, again encompassing the entire range of pilchards in Australia. This outbreak killed about 70% of the adult population (Gaughan et al. 2008). The virus is now permanently established in Australian pilchard populations (Whittington et al. 2008).

3.3.2 Abalone virus in Victoria

Australia is one of the few countries in the world that still maintains a successful wild caught abalone fishery. The legal catch was valued at $229 million in 2004/05 (Seafood CRC 2009). The Victorian catch of around 160 tonnes is valued at about $60 million. In May 2006 a herpes-like virus was detected on two abalone farms near Port Fairy, Victoria, where it caused a complete mortality of blacklip, greenlip and hybrid abalone. Shortly afterwards the virus was found in wild abalone populations. Over the next few months the disease spread to infect reefs over some 90 km of coastline in the Western Zone of the Victorian abalone fishery, an area that produces 65% of the Victorian catch. Mortality rates of 40 - 95% occurred on both blacklip and greenlip reefs (Prince 2007). There were three possible sources of the infection:

- the virus occurred naturally in the region, but became lethal in an aquaculture environment;
- the virus was present naturally in restricted areas, but was spread into new areas by abalone farms; or
- it is an exotic species that has moved from another abalone species or has developed on a farm.

While no definitive answer can be obtained, Thyer (2007) suggested the virus is a new one to which Victorian abalone populations had not previously been exposed. The disease is very similar to one known from Taiwan. Thyer (2007) drew the link that Taiwanese feed used by abalone aquaculture farms in Victoria could have provided the source of the disease.

3.3.3 Diseases in prawns

Day & Prince (2007) stated that 20 different viruses have been recorded in prawn aquaculture. Many have spread from one prawn species to another, with disease more severe in new species that had not yet developed immunity. There have also been translocations of diseases between countries. The white spot disease alone has caused up to $30 billion in damage internationally (ABC 2007).

Australian prawn fisheries and farms have a reputation for being disease free, but this is not strictly true. For example, the *Penaeus merguiensis* densovirus stunts the growth of farmed prawns, makes them more susceptible to other infections, and often results in death. When the disease strikes, the only option available to a prawn farmer is to drain the pond, dry it out and restock it (ANSTO 2008).

However, there are relatively few diseases in Australian wild caught and farmed prawns compared to other countries. To help prevent such diseases from being introduced into Australia, on 24 July 2007 the Commonwealth government banned the importation of prawn flesh that had not been cooked or heavily processed from countries that are not disease free. This effectively stopped importation of raw prawn flesh as there are no countries where prawns are reliably certified as being disease free (ABC 2007).

3.3.4 Diseases in the Western Australian pearl industry

The Pearl Oyster Managed Fishery is the second largest fishery in Western Australia, with an estimated value of $122 million in 2003/04. The fishery operates along the entire north coast of Western Australia from North West Cape to the Northern Territory border. In addition, pearl farms in the Northern Territory use wild caught pearl oysters from Western Australia (Hart & Murphy 2007).

It is important to note that the present section refers only to pearling and pearl farms for the silver lipped pearl oyster, *Pinctada maxima.* These are managed by DoF under the provisions of the Western Australian *Pearling Act 1990.* The definition of *P. maxima* in the act includes any hybrids of *P. maxima* produced through laboratory technology. The act is currently being rewritten. Management of other pearl oysters, such as *P. margaritifera,* is undertaken through the *Fish Resources Management Act 1994,* and many of the regulatory procedures are different.

Harvesting of wild pearl oysters occurs from Cape Leveque to Exmouth Gulf, with most collected off Eighty Mile Beach (Figure 3-1) (Wells 1998, Wells & Jernakoff 2006). Wild pearl oysters are hand collected by divers. At the end of each dive encrusting organisms are scraped off the pearl shells with a dive knife or other blade. A high pressure hose is then used to wash the shells; no chemicals are used. The pearl oysters are placed in wire frame panels and taken to a holding area where they are placed on the sea bottom for up to two months to recover before the pearl nucleus is inserted. After the nucleus is inserted the animals are returned to the holding area, again to minimise stress to the pearl oyster.

The next step is to transport the pearl oysters to the farm by boat, during which the animals are kept in holding tanks with running seawater. The water is changed in the tanks about every 10 minutes and may be coarsely filtered to remove large particles. The animals are not fed and no chemicals are used during the transportation.

At the farm the pearl oysters are kept in panels hung from surface long lines in the ocean for two years to allow the pearls to grow. The oysters are regularly cleaned by machines using high pressure water to remove as much growth as possible; calcareous encrustaceans such as barnacles are scraped off by hand.

In recent years hatchery grown spat have been increasingly used to supplement wild stock. This allows the controlled development of the industry and ensures a steady supply of stock. Several hatcheries are now in operation.

3 Introduced Bacteria, Viruses and Parasites (Marine Health)

Disease outbreak in the pearl industry in the 1970s and 1980s

During the late 1970s and early 1980s serious mortality of pearl oysters occurred during transportation to the pearl farms (Wells 1998). The mortality was caused by vibriosis due to the bacterial genus *Vibrio* that occurs widely in the marine environment. Prior to the 1980s outbreak, 10 - 20% of pearl oysters died during transport to the farms, but this rose to up to 80% during the disease outbreak. Surviving oysters were unsuitable for half pearl or mother of pearl production as the glossy surface of their nacre was deformed.

A detailed examination of the fishery determined that poor water circulation and accumulations of mollusc faeces on the bottoms of the tanks caused exponential increases in bacterial numbers during transport to the farms. The main cause of mortalities was that pearl oysters were weakened during the low temperatures of winter and became infected when they came into contact with high bacterial concentrations.

A number of changes were made to improve treatment of the animals. The various processes are now staged to allow the animals to recover from each procedure (collection, transportation, seed implantation, etc.) before the next stage is started. Water circulation during transportation has been improved considerably, and high density raft culture has been replaced with long lines using a lower stocking density.

Pearl industry zones and translocation

The development and increasing use of hatcheries potentially increases the risk of the spread of disease as pearl oysters are moved from one area to another. This is particularly important if the hatchery producing the spat is located in a different area from grow out. To manage this issue, DoF developed detailed protocols for maintaining hatchery sterility and translocating pearl oysters (DoF 1997, DoF 2001). The pearl oyster fishery is divided into four zones (Figure 3-1):

Zone 1: North West Cape (including Exmouth Gulf) to 119°30'E. There are five licensees in this zone.

Zone 2: East of Cape Thouin (118°20´ E) and south of latitude 18°14´ S. The nine licensees in this zone also have full access to Zone 3.

Zone 3: West of longitude 125°20´ E and north of latitude 18°14´ S. The two licensees in this zone also have partial access to Zone 2.

Zone 4: East of longitude 125°20' E to the Northern Territory border. Pearl farming occurs in this area, but wild stocks in this area are not economically viable and no fishing for pearl oysters occurs.

There is also a 'buffer zone' between Zones 1 and 2 which may be accessed by licensees from either zone, but in practice it is used only by licensees from Zone 1 (Hart and Murphy 2007).

3 Introduced Bacteria, Viruses and Parasites (Marine Health)

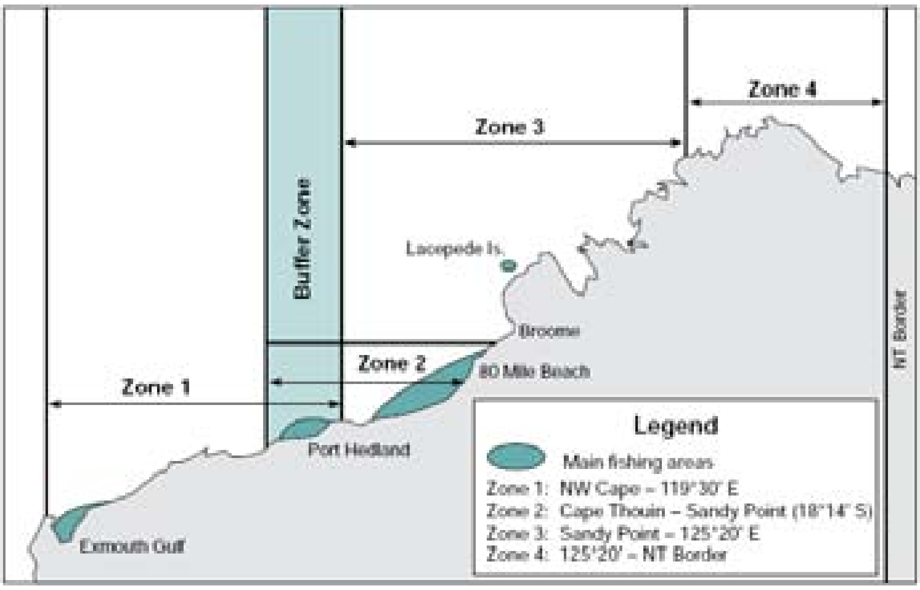

Figure 3-1 Management Zones in the Pearl Oyster Managed Fishery (after Hart and Murphy 2007)

Other diseases in pearl oysters

Several other disease incidents have been recorded in *P. maxima* (Jones & Creeper 2006). A haplosporidean virus has been detected on three occasions, each time requiring oysters on the infected farms to be destroyed. An intracellular ciliate was first found in oysters from a farm in Exmouth Gulf in 2001, and is of concern as it causes an inflammatory response in juvenile oysters. The disease *Perkinsus olseni/atlanticus* has been found in pearl oysters in Torres Strait, but has not been recorded in Western Australia. Altogether, Jones & Creeper (2006) recorded a total of nine diseases or parasites in *P. maxima*. For all marine molluscs in Western Australia, this figure was 26 different types of diseases or parasites in either aquaculture or natural environments. Jones & Creeper (2006) concluded that many more pathogenic organisms remain to be discovered in molluscs in aquaculture or in natural environments stressed by human activity. Strict controls are in effect to minimise translocation of these diseases and parasites by aquaculture.

Beginning in 2006, there has been an unexplained high mortality of pearl oysters on farms and in hatcheries on nine leases, primarily in Exmouth Gulf. The outbreak caused losses in the millions of dollars, and steps were undertaken immediately to avoid spreading the mortality to farms in other areas (ABC 2006, Hart & Murphy 2007). The cause has not been publicly announced, but it may be due to bacteria (ABC 2008).

3.3.5 Worm disease in Sydney rock oysters

Saccostrea glomerata and *Ostrea angasi* were the dominant oysters in southeastern Australia when the First Fleet arrived in 1788. Both species formed extensive shallow water reefs that were used for food by Aboriginal communities and the early settlers. These reefs have now disappeared. Ogburn et al. (2007) have recently examined the oyster loss in detail.

Both oyster species also occur in New Zealand. In the 1880s oysters shipped from New Zealand were cheaper in New South Wales ports than the same two species sourced from other parts of New South Wales. Ogburn et al. (2007) document the first arrival of oyster shipments from New Zealand as occurring in the early 1880s. When the oysters arrived in Australia, they were held in the open seawater to allow them to recover from the time out of water during transportation to Australia.

The oyster “worm disease” was first recorded in *S. glomerata* in the Hunter River, near Newcastle, in about 1882. The “disease” is caused by a parasitic spionid polychaete, *Polydora* sp. Ogburn et al. (2007) trace the arrival of the first shipments of oysters from New Zealand in various east coast ports and correlate this with the first disease outbreaks. By the end of the 1880s, there had been a catastrophic decline in the oyster fishery.

Previous hypotheses were that the oyster fisheries were destroyed by destructive practices such as oyster dredging, over harvesting or removal for use as lime. Ogburn et al. (2007) argue that the loss was in fact due to the introduction of parasitic worms from New Zealand. The loss of oyster reefs has caused substantial changes to shallow water estuarine communities that are probably irreversible.

Saccostrea glomerata, the Sydney rock oyster, is still one of the most successful aquaculture industries in Australia. However, this is because the industry is now intertidal, with the oysters being maintained at above the mean low tide level, where they are exposed for 30% or more of the time, a level of exposure that the parasitic worms cannot survive. The extensive subtidal areas of eastern Australian estuaries cannot be used for oyster production because of the worms.

3.4 Management of Bacteria, Viruses and Parasites

As with marine pests, there are a variety of methods used to combat the spread of bacteria, viruses and parasites.

3.4.1 Importation into Australia

AQIS has the authority to inspect all shipment of goods into Australia for their disease status. Cargos entering the country must be declared if they contain food, plant or animal products to protect the relatively disease free status of the country. In addition to the AQIS requirements, individual jurisdictions may have their own requirements. Often these are not apparent, as one inspector may be endorsed to administer inspections for different agencies and two sets of regulations are enforced simultaneously.

3.4.2 Importation into Western Australia

Importation of “fish” into Western Australia or their translocation within the state is regulated by the DoF. Strict protocols are in force; this includes the importation of live “fish” such as oysters for restaurants. Advance permission and permits must be sought for importing species for aquaculture, and the organisms must be independently certified as being free of diseases.

3.4.3 Consultative Committee on Exotic Animal Diseases

The Consultative Committee on Exotic Animal Diseases (CCEAD) undertakes a coordination role similar to that done by CCIMPE for marine pests. There is no requirement that CCEAD be notified of a disease outbreak, but once notified, CCEAD can provide support from other jurisdictions in managing the outbreak.

4

Marine Biosecurity Management Plan for the Wheatstone Project

4.1 Risks of Introducing Marine Pests into Western Australia via the Wheatstone Project

The risks of introducing marine pests into Western Australia via the Wheatstone Project are assessed as low because of several factors as detailed below

4.1.1 Marine biogeographic affinity with adjacent regions

Firstly, the north coast of Western Australia, including the Wheatstone Project area, is part of the vast Indo-West Pacific marine biogeographic region (Section 2.4.1). Over the millenia there has been considerable opportunity for tropical species in the Indo-West Pacific to become distributed to Australia and, if suitable conditions were encountered, to survive. These species are part of the northern Australian native biota. The Asian green mussel is an example of one of the few species in the Indo-West Pacific that is considered to be a potential marine pest in northern Australia. Another source of potential pests from tropical localities are species from other marine biogeographic regions (eastern Pacific, western Atlantic and eastern Atlantic). These species could potentially be brought directly to Western Australia on vessels that have visited these regions, or indirectly on vessels that have visited various Asian ports where these species have been distributed. The black striped mussel, which is in numerous Asian ports, is an example of such a species.

Potential marine pest species could also be brought into the Wheatstone Project region from temperate locations, but they are unlikely are to survive in the tropical waters of northern Australia.

4.1.2 Resilience of tropical areas to marine pest invasions

Secondly, the mega diverse tropical regions appear to have a natural resistance to introduced marine species becoming pests (Section 2.5.2). While the reasons for this are not fully understood, the study by Hewitt (2002) demonstrated that this is a real phenomenon, not an artefact of lack of study or poor knowledge of the taxonomy of the mega diverse tropical regions. The most likely reason is that niche sizes are smaller in areas where the biota is diverse, and there is little room for an exotic species to enter and survive the interactions with the numerous species that are already present.

4.1.3 Lack of existing marine pest introductions in the Pilbara

Iron ore shipments from the Pilbara started in the late 1960s, and the North West Shelf Joint Venture started in the early 1970s. The associated shipping movements have been continuing for four decades and have grown in more recent years as a result of the resources boom Dampier and Port Hedland annually vie for the title of largest port in Australia in terms of tonnage. McDonald (2008) analysed vessel movements in 15 Western Australian ports in calendar year 2006. There were 8,876 movements with a total of 123 million tonnes of ballast water discharged. The majority of this activity occurred in the Pilbara (ports on Table 2-1 plus Port Hedland and Cape Lambert) where there were 4,918 vessel movements and nearly 83 million tonnes of ballast water discharged. The great majority (3,418) of the 3,967 entries of international vessels into Western Australia during the year was into Pilbara ports. Three of the top five ports in terms of the risk of introducing marine pest species are in the Pilbara (Dampier, Port Hedland and Cape Lambert), but there are no known marine pests in these ports (Huisman et al. 2008; Wells et al. 2009).

4.2 Risks of Introducing Bacteria, Viruses and Parasites into Western Australia via the Wheatstone Project

As discussed in Section 3.3, there have been a number of major disease outbreaks in aquaculture industries and wild caught fisheries in Australia. Most of these are believed to have been caused by the introduction of diseases through activities of the commercial aquaculture industries, via contaminated bait or feed. There is also a potential for the introduction of diseases in unprocessed seafood products intended for human consumption. The risks from these vectors are not increased by the Wheatstone Project.

Ballast water and biofouling associated with vessel movements can pose a risk in terms of potentially introducing marine bacteria, viruses and diseases, but these risks are considered low for the reasons presented in Section 4.1.1.

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Dr Brian Jones, Western Australian Department of Fisheries, generously contributed information on the management practices for disease vectors.

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7 Limitations

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The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

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Appendix S1

Draft Dredging and Spoil Disposal Management Plan

Tables

Figures

DRAFT DSDMP COMMITMENTS REGISTER

No	Reference	Commitment	Criteria (Evidence to Collect)	Timing
Water Quality and Benthic Primary Producer Management				
1	**Section 8.1.2**	Trailing Suction Hopper Dredges (TSHD) will be fitted with a turbidity-reducing valve within the overflow pipe.	Evidence of compliance provided by dredge contractor	Prior to commencement of TSHD operations
2	**Section 8.1.2**	Diffusers will be utilised during offshore dredge material placement via the Cutter Suction Dredge (CSD) at placement sites A.	Dredge vessel records	During offshore placement with CSD activities
3	**Section 8.1.2**	Where reasonably practicable the works will be managed to reduce sediment re-suspension via propeller wash by controlling the under-keel clearance of the TSHD.	Dredge vessel records	When practicable
4	**Section 8.1.2**	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.	Visual inspection	During all sediment transport by TSHD
5	**Section 8.1.2**	Hopper door on the TSHD and barges will be maintained to reduce the potential for sediment loss during transport.	Evidence of compliance by dredge contractor	Prior to commencement of TSHD operations
6	**Section 8.1.2**	Well-maintained and properly calibrated dredging equipment will be utilised.	Dredge calibration records	Prior to commencement of dredge
7	**Section 8.1.2**	Hopper dewatering will be confined to areas away from sensitive receptors where reasonably practicable.	Dredge vessel records	Throughout TSHD operations
8	**Section 8.1.2**	A restriction of overflow should occur in designated Restricted Overflow Areas when sensitive receptors are at risk. An example is illustrated in **Figure 8-2** however the areas will vary depending on conditions and dredging operations.	Throughout TSHD works	Throughout TSHD operations, dependent on weather conditions
9	**Section 8.1.2**	Impacts to BPPH will be minimised by limiting anchor and anchor chain interference by construction vessels to established 'no anchoring areas'.	Evidence of establishment of no anchor zones	Prior to vessel arrival on site
10	**Section 8.1.2**	Discharge of decant water from the onshore dredge material placement area will be via a controlled point which will include the use of a weir box to control water height. A target discharge quality of 250 mg/l will apply. However, this may be refined based on feedback	Evidence of installation of weir box. Daily discharge	Throughout project

No	Reference	Commitment	Criteria (Evidence to Collect)	Timing
		information from monitoring programs.	monitoring results	
11	**Section 8.1.2**	Dredged material will be contained in a bunded area to prevent unconfined release of seawater and sediments.	Onshore reception area design drawings	Prior to commencement of decant water discharge
12	**Section 8.1.2**	The placement of material into onshore material placement sites will promote trapping of fines in the settled material and reduce the amounts of fines in suspension.	Onshore reception area design drawings	If onshore placement option is adopted
13	**Section 8.1.2**	Drainage of slurry water over the onshore placement area will be to the south, away from the mangrove systems therefore managing the potential impact from rising groundwater levels.	Onshore reception area design drawings	If onshore placement option is adopted
14	**Section 8.1.2**	Where practical, placement in the eastern half of the onshore placement area will be preferred to limit water levels in (and seepage from) the western half of the placement area.	Onshore reception area design drawings	If onshore placement option is adopted
15	**Section 8.1.2**	Onshore placement area bunds will be designed to withstand erosion during inundation events.	Onshore reception area design drawings	If onshore placement option is adopted
16	**Section 8.1.2**	Discharge of decant water from the onshore placement area will be pumped via pipeline to the marine outfall thereby avoiding the mangroves within the Ashburton Delta.	Onshore reception area design drawings	If onshore placement option is adopted
17	**Section 8.1.2**	Water levels within the bunded area of the onshore placement area will be managed to avoid overtopping of the bunds, particularly during extreme high rainfall events.	Onshore reception area design drawings	If onshore placement option is adopted
Water Quality and BPP (Hard Coral) Management				
18	**Section 8.1.2**	Responsive monitoring and associated tiered responsive management will be implemented to manage any potential impacts that increased turbidity may have on sensitive BPPH. ♦ Water quality, sedimentation and coral health monitoring to be carried out throughout the dredging program and following completion of dredging. ♦ Implementation of a tiered management response program associated with water quality and coral health monitoring. ♦ Monitoring of decant water discharged from the onshore dredge material placement area to be assessed against discharge criteria (<250 mg/l TSS). ♦ Groundwater monitoring in the vicinity of the onshore dredge material placement area	Water Quality and Coral Health Monitoring Reports	Throughout works

No	Reference	Commitment	Criteria (Evidence to Collect)	Timing
		to detect an alteration of groundwater conditions that may indicate a potential impact on the Ashburton Delta system.		
Benthic Primary Producer Habitat (Mangroves) Management				
19	**Section 8.1.3**	Manage construction activities to prevent, as far as practicable, a demonstrable reduction in mangrove habitat aerial extent as a result of Project attributable impacts, within the East Ashburton Delta and Hooley Creek – Four Mile Creek systems. This will ensure: • Not more than 5% long-term loss of mangrove habitat in the Hooley Creek – Four Mile Creek mangrove system. • No long-term (>5 years) net detectable loss of mangrove habitat in the Ashburton Delta mangrove system. Establish early warning indicators for the purpose of managing mangrove loss to the above commitments.	Annual mangrove monitoring reports	On a quarterly basis throughout the construction period commencing six months prior to the construction of infrastructure within intertidal areas.
20	**Section 8.1.3**	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 East Ashburton Delta and Hooley Creek – Four Mile Creek systems.	TBC	TBC
21	**Section 9.5**	Monitoring of the aerial extent of mangrove habitats within both the Hooley Creek – Four Mile Creek and East Ashburton Delta systems, 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. This will include an assessment of both seaward and shoreward mangrove habitat boundaries.	TBC	Pre- and post-dredging and in the event of an exceedance
22	**Section 9.5**	Monitor mangrove condition as an early warning of potential project attributable changes to mangrove habitat, including a quantitative assessment of one or more mangrove condition indices such as: • Mangrove species composition and density; • Groundwater salinity and water table depths; • Sediment heights and ground levels; and/or • Hydrocarbon and heavy metal concentrations in mangrove sediments.	Annual mangrove monitoring reports	TBC
Marine Fauna Management				

No	Reference	Commitment	Criteria (Evidence to Collect)	Timing
23	**Section 8.2**	Personnel trained in marine fauna observations will be present on dredge vessels, during daylight hours.	Record of training courses	Prior to works commencing
24	**Section 8.2**	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, as outlined in **Figure 8-3** of the DSDMP**.**	Mammal sighting reports	Throughout works
25	**Section 8.2**	Selected personnel will maintain a watch, during daylight hours, for humpback whales and dugongs while any dredge is en route to and from the dredge area to dredge material placement sites. If sighted, direction/speed will be adjusted to avoid potential impact (within the safety constraints of the vessel) to marine mammals.	Mammal sighting reports	Throughout works
26	**Section 8.2**	Management of cetacean interactions will be in accordance with the requirements for cetacean interactions specified under Part 8 of the EPBC Regulations 2000 (Cth), the Australian National Guidelines for Whale and Dolphin Watching.	Mammal sighting reports	Throughout works
27	**Section 8.2**	The presence of cetaceans/dugongs in or near exclusion zones established for key dredging and construction activities will be recorded.	Record of mammal sightings	Throughout works
28	**Section 8.3**	Dredge pumps will be stopped as soon as possible after completion of dredging and where reasonably practicable the draghead will remain within 4 m of the seabed until the dredge pump is stopped.	Dredge vessel reports	Throughout works
29	**Section 8.2**	When operating with less than 5 m under-keel clearance, the dredge will initially move slowly through the area before commencing dredging so that associated noise and vibration will alert marine turtles in close proximity and encourage them to leave. This will only be applied to dredging in new areas and not once the work area has been established.	Dredge vessel reports	Throughout works
30	**Section 8.2**	The Proponent will provide marine fauna aerial sighting data (as presented in the EIS/ERMP) for DEC planning purposes in the Onslow region.	TBC	TBC
31	**Section 8.2**	Boats and recreational vehicles will not be permitted within the workforce accommodation village or the access road from the Onslow Road.	TBC	Throughout works
32	**Section 8.2**	Conservation and induction programs will be established to ensure staff/contractors are informed of DEC rules relating to offshore nature reserves.	Record of inductions	Prior to staff/contractors mobilisaiton

No	Reference	Commitment	Criteria (Evidence to Collect)	Timing
Introduced Marine Pests (IMP) Management				
33	**Section 8.3.2**	All dredging and support vessels will be subjected to a risk assessment to assess whether the vessel presents a low, high or uncertain risk of acting as a vector for IMP. The risk assessment will be based on the vessel's recent history and origin, recent inspections, anti-fouling coating status and whether it will be undertaking a direct sail from its point of origin.	Vessel Risk Assessment Pre-mobilisation "Assessment Report"	Throughout works
34	**Section 8.3.2**	All dredging and support vessels determined to be uncertain or high risk will be subjected to a pre-mobilisation inspection and will not be mobilised until determined to be a low IMP risk.	Vessel Inspection Checklist Pre-mobilisation "Assessment Report"	Throughout works
35	**Section 8.3.2**	All dredges will comply with the Australian Quarantine Regulations 2000 and with the AQIS mandatory ballast water requirements.	Dredge Vessel Ballast Water Logbook	Throughout works
36	**Section 8.3.2**	In the event that IMP are identified on the dredging or support vessels during the arrival inspection or at any time while the construction vessel is on site: ♦ The Department of Fisheries (DoF) and Department of Environment and Conservation (DEC) will be notified. ♦ The dredging or support vessel will be moved offshore as soon as practicably possible. Within vessel operating constraints, the construction vessel should be moved to offshore waters, greater than 12 nm from shore or to a water depth greater than 50 m. ♦ The dredging or support vessel will not be permitted to return to site until it has undergone treatment and re-inspection to confirm that the vessel is a low risk. The mobilisation procedure described above will be required to be followed including the mandatory arrival inspection with 48 hours of arrival on site. ♦ A detailed response plan including monitoring and control measures will be developed and implemented. This plan will aim to determine if the identified species has become established and if measures to control the species are required.	IMP incident report. Detailed response plan developed	In the event of identification of invasive marine pests on construction vessels
Potential Acid Sulphate Soils (PASS) Management				
37	**Section 8.4.2**	The majority of dredged material containing PASS will be placed at a nearshore dredge material placement area to maintain saturation and avoid oxidation. PASS material will be dredged using the CSD and pumped directly to the nearshore placement site to achieve	Dredge vessel reports	Throughout works

No	Reference	Commitment	Criteria (Evidence to Collect)	Timing
		this objective.		
38	**Section 8.4.2**	A PASS monitoring program will be implemented for the onshore placement of dredged material, where reasonably practicable, and will include: ♦ Monitoring of pH of the placement area discharge waters. ♦ Monitoring of the material within the placement area to assess whether actual acid sulphate soil (ASS) conditions have developed.	PASS Monitoring Reports	If onshore placement of dredge material is adopted
39	**Section 8.4.2**	Where the Department of Environment and Conservation (2009) action criteria for ASS are reached or exceeded, management of disturbed PASS will occur utilising best management practice methods (e.g. targeted lime dosing) as outlined in the Construction Environmental Management Plan (CEMP). ♦ Monitoring pH in the receiving environment will occur in the event that pH criteria within the onshore dredge material management are exceeded.	PASS Monitoring Reports	In the event of an exceedance of ASS criteria.
Dredge Material Placement Area Management				
40	**Section 8.5.2**	The placement of dredge material will comply with the requirements of Sea Dumping Permit (SDP), including: ♦ Establish by Differential Global Positioning System (DGPS) that, immediately prior to disposal, the vessel is within the approved dredge material placement area. ♦ Any dredge used in connection with the dredge material placement activities and any associated towing vessels must comply with the relevant state, national or international standards with respect to seaworthiness, safety and environmental requirements, or any rules or conditions laid down by the certifying classification society, and be capable of disposing dredged material at the dredge material placement sites in accordance with the SDP. ♦ Marine mammal management procedures as detailed in **Section 8.2** will be followed during dredge material placement activities. ♦ Records comprising either weekly plotting sheets or a certified extract of the ship's log will be retained (for verification and auditing purpose), which detail: o the times and dates of when each disposal run is commenced and finished o the position (as determined by DGPS) of the vessel at the beginning and end of each disposal run, with the inclusion of the path of each disposal run; and	Dredge Logs, dredge vessel reports	Throughout works

No	Reference	Commitment	Criteria (Evidence to Collect)	Timing
		o the volume of dredge material (in cubic metres) dumped and quantity (in dry tonnes) for the specified operational period and compare these quantities with the total amount permitted under the SDP.		
41	**Section 8.5.2**	A bathymetric survey of the dredge material placement areas will be undertaken: ♦ Prior to the commencement of dredging. ♦ Within two months of the completion of all dredge material placement activities authorised under the SDP.	Sea dumping compliance reports	Pre-dredging and two months post-dredging
Waste Management				
42	**Section 8.6.2**	Adherence to the requirements of the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (Cth)* and MARPOL 73/78 Convention Annex IV (Sewage) and Annex V (Garbage).	Regular audits	Throughout works
Hazardous Waste and Oil Management				
43	**Section 8.7.2**	Hazardous material storage areas will be designed to handle the volumes and operating conditions specifically required for each substance, including product identification, transportation, storage, control and loss prevention (e.g. bunding and drainage).	Regular audits	Throughout works
44	**Section 8.7.2**	Industry standards, port authority and pollution prevention regulations will be adhered to during refuelling, transfer, storage and handling of hazardous materials (e.g. bunding, level gauges, overflow protection, drainage systems and hardstands).	Regular audits	Throughout works
45	**Section 8.7.2**	Hazardous materials (including hazardous waste) will be stored in appropriately labelled drums or tanks. Complete up to date list of material safety data sheets (MSDS) will be available and stored with relevant products.	Regular audits	Throughout works
46	**Section 8.7.2**	The hydraulic oil system will be high quality, well-maintained and regularly inspected.	Regular audits	Throughout works

No	Reference	Commitment	Criteria (Evidence to Collect)	Timing
47	**Section 8.7.2**	The main hydraulic system on each dredging vessel will be equipped with standard low pressure alarms and shut down systems to limit hydrocarbon loss in the event of a burst hydraulic hose.	Regular audits	Throughout works
48	**Section 8.7.2**	Detailed refuelling procedures will be developed by the dredge contractor prior to commencement of work on site and will include the following requirements: ♦ Fuel transfer to occur in accordance with port authority and pollution regulations. ♦ Specific safety boundaries used when refuelling. ♦ Requirement of refuelling to be undertaken in fair weather conditions to reduce risk of spills. ♦ Requirement for open communication channels to be maintained during refuelling. ♦ Instructions for visual monitoring. ♦ Emergency response procedures.	Refuelling procedures developed by contractor	Prior to commencement of works
49	**Section 8.7.2**	Personnel involved with refuelling or fuel transfer will be trained in their roles, functions and responsibility, including emergency response, prior to engaging in refuelling or fuel transfer.	Induction records	Prior to commencement of works
50	**Section 8.7.2**	All vessels greater than 400 gross tonnage will have bilge oil/water separators that comply with the requirements of Annex I of MARPOL 73/78 and Part II of the Protection of the Sea (Prevention of Pollution from Ships) Act 1993 (Cth) so that that oil concentrations in discharges are less than 15 ppm.	Regular audits	Throughout works
51	**Section 8.7.2**	Drainage from decks and work areas with potential for oil, grease or hydrocarbon contamination will be collected and processed through an oil/water separator and managed according to International Oil Pollution Prevention (IOPP) procedures prior to discharge or stored for onshore placement.	Regular audits	Throughout works
52	**Section 8.7.2**	Sufficient and appropriate equipment, materials and resources will be available to: ♦ Prevent spills to marine environment from working machinery (e.g. spill trays, one-way valves or other spill prevention features). ♦ Respond to spills to the marine environment.	Regular audits	Throughout works

No	Reference	Commitment	Criteria (Evidence to Collect)	Timing
		Respond to spills to ground (on board vessels).		
53	**Section 8.7.2**	The dredge contractor will comply with and align spill response preparedness with the Oil Spill Contingency Plan (OSCP).	Regular audits	Throughout works
54	**Section 8.7.2**	All relevant personnel will be trained in spill response and reporting.	Induction records	Prior to commencement of works
55	**Section 8.7.2**	All vessels will have a current IOPP Certificate issued by the state in which the vessel is registered and an approved Shipboard Oil Pollution Emergency Plan (SOPEP).	Regular audits	Throughout works
56	**Section 8.7.2**	If vessel does not have an existing approved SOPEP, the vessel will prepare a vessel specific Spill Contingency Plan (SCP) that bridges to the Chevron OSCP to enable an effective, integrated response to any spill.	Spill contingency plan developed	Prior to commencement of works
57	**Section 8.7.2**	Onboard spills will be contained and cleaned up immediately and will not be washed overboard. Product MSDSs will be adhered to during clean-up.	Regular audits	Throughout works

ACRONYMS AND ABBREVIATIONS

ABU	Australasian Business Unit
ADCP	Acoustic Doppler Current Profiler
ALARP	As Low as Reasonably Practicable
ANZECC	Australian and New Zealand Environment Conservation Council
APPEA	Australian Petroleum Production and Exploration Association
AQIS	Australian Quarantine and Inspection Service
BPP	Benthic Primary Producers
BPPH	Benthic Primary Producer Habitat
CAMBA	China-Australia Migratory Bird Agreement
CCIMPE	Coordinating Committee for Introduced Marine Pest Emergencies
CSD	Cutter Suction Dredge
Chevron ABU	Chevron Australasia Business Unit
Cth	Commonwealth
DBNGP	Dampier Bunbury Natural Gas Pipeline
DEC	Department of Environment and Conservation (state)
DEWHA	Department for the Environment, Water, Heritage and the Arts (Commonwealth)
DoE	Department of Environment (state), now the DEC
DoF	Department of Fisheries (state)
DPI	Department for Planning and Infrastructure (State)
DSDMP	Dredging and Spoil Disposal Management Plan
EA	Environment Australia (now DEWHA)
ECU	Ecological Unit
EIS/ERMP	Environmental Impact Statement/Environmental Review and Management Programme
EMP	Environmental Management Plan
EPA	Environmental Protection Authority (state)
EPBC Act (Cth)	*Environmental Protection and Biodiversity Conservation Act 1999*
EQO	Environmental Quality Objective
EQC	Environmental Quality Criteria
FCC	Fouling Control Coat
IMO	International Maritime Organisation
IMP	Introduced Marine Pests
IOPP	International Oil Pollution Prevention
JAMBA	Japanese-Australia Migratory Bird Agreement
KPI	Key Performance Indicators
LAT	Lowest Astronomical Tide
LEP	Level of Environmental Protection
LNG	Liquefied Natural Gas
MCMP	Marine and Coastal Management Plan
MEB	Marine Ecosystem Branch
Mm^3	Million cubic metres
MODIS	Moderate Resolution Imaging Spectoradiometer
MOF	Materials Offloading Facility

Mtpa	Million tonnes per annum
NADG	National Assessment Guidelines for Dredging
NIMPCG	National Introduced Marine Pests Coordination Group
NTU	Nephelometric Turbidity Units
OBC	Outcome Based Conditions
OE	Operational Excellence
OEMS	Operational Excellence Management System
OSCP	Oil Spill Contingency Plan
PLF	Product Loading Facility
PWQMG	Pilbara Water Quality Management Guidelines
SDP	Sea Dumping Permit
SMFG	Size Management Fish Grands
SSC	Suspended Sediment Concentration
SWQMG	State Water Quality Management Guidelines
TSHD	Trailing Suction Hopper Dredge
TSS	Total Suspended Solids
WA	Western Australia

1.0 INTRODUCTION

1.1 Wheatstone LNG Project

Chevron Australia Pty Limited (Chevron Australia) proposes to construct and operate a multi-train Liquefied Natural Gas (LNG) and domestic gas (Domgas) plant near Onslow on the Pilbara Coast, Western Australia. The Wheatstone Project will process gas from various fields located offshore in the West Carnarvon Basin. Ashburton North is the proposed site for the LNG and Domgas plants. The Project will require the installation of gas gathering, export and processing facilities in Commonwealth and State waters and on land. The Wheatstone Project will produce gas from petroleum titles WA-253-P, WA-17-R, WA-356-P and WA-16-R, located 145 km offshore from the mainland, approximately 100 km north of Barrow Island and 225 km north of Onslow. **Figure 1-1** shows the location of the Wheatstone Project.

The Ashburton North site is located approximately 12 km south-west of Onslow along the Pilbara coast within the Shire of Ashburton. The initial Project is expected to consist of two LNG processing trains, each with a capacity of between 4 and 7 million tonnes per annum (Mtpa). Environmental approval is being sought for a 25 Mtpa plant to allow for the expected further expansions. The Domgas plant will be a separate but co-located facility and will form part of the Wheatstone Project. The development of the Domgas plant also includes onshore pipeline installation to tie-in to the existing Dampier-to-Bunbury Natural Gas Pipeline (DBNGP) infrastructure. **Figure 1-2** shows a conceptual design of the downstream infrastructure associated with the Wheatstone Project at Ashburton North.

1.2 Proponent

Chevron Australia is the sole operator and proponent of the Wheatstone Project.

1.3 Aim of Plan

The aim of this Draft Dredging and Spoil Disposal Management Plan (DSDMP) is to manage potential environmental impacts associated with the capital dredging and dredge material placement management activities in a manner that achieves the environmental objectives as detailed within the Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP). Outcomes Based Environmental Conditions developed for the project will be included within the Draft DSDMP following review of the EIS/ERMP by the Environmental Protection Agency (EPA) and the Department of Environment, Water, Heritage and Arts (DEWHA).

As required by Condition XX <Hold> of the proposed environmental conditions, the DSDMP will:

1) provide a management structure to achieve the environmental objectives outlined within the Outcome Based Conditions (OBC) relating to dredging and dredge material management
2) provide monitoring programs suitable to show compliance with the environmental objectives outlined within this statement relating to dredging and dredge material management

This Draft DSDMP has been prepared for inclusion into the Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP) for the Wheatstone Project.

The finalised DSDMP will address the requirements of applicable State Ministerial Conditions, Commonwealth Approvals Decision and the Commonwealth Sea Dumping Permit (SDP).

NOTE: This draft document is considered incomplete, pending input from various parties. Various "Hold" points are identified throughout the document where data gaps or other inputs are required.

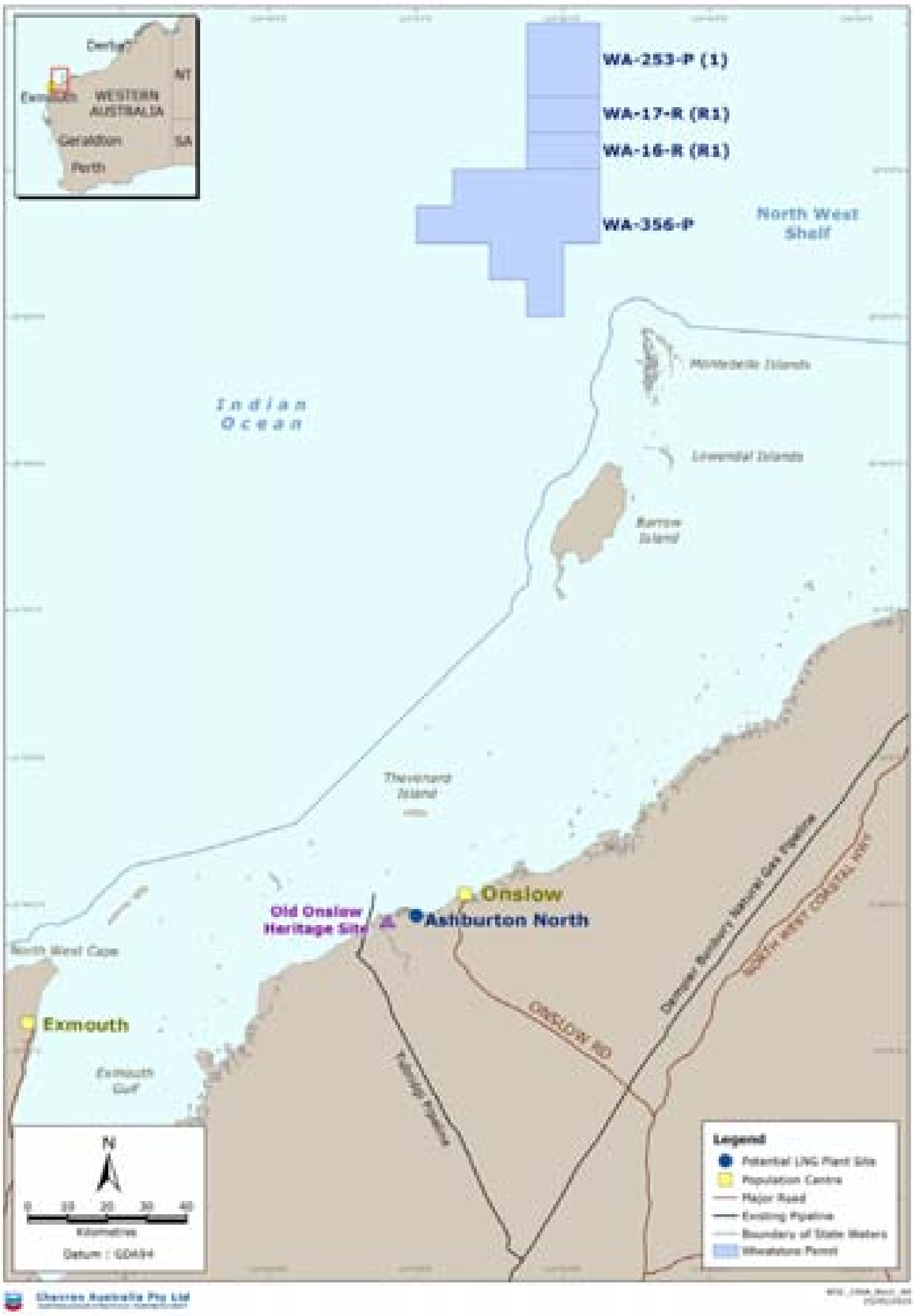

Figure 1-1: Location of Wheatstone Project

Figure 1-2: Illustrative Representation of Downstream Infrastructure

1.4 Scope

This Draft DSDMP covers the proposed environmental management and monitoring of the capital dredging and dredge material management activities associated with the Wheatstone Project which include:

- 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.

Potential environmental impacts, management and monitoring associated with the nearshore trunkline installation and pipeline dredging are not addressed within this DSDMP.

1.5 Legislative Requirements

The applicable Commonwealth and State legislation pertinent to the activities described with this plan includes, but is not limited to, the following Acts and Regulations (and relevant amendments):

State

- *Wildlife Conservation Act 1950 (WA)*
- *Environmental Protection Act 1986 (WA)*
- Environmental Protection Regulations 1987
- *Pollution of Waters by Oil and Noxious Substances Act 1987 (WA)*
- Pollution of Waters by Oil and Noxious Substances Regulations 1993 (WA)
- *Conservation and Land Management Act 1994 (WA)*
- *Fish Resources Management Act 1994*
- *Marine and Harbours Act 1981*
- *Petroleum (Submerged Lands) Act 1982*
- Wildlife Conservation Regulations 1970
- *Shipping and Pilotage Act 1967.*

Commonwealth

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- *Environment Protection (Sea Dumping) Act 1981*
- Environment Protection (Sea Dumping) Regulations 1983
- Australian Ballast Water Management Requirements 2001
- Australian Quarantine Regulations 2000

- *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*
- *Marine Act 1982*
- Navigable Waters Regulations 1958
- Port and Harbour Regulations 1966.

1.6 Chevron ABU Policy 530

The Chevron Australasia Business Unit (ABU) has stated its commitment to achieving operational excellence in ABU Policy 530 (**Figure 1-3**). The Chevron ABU strives to achieve Operational Excellence (OE) through the implementation of the ABU Operational Excellence Management System (OEMS).

Chevron Australia is committed to implementing the Wheatstone Project in accordance with ABU Policy 530.

1.7 APPEA Code of Environmental Practice

The Australian Petroleum Production and Exploration Association (APPEA) Code of Environmental Practice (Australian Petroleum Production and Exploration Association 2008) is the most relevant Code of Practice for production operations in Australia. Specific requirements of the APPEA Code of Environmental Practice that are relevant to dredging and dredge material placement include:

- Compliance with applicable laws, regulations, standards and guidelines and, in their absence, adopting the best practicable means to prevent or minimise adverse environmental impacts.
- Providing adequate training to enable employees and contractors to adopt environmentally responsible work practices.
- Developing emergency plans and procedures so that incidents can be responded to in a timely and effective manner.
- Developing and maintaining management systems to identify, control and monitor risks.
- Identifying elements of the environment with natural, cultural, scientific or other significance which require avoidance (e.g. shipwrecks, reefs) or special protection procedures.
- Identifying and addressing special impacts from construction and installation techniques.
- Minimising air emissions and water discharges.
- Managing all waste materials generated and chemicals utilised in the construction and commissioning phase in accordance with site waste and chemical management plans and relevant regulations.

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		Revision:	0
		Revision Date:	28/05/2010

ABU

Policy 530 - Operational Excellence
Achieving World-Class Performance

Chevron
Human Energy

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

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

Leadership is the largest single factor for success in OE. Leaders are accountable not only for achieving results, but achieving them in the right way by behaving in accordance with our values. Leaders direct the Management System Process to drive improvement in OE results. The Management System Process consists of five steps:

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

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

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

Roy Krzywosinski, Managing Director
25/02/2008

Figure 1-3: Chevron ABU Policy 530

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1.8 International Conventions

International agreements applicable to this Draft DSDMP include, but are not limited to:

- The 1996 London Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (ratified by Australia in 2000)
- The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the protocol of 1978 (MARPOL 73/78) (International Maritime Organization 1973)
- The Convention on the Conservation of Migratory Species of Wild Animals (Secretariat of the Convention for the Conservation of Migratory Species of Wild Animals 1979)
- Japan-Australia Migratory Bird Agreement (JAMBA)
- China-Australia Migratory Bird Agreement (CAMBA)
- The International Convention for the Control and Management of Ship's Ballast Water and Sediments (note: subject to ratification by the International Maritime Organisation - IMO).

1.9 Relevant Standards

A number of Australian Standards are relevant to various aspects of this Draft DSDMP. These include, but are not limited to:

- Australian Standard/New Zealand Standard (AS/NZS) ISO 14001:2004 Environmental Management Systems – Requirements with Guidance for Use (Standards Australia/Standards New Zealand 2004): specifies the requirements for an environmental management system to enable the development and implementation of a policy and objectives which takes into account legal requirements and includes information about significant environmental aspects
- AS/NZS 4360:2004 Risk Management (Standards Australia/Standards New Zealand 2004a): provides a generic guide for managing risk and specifies the elements of risk management systems
- HB 203:2006. Environmental Risk Management – Principles and Process (Standards Australia/Standards New Zealand 2006): is based on the generic risk management process developed in AS/NZS 4360:2004, but explains the principles and process of environmental risk management, and provides guidance on implementation
- AS 1940:2004 The Storage and Handling of Flammable and Combustible Liquids (Standards Australia 2004).

1.10 Regulatory Guidance

A number of government strategy and guideline documents have been developed to provide advice to proponents in the development of environmental management and monitoring programs. In the development of the Draft DSDMP the following documents, both Commonwealth and State, have been considered:

Commonwealth

- National Assessment Guidelines for Dredging (Commonwealth Government of Australia 2009)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council (ANZECC) and

Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000)

- National Strategy for Ecologically Sustainable Development (Commonwealth Government of Australia 1992)
- National Water Quality Management Strategy (Commonwealth Government of Australia 1992a)
- Intergovernmental Agreement on the Environment (Commonwealth Government of Australia 1992b)
- National Strategy for Conservation of Australia's Biological Diversity (Commonwealth Government of Australia 1996)
- Intergovernmental Agreement on a National System for the Prevention and Management of Marine Pest Incursions, April 2005.

Western Australia

- The Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006)
- State Water Quality Management Strategy (Document No. 6) (Government of Western Australia 2004)
- WA EPA Environmental Assessment Guidelines No. 3 – Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment (Environmental Protection Authority 2009)
- WA EPA Guidance Statement No. 1 – Protection of Tropical Arid Zone Mangroves Along the Pilbara Coastline (Environmental Protection Authority 2001).
- WA EPA Environmental Assessment Guidelines No. 4 – Towards Outcome-based Conditions, Draft, December 2009 (Environmental Protection Authority 2009a).

1.11 Existing Management Frameworks

The Pilbara Coastal Water Quality Consultation Outcomes – Environmental Values and Environmental Quality Objectives (DoE 2006) provides various environmental values and Environmental Quality Objectives (EQOs) as a guideline for management of water quality in the Pilbara.

The guidelines recommend a set of environmental values and spatially-allocated EQOs and Levels of Ecological Protection (LEP) for the Pilbara coastal waters (DoE 2006). The LEPs are defined from low to maximum, where areas defined as 'low' have high levels of contaminants and are largely changed from natural variation, while areas defined as 'maximum' are pristine with no contaminants above background levels.

The Wheatstone Project EIS/ERMP details the key water quality values and sensitivities in the Ashburton North area. These environmental values include ecosystem health, recreational and aesthetic values, commercial and recreational fishing and aquaculture activities, cultural and spiritual values and industrial water supply.

Table 1-1 outlines the environmental values, the EQOs and the Environmental Quality Criteria (EQC) for the Ashburton North areas and the management strategies and performance monitoring that will be applied to meet these objectives.

Table 1-1: Pilbara Water Quality Objectives and Management Response

Environmental Values	Context	Environmental Quality Objectives	Environmental Criteria	Management Strategies
Ecosystem Health (ecological value)	Majority of the marine area adjacent to Onslow has a high LEP. Potential dredge material placement areas, 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. 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 (Department of Environment and Conservation 2008).	Maintain Ecosystem Integrity.	Impacts on water and sediment quality are restricted to ANZECC guidelines.	♦ **Section 8.1.2** – Benthic Primary Producer Habitat (Hard Coral) Management ♦ **Section 8.1.3** – Benthic Primary Producer Habitat (Mangroves) Management ♦ **Section 8.2** – Marine Fauna Management ♦ **Section 8.3**– Invasive Marine Species Management ♦ **Section 8.5** – Dredge Material Placement Area Management ♦ **Section 8.6** – Waste Management ♦ **Section 8.7** – Hydrocarbon Management
Recreation and Aesthetics (social value)	Recreational boating occurs from the Onslow Maritime Facility in Beadon Creek. Onshore and offshore fishing including residential facilities on the Mackerel Islands. Diving and snorkelling around reefs and islands.	Water quality is safe for activities on and in the water (e.g. swimming and boating). Aesthetic values of the marine environment are protected.	<Hold> to be included in future revision	♦ **Section 8.1.2** – Benthic Primary Producer Habitat (Hard Coral) Management ♦ **Section 8.6** – Waste Management ♦ **Section 8.7** – Hydrocarbon Management
Cultural and Spiritual	<Hold> to be included in future revision	Cultural and spiritual values of the marine environment are protected.	<Hold> to be included in future revision	<Hold> to be included in future revision
Fishing and Aquaculture (social value)	Onslow Prawn Managed Fishery. Pilbara Fish Trawl (Interim) Managed Fishery.	Fish and seafood (caught or grown) is of a quality safe for	Relevant criteria from Food Standards Australian New Zealand code.	♦ **Section 8.3** – Invasive Marine Species Management ♦ **Section 8.6** – Waste

		eating. Water quality is suitable for aquaculture purposes.	Relevant ANZECC guidelines for LEP.	Management ♦ **Section 8.7** – Hydrocarbon Management
Industrial Water Supply	<Hold> to be included in future revision	Water quality is suitable for industrial supply purposes.	<Hold> to be included in future revision	♦

1.12 Wheatstone Project Approvals

The Wheatstone Project was referred to the Western Australia Environmental Protection Authority (EPA) under the *Environmental Protection Act 1986* (EP Act) in October 2008. The EPA set the level of assessment as an ERMP. The proposal was also referred to the Department for the Environment, Water, Heritage and the Arts (DEWHA) under the Commonwealth *Environment Protection Biodiversity and Conservation Act 1999* (EPBC Act). It was determined by DEWHA that the proposal is a controlled action and the level of assessment was set as an EIS.

The Wheatstone EIS/ERMP will be assessed through a parallel process and will be prepared to meet both the WA EPA Guidelines for Preparing a Public Environmental Review/Environmental Review and Management Programme (2009) and the DEWHA Guidelines for the content of a Draft Environmental Impact Statement.

The Project also involves sea disposal of dredge material within Commonwealth and State waters and will consequently require a Sea Dumping Permit (SDP) under the *Environmental Protection (Sea Dumping) Act 1981.* The aspects related to the SDP for dredge material management will be assessed as part of the EIS/ERMP under the *EPBC Act (Cth)*, as agreed with DEWHA.

1.13 Requirements

This Draft DSDMP has been developed to meet the anticipated State and Commonwealth Ministerial Conditions and to be in accordance with Chevron Australia environmental procedures. The Draft DSDMP details the procedures for dredging and dredge material management in order to minimise the environmental risks associated with the project to 'as low as reasonably practicable' (ALARP).

The finalised DSDMP will include the ministerial conditions that pertain to the dredging operations and a cross reference to the section of the DSDMP where the requirement is addressed.

1.14 Stakeholder Consultation

Summary of stakeholder consultation process, key concerns and how they are being addressed to be included in future revision

1.15 DSDMP Approval, Review and Distribution

This Draft DSDMP has been prepared as an appendix to the Wheatstone EIS/ERMP (**Figure 1-4**) in order to outline the management and mitigation measures proposed for management of the environmental risks associated with the dredging and dredge material management activities. The management measures to be implemented for some elements of risk (such as accidental spills of hazardous chemicals or hydrocarbons) are presented in detail as standard approaches that will be followed in accordance with the regulatory framework. However, management measures for other components of environmental risk (e.g. the risk of mortality to corals from elevation in suspended sediment in the water column) are conceptual with more detail required once State and Commonwealth Ministerial Conditions have been set.

On completion of the environmental approvals process, this Draft DSDMP will be finalised. The final DSDMP will address the requirements of the State Ministerial

Conditions, Commonwealth approvals decisions and the SDP. The final plan will be made publically available in an approved manner.

In the event that there is a significant change in the methods of the dredging works after this plan has been finalised, the plan will be reviewed. The review will include a reassessment of the environmental risks presented by the works and the corresponding management strategies being implemented. Where considered necessary, this plan will be updated to reflect the re-assessment.

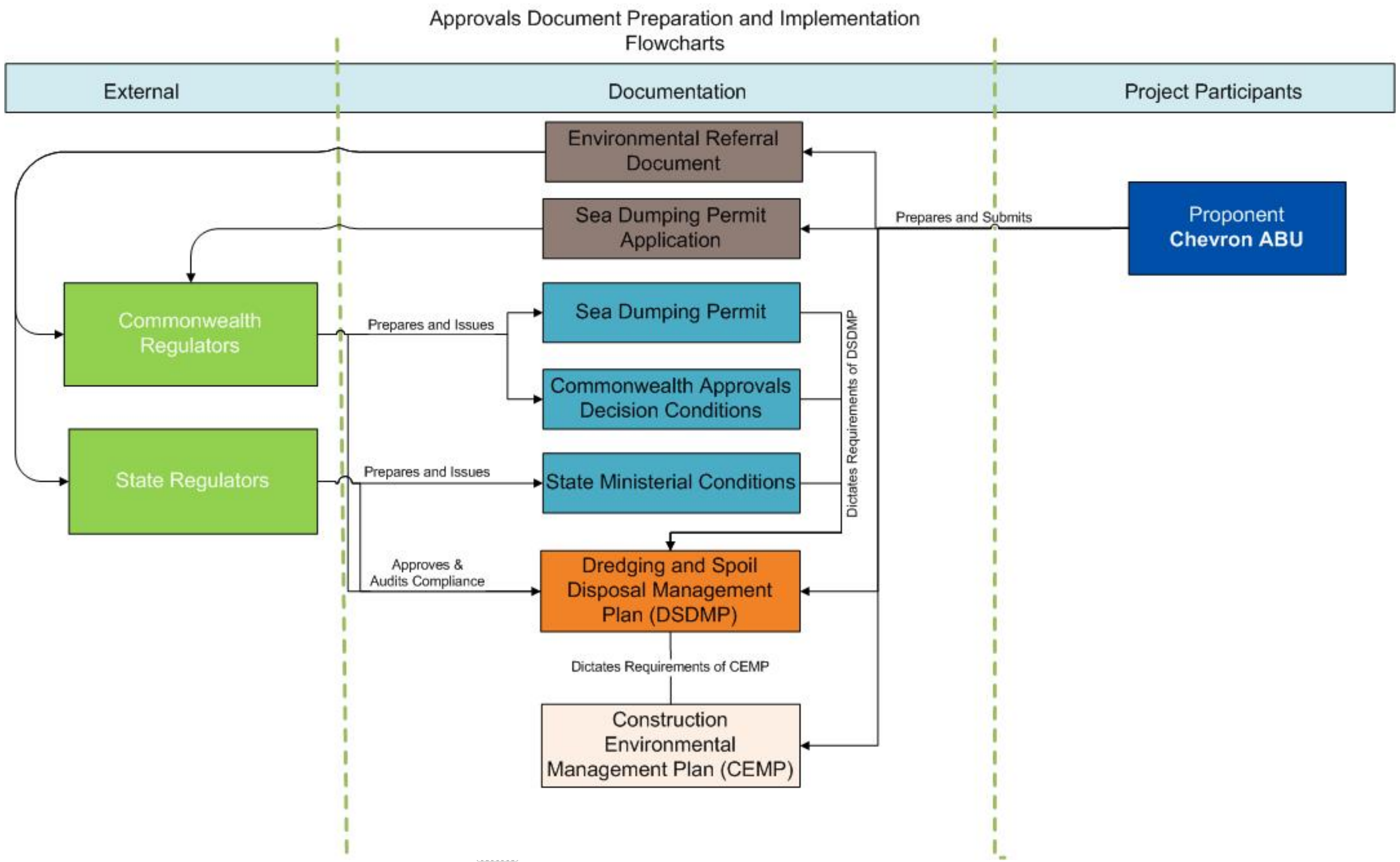

Figure 1-4: Approvals Document Preparation and Implementation Flowchart

2.0 PLAN STRUCTURE

This Draft DSDMP aims to provide an outcomes based management approach for the environmental management of the dredging, dredge material management and potential onshore placement.

The Plan is structured as follows:

- **Section 3** of this plan details the methods and results of the Environmental Risk Assessment (ERA) that has been undertaken.
- **Section 4** of this plan provides an overview of the works that this plan is applicable to.
- **Section 5** details the environmental management structure that will be implemented.
- **Section 6** provides a high-level overview of the existing environment and the key studies that have been completed.
- **Section 7** details the results of the sediment plume modelling and the development of the relevant impact zones that will be applied.
- **Section 8** details the management strategies that will form the monitoring programme. The management strategies provide the outcomes and performance objectives/indicators against which environmental performance will be measured. The structure of each individual management strategy is shown in **Table 2-1.**
- **Section 9** presents the options for monitoring and inspection under consideration.
- **Section 10** details the reporting requirements for the project under consideration.

Table 2-1: Structure of Management Strategies

Management Area:	**Specific area to be managed (e.g. BPPH)**
Performance Objective:	The applicable performance objectives against which environmental performance will be measured.
Management:	The proposed management strategies including trigger levels and responses and contingency measures.
Monitoring:	The applicable proposed monitoring programs.
Reporting:	The required reporting including frequency and recipient.
Risk Assessment:	The residual risk ranking (i.e. end risk, taking into consideration management and monitoring measures).

3.0 ENVIRONMENTAL RISK ASSESSMENT AND PERFORMANCE MEASUREMENTS

3.1 Overview

A series of environmental risk assessments have been completed to identify the most significant risks that will represent the focus of environmental management and monitoring. These risk assessments have addressed each aspect of the Wheatstone Project including the dredging and dredge material management activities. The risk assessments have been undertaken in two phases:

- Phase 1 – An environmental risk assessment was conducted during the scoping phase of the Wheatstone Project to identify key areas of environmental risk requiring detailed assessment.
- Phase 2 – A detailed environmental risk assessment was conducted during the preparation of the EIS/ERMP and this Draft DSDMP. This assessment assisted in reviewing the environmental acceptability of the Wheatstone Project, identifying key areas of risk and developing potential monitoring and management strategies.

3.2 Risk Assessment Method

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

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

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

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

3.3 Risk Assessment Outcomes

Note that the information presented below does not reflect the consolidated risk tables presented in Chapter 8 of the Draft EIS/ERMP. Reviewer is referred to Chapter 8 of Draft EIS/ERMP. The final risk tables presented in Chapter 8

The results of the environmental risk assessment of the dredging and dredge material placement management activities are provided in **Chapter 8** of the EIS/ERMP. Environmental risks that have been assessed as posing either a medium or high residual risk include:

Benthic Primary Producer Habitat

- Direct loss of subtidal benthic primary producer habitat (BPPH) through removal within footprint and loss of structural function of BPPH at the dredge material placement sites.
- Indirect impact on benthic primary producers (BPP) and habitats due to increased turbidity, sedimentation and light attenuation leading to loss of habitat in excess of acceptable levels as defined in EPA Guidelines associated with construction (capital) dredging channel and berthing area.

Marine Water Quality and Sediments

- Increased turbidity and light attenuation exceeds agreed water quality targets associated with construction (capital) dredging of the channel, pipeline and berthing area.

3.4 Performance Measurements

The environmental risk assessment detailed in Chapter 8 of the EIS/ERMP has been used to develop a series of environmental objectives and associated performance criteria for the dredging and disposal management works. These environmental objectives, performance criteria, management commitments, evidence of compliance measures and timing requirements are provided within **Section 8.0**.

3.4.1 Outcome Based Conditions

The EPA's support for the use of Outcome Based Conditions (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 where it is difficult to predict the environmental outcome.

OBCs are defined in these Guidelines as those conditions that are recommended in an EPA Report or set in a Ministerial 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.

4.0 WORKS OVERVIEW

4.1 Introduction

Dredging and dredge material management will be required for the construction of the:

- temporary access channel to support construction activities;
- Material Offloading Facility (MOF) and MOF approach channel;
- product loading facility (PLF) including turning basins and berth pockets; and
- approach channel.

Clean-up dredging of fine material that settles in the dredging area during the dredging program will also be required. Up to 45 Mm^3 of dredge material may be generated during the dredge works for the key marine infrastructure. This volume does not include dredging volumes that may be generated from the installation of the trunkline.

Dredge material will be disposed of at the proposed nearshore and offshore dredge material placement sites with an option to place up to 10 Mm^3 of dredge material at the proposed onshore dredge material placement area.

Figure 4-1 and **Figure 4-2** show the proposed dredging area, dredge material placement sites and MOF. The dredging and dredge material management works are expected to be undertaken over a four-year period commencing mid 2011.

4.2 Dredged Material Management

4.2.1 Nearshore Dredge Material Placement Sites

Three nearshore dredge material placement sites have been identified for the placement of dredged material and are shown in **Figure 4-3**. Within each of these sites, the target placement areas will be the naturally deeper waters within each site.

Proposed Dredge Material Placement Site A has a capacity of approximately 1.5 Mm^3 and will be used early in the works program. Material will be placed here using CSD and a near bed diffuser.

Dredge Material Placement Site B has a capacity of approximately 2–3 Mm^3. Site B may be used as a barge dumping location for any rock that is removed from the channel by a backhoe excavator.

Placement Site C is the primary placement site for coarse material and has a capacity of up to 40 Mm^3. Material will be placed at the site by the TSHD via bottom opening doors. If necessary, bed levelling (e.g. via the use of an underwater plough) may be undertaken to minimise the localised raising of sea bed levels.

4.2.2 Offshore Dredge Material Disposal Sites

In addition to the three identified inshore material disposal sites, two offshore disposal sites (Site D and E), located in approximately 40 m water depth to the west of Thevenard Island, will be used for placing the finer muddy material from clean-up operations (**Figure 4-3**). Each of these offshore sites is anticipated to have a capacity of up to 40 Mm^3.

4.2.3 Onshore Dredge Material Placement Area (Optional)

The Project considers two placement options for material dredged by CSD. The preferred option includes offshore placement with the CSD loading barges. The onshore placement of material dredged by CSD would involve dredged material being transported hydraulically and discharged through a pipeline into a purpose-built placement area located within the plant pad footprint. Approximately 10 Mm^3 could be placed in the Onshore Dredge Material Area (**Figure 4-4**).

Typically, the dredging operations will produce seawater slurry with a solids to water ratio of about 1:5. The placement area will be bunded around the perimeter, using the dunes as part of the western bund. 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 bunded sump area will be created with weirs controlling the water flow from either of the two placement areas.

It is proposed that dredged material be initially placed into the eastern part of the placement site, filling from the north. The coarse material will settle out first, the finer fractions being transported over greater distances, and waters flowing to the south are expected to have reduced suspended sediment concentrations. Over time the coarse material will trap fines within the placement site. The decant water will be pumped to the marine outfall from a sump at the south of the placement area. As the amount of material placed into the area increases, the spread of settled fines will approach the southern limit of the site. During the onshore placement operations (approximately 6–12 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 swap to the western part of the placement area and the filling process be repeated.

Decant water and rainfall on to the area will be pumped offshore from the southern sump and discharged by pipeline to the marine outfall. This pumped discharge will occur for approximately 18–24 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 and groundwater into the south-west catchment.

The Dredge Material Placement Area design has been based on the following considerations:

- 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 placement of material into the sites will promote trapping of fines in the settled material and reduce the amount of fines in suspension.
- Drainage of decant water over the placement area will be to the south, away from the mangrove systems, therefore managing the potential impact from rising groundwater levels.
- Seepage will concentrate on the southern perimeter bund.
- The placement approach will potentially reduce water levels in the placement areas and seepage.
- 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 will be pumped via pipeline to the marine outfall and not to the Ashburton Delta.
- Water levels within the bunded area will be managed to avoid overtopping of the bunds, even during extreme high rainfall.
- Groundwater monitoring bores will be installed to detect an alteration of groundwater conditions that may indicate a potential impact on the Ashburton Delta system.

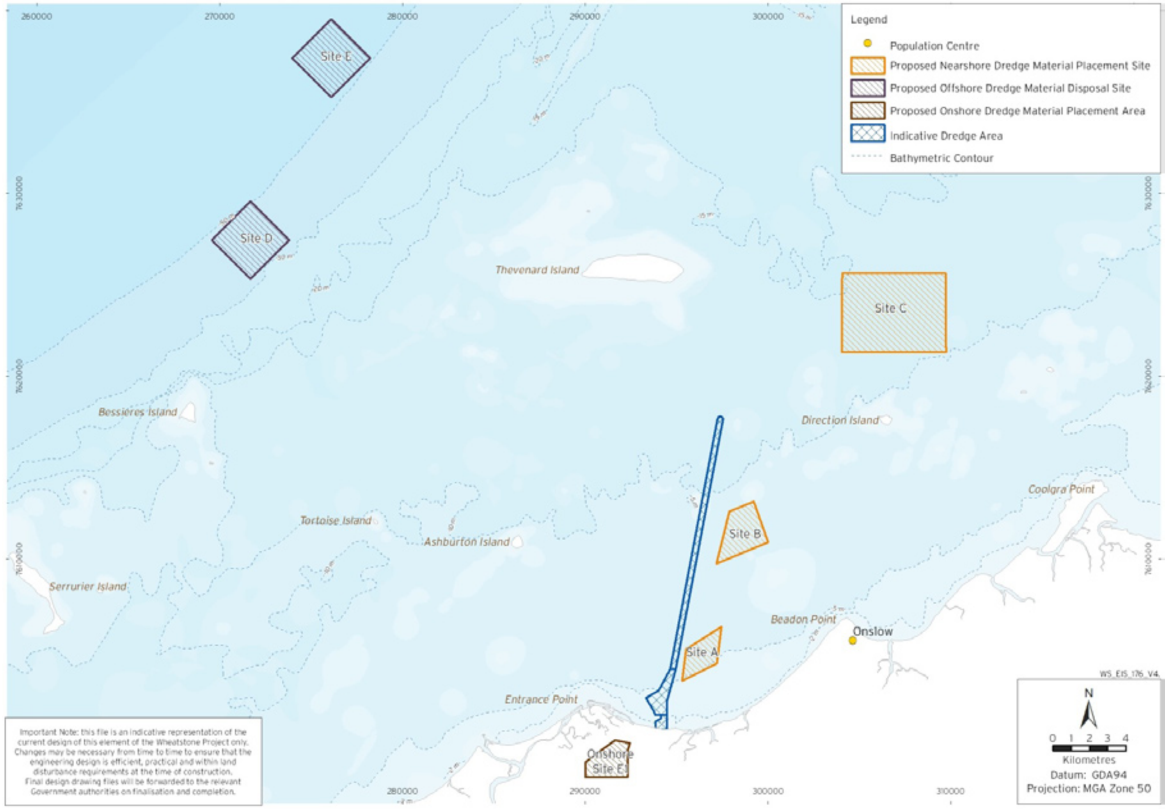

Figure 4-1: Wheatstone Project Dredging and Dredge Material Placement Areas

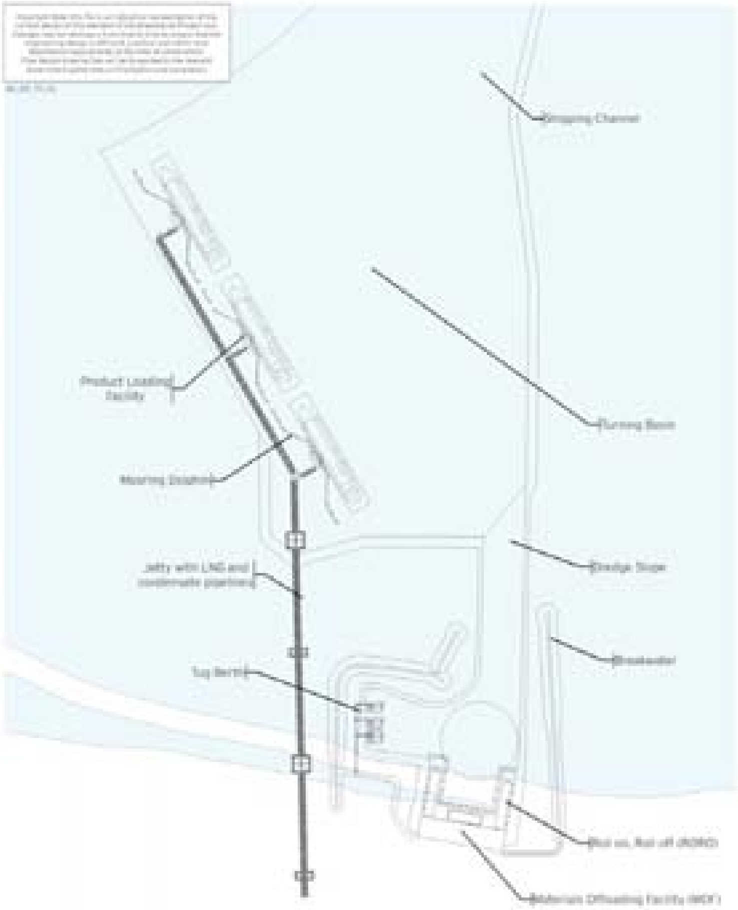

Figure 4-2: Entrance Channel, Turning Basin and Berth Alignment

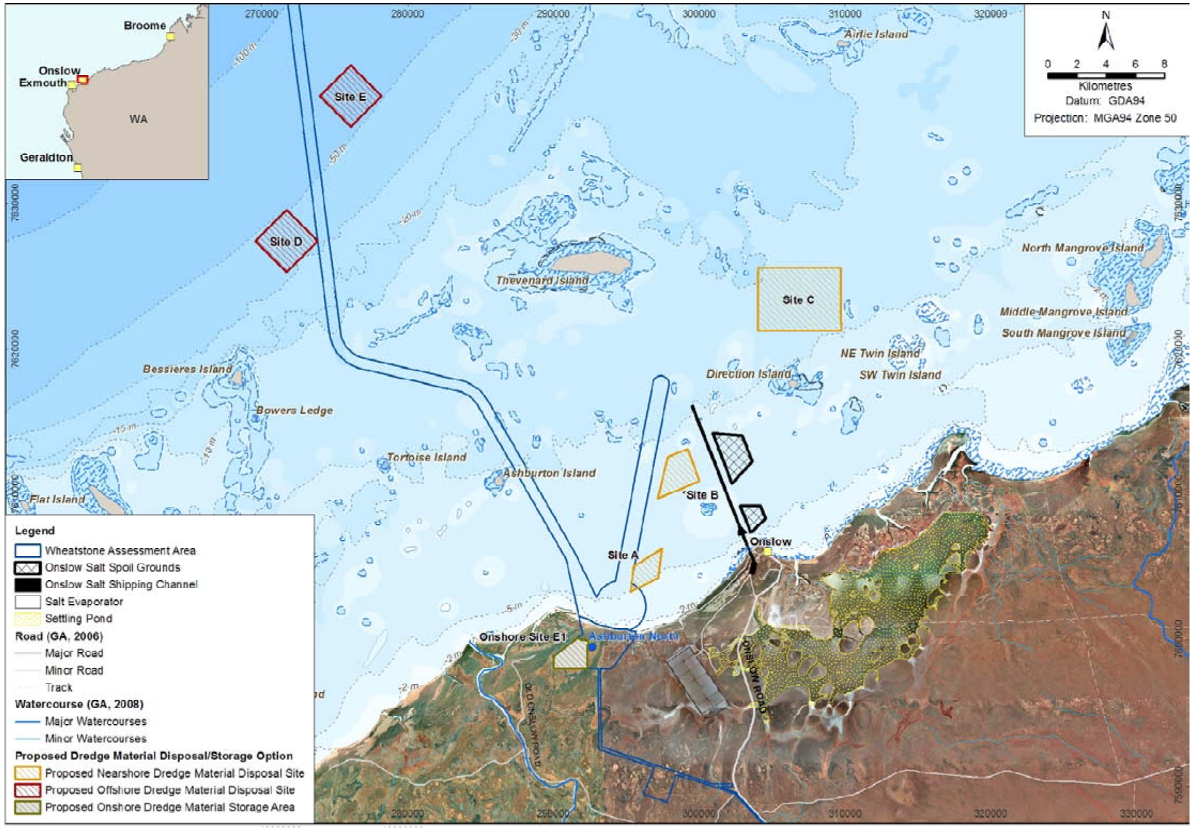

Figure 4-3: Location of Onshore, Nearshore and Offshore Placement Sites

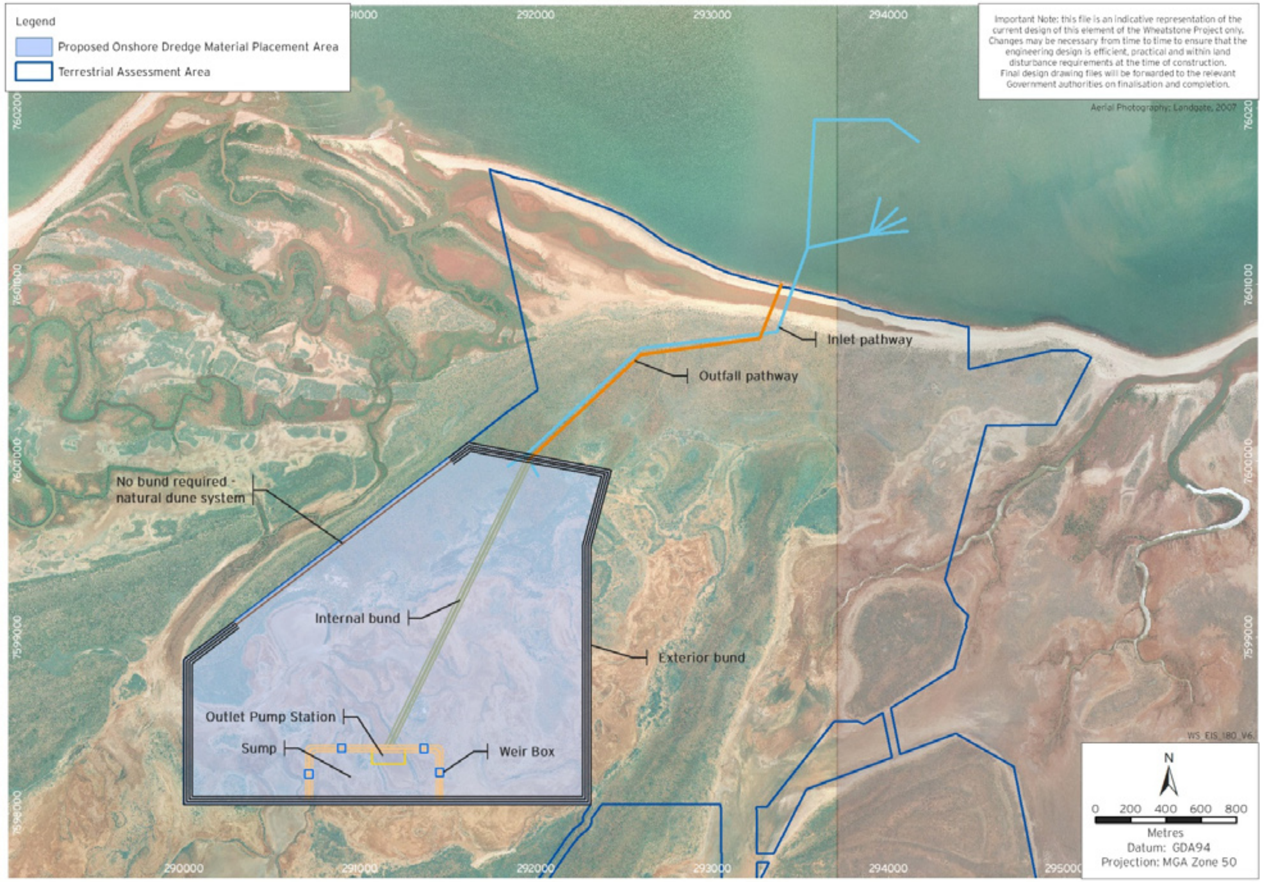

Figure 4-4: Location and Layout of Onshore Reception Area

4.3 Dredging Equipment

The dredging and dredge material placement management works will be undertaken by a combination of dredges, support vessels and land based equipment. It is envisaged that the following dredging equipment will be utilised:

- two large-sized (~10,000 m³) Trailing Suction Hopper Dredges (TSHD);
- one small (~5,000 m³) TSHD;
- one large (4,000 KW) Cutter Suction Dredge (CSD);
- one large backhoe excavator;
- self-propelled barges; and
- a range of ancillary small craft to service the dredges, transport crew and survey the channels.

The final vessel selection will be made upon awarding of the dredging contract. **Figure 4-5** and **Figure 4-6** provide typical examples of the envisaged dredge vessels.

Figure 4-5: Example of Trailing Suction Hopper Dredge (TSHD)

Figure 4-6: Example of Cutter Suction Dredge (CSD)

4.4 Methods

4.4.1 Temporary Access Channel

A temporary access channel will be constructed during the initial phase of the works to enable the delivery of equipment and supplies to the site. The temporary channel will be 75 m wide and will extend to the -6 m Lowest Astronomical Tide (LAT) contour to accommodate barges and small vessels. Dredging of the temporary channel will involve the dredging of approximately 650,000 m³ of material by a CSD.

Dredging of the temporary access channel will be undertaken in two phases. During the first phase material will be dredged directly with the CSD and pumped via a pipeline to proposed Nearshore Dredge Material Placement Site A. This material will be deposited at the placement site via the use of a diffuser.

During the second phase, dredged material may be pumped via a combination of sunken and floating pipeline by the CSD up to 2–3 km to the proposed onshore dredge material placement area. Alternatively it may be pumped to proposed nearshore dredge material placement Site A.

This temporary access channel will then become part of the MOF and approach channel.

4.4.2 MOF and MOF Approach Channel

The MOF and MOF approach channel require dredging to a depth of ~7 m. The MOF approach channel is estimated at approximately 1 km long and 120 m wide.

Dredging of the MOF and MOF approach channel will be undertaken using a CSD and will involve the dredging of approximately 1.4 Mm³ of material which will be placed offshore. Alternatively, the material may be pumped to the onshore material placement area via a combination of sunken and floating pipeline. This activity will follow in a sequence from the temporary access channel dredging. The CSD will commence operations in the nearshore area initially by dredging the MOF and progressively working offshore to dredge the MOF approach channel.

4.4.3 Product Loading Facility

The product loading facility (PLF) area, including the turning basin and berth pocket, will be dredged to a final dredge depth of ~15 m and will require the dredging of 7.2 Mm³ of material. The PLF approach channel will be approximately 16 km long and 260 m wide.

Dredging of the PLF will be completed in two or three stages. Initially, the CSD used to dredge the MOF and MOF approach channel will dredge to -8 m LAT. This material will placed offshore or, alternatively, pumped to the onshore dredge material placement area. From -8 m LAT to the final dredge depth of -14.1 m LAT, a TSHD will be used to remove up to 4.5 Mm^3 of material for placement at Site C. If rock patches are encountered, a backhoe excavator may be required to remove the rock and load onto a self-propelled hopper barge for placement at Site C.

4.4.4 PLF Approach Channel

The approach channel will be extended approximately 15 km from the edge of the PLF and will be dredged to a final dredge depth of -14.1 m LAT. This will involve dredging of approximately 20.7 Mm³ of material.

Initial dredging will be undertaken using a CSD to dredge all high spots above the -6 m LAT level within 1–2 km of the PLF. This is required to allow access for the TSHD. Removal of these high spots will include dredging of 0.2 m³ of material which will be pumped to nearshore placement Site A via a pipeline and diffuser.

The dredging from -8 m LAT to -14.1 m LAT within the channel will be undertaken by a small TSHD which will dredge approximately 1.5 Mm^3 of mostly sandy material. The TSHD will transport and dispose of this material at offshore placement Site C via direct bottom opening doors. This dredging will involve the use of hopper overflow except when dredging in sensitive areas with restricted overflow (see **Section 8.0**).

Dredging from -10 m LAT to -14.3 m LAT will involve the dredging of approximately 19.1 Mm³ of material. The unconsolidated sands will be dredged using the small TSHD and disposed of at placement Site C. The weak rock material that cannot be directly dredged using the TSHD will instead be dredged by the backhoe excavator and loaded onto barges and transported to Site C.

4.4.5 Clean-up Dredging

Throughout the dredging works fine material is likely to accumulate within the dredge footprint, some of which will be removed by the main capital dredge activities. An allowance has been made for approximately 0.3 Mm^3 of clean-up operations. This material will be dredged during a clean-up phase using a small- and medium-sized TSHD and disposed of at the offshore material placement Site D via bottom opening doors.

4.5 Methods Justification

The decision on the proposed methods, including the selection of the dredging equipment type, will be made based on a number of factors including:

- anticipated vessel availability;
- vessel operability (including vessel draft, cutting strength, pumping distance capability);
- soil strength;
- transport distances;
- required dredging accuracy; and
- required environmental performance.

In terms of environmental suitability, the methods present a number of environmental benefits including:

- Where operational restrictions allow, medium-sized TSHDs and CSDs will be used as opposed to smaller vessels, to minimise the duration of the works and thus reduce the temporal extent of any environmental impacts.
- The use of large CSDs will reduce the risk that the pre-treatment of material via drilling and blasting is required.
- The methods will minimise the double-handling (side casting and re-dredging) of material via direct placement onshore or to dredge material placement sites via a diffuser.

- The dredging and dredge material placement accuracy of modern TSHDs and CSDs is of a high standard and will be operated by leading dredge contractors that are experienced in the environmental management of dredging operations, thus providing surety in environmental performance.

5.0 ENVIRONMENTAL PROJECT MANAGEMENT

5.1 Key Roles and Responsibilities

Key roles and responsibilities for Project personnel, both Chevron-employed and contractor companies, will be defined in subsequent versions of the Draft DSDMP.

5.2 Inductions and Training

All personnel (including contractors and subcontractors) are required to attend environmental inductions and training that are relevant to their roles on the Wheatstone Project. Training and induction programs will facilitate the understanding that personnel have of their environmental responsibilities, and increase the awareness of the management and protection measures required to reduce potential impacts on the environment.

Environmental training and competency requirements for personnel, including contractors and subcontractors, will be maintained in Health, Environment and Safety (HES) training matrices. These matrices will be reviewed and updated on an ongoing basis to ensure that the required competencies are met and the required training has been completed. Training will be provided to relevant personnel on the requirements of this Draft DSDMP.

5.3 Environmental Documentation Management

5.3.1 Chevron ABU OE Documentation

As part of the Chevron ABU, the Wheatstone Project is governed by the requirements of the ABU OEMS, within which a number of OE Processes exist. The Wheatstone Project will implement internal OE Processes (and supporting OE Procedures) that apply to the Wheatstone Project's activities. The OE Processes have been prepared by Chevron Australia to address various issues that Chevron Australia internally requires its employees, contractors, etc to comply with (or equivalent contractor process). These Processes will also be applied to the requirements of this Draft DSDMP where this is appropriate and reasonably practicable.

5.4 Performance Reporting

To be included in future revision

5.5 Auditing

To be included in future revision

5.6 Management Review

To be included in future revision

6.0 EXISTING ENVIRONMENT AND RELEVANT STUDIES

6.1 Overview

The characterisation of the marine environment within the Project Area has been undertaken as part of the environmental impact assessment which underpins the environmental approvals process. A brief overview of the existing environment, the studies associated with the impact assessment and the development of impact zones and management trigger levels is provided here. This information provides context for determining the management strategies detailed in **Section 8.0** and the monitoring programs detailed in **Section 9.0**. Full details of the existing marine environment and the environmental impact assessment undertaken for the project can be found in **Section 6** and **Section 8, respectively,** of the EIS/ERMP.

6.2 Key Environmental Sensitivities

The key environmental sensitivities that could potentially be impacted upon by the proposed dredging and dredge material placement management activities include:

- hard corals;
- seagrasses;
- mangroves;
- marine turtles;
- humpback whales;
- dugongs.

6.3 Marine Reserves and Conservation Areas

There are no protected areas in the immediate vicinity of the Project Area, although a number of marine parks and reserves occur within the Pilbara Nearshore and Pilbara offshore bioregions. It is not expected that the dredging and dredge material placement management activities will impact on any of these marine parks and reserves.

The Project Area does not contain any World Heritage Properties, National Heritage Properties or Ramsar Wetlands of International Significance.

6.4 Existing Physical Environment

6.4.1 Water Quality

A review of studies in the Onslow region (MScience 2009) indicate that the regional median turbidity was usually <1 NTU and the 80^{th} percentile was <3 NTU during non-cyclonic periods. Corresponding total suspended solids (TSS) values ranged from 3–5 mg/l. Across 30 sites median turbidity ranged from <1 NTU during winter up to 6 NTU during non-cyclonic periods in summer. Discharge from the Ashburton River during inland rainfall is the primary source for input of terrestrial sediments to the near shore waters of the Project Area. These events can cause large-scale turbidity of nearshore waters over a period of months. Spring and summer are times of the year when there are persistent westerly winds and increased runoff from rainfall as well as periodic cyclones. Turbidity approached or exceeded 12 NTU at 20 % of the sites assessed during some weeks of summer. Turbidity and TSS are significantly elevated by cyclonic activity.

During the passage of Tropical Cyclone Dominic in January 2009, daily median turbidity increased to approximately 80 NTU and remained above 20 NTU for at least ten days. Offshore waters in general tend to have lower turbidity levels.

Contaminant levels within the water column are expected to be near background and representative of uncontaminated coastal and marine areas along the Pilbara coast.

Sediment re-suspension is frequent immediately seaward of the intertidal zone, and leads to considerable turbidity (Forde 1985). Re-suspension is mainly due to wind-driven waves; further offshore the sediment movement is a result of internal or subsurface waves (Heywood et al. 2006).

6.4.2 Marine Sediments

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

Broadly, two types of soils are to be dredged: sands intermixed with variable fractions of clays, silts and or gravels, and; rock (siltstone, claystone and sandstone) that is generally weathered and weak. The proportion of the two soil types is assumed to change with increasing distance from the shore. It is assumed that for the MOF and PLF basin the material to be dredged consists of 75% sand and 25% weak rock. In the PLF approach channel, the assumption is that the material will be 60% sand and 40% weak rock. In both cases, sand is assumed to overly the rock. Sediments become increasingly coarse and increase in calcium carbonate content with distance offshore, due to decreasing input of terrigenous silts and clays from river runoff and coastal erosion.

The chemical characteristics of marine sediments in the vicinity of the Project Area has been assessed on two previous occasions; once in 2005 by the DEC (2006) and more recently in the pilot study conducted by URS in the Wheatstone dredging area (URS 2009).

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

During the URS (2009) survey, marine surface sediments in the Project Area were sampled at 25 nearshore sites corresponding to the proposed dredging area and dredge material disposal sites. Detailed results of this study are provided within the EIS/ERMP. The study recorded concentrations of all contaminants and trace metals as being below the laboratory limit-of-recording (LOR) or below the relevant National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia 2009d) screening levels, with the exception of arsenic and nickel (URS 2009).

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

6.4.3 Metocean Conditions

6.4.3.1 Waves

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

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

6.4.3.2 Winds

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

6.4.3.3 Currents

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

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

6.4.3.4 Tides

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

Modelling of extreme cyclonic water levels for the Onslow town site and Onslow Salt (GEMS 2000, Nott & Hubbert 2005) has estimated the 100-year ARI water level as 4.7 m AHD (6.2 m CD), including allowance for wave setup.

6.5 Existing Biological Environment

6.5.1 Marine Habitats

A marine habitat map has been developed for the Project Area and is shown in **Figure 6-1.** As can be seen from **Figure 6-1**, the majority of the seafloor in the vicinity of the Project Area (between the mainland shore and Thevenard Island) is comprised of unvegetated sand and silts or subtidal sand and silts.

BPPH within the Project Area is sparsely distributed and is present at discrete locations. BPP present include sparse macroalgae, hard coral, seagrasses and mangroves.

On the basis of field surveys, URS (2009a) concluded that the most significant locations with respect to nature conservation value are the shallow fringing coral reefs and macroalgal platforms surrounding Serrurier, Ashburton, Thevenard, Direction, Mangrove, and the Mary Anne Group of Islands (**Figure 6-1**). The Mangrove and Mary Anne Group of Islands are the largest and most important nature conservation resource in the vicinity of the project and are important foraging areas for turtles and dugongs. Ward Reef is an unusually large patch of reef and is located 4.5 km from the proposed PLF approach channel. Ward Reef is an important recreational fishing area as well as possessing some conservation value.

In addition, there are a number of shallow shoals containing coral communities in close vicinity to the dredging area.

Table 6-1 shows the details of the key sensitive receptors in the Project Area.

Four major ecosystem units (ECU) have been identified within the EIS/ERMP:

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

These ECUs are shown in **Figure 6-2**.

Table 6-1: Sensitive Receptors in the Project Area

Sensitive Receptor	Habitat Biotype*	Geographic Name	Easting	Northing	Depth (m)	Site/species Descriptor
1	CR & MA	Tortoise Island	278710	7612383	3.5	Tortoise Island, east side. Reef, with 25-50% live hard coral cover close to shore. *Lobophyllia*, *Turbinaria*, *Porites* and faviids present, dominated by *Montipora* with occasional large *Acropora* plates. Patches of coarse sand and shell fragments. Macroalgae on bare rocks.
2	CR & MA	Roller Shoal	285367	7604532	5.8	Roller Shoal. Reef of up to 50% cover in places of hard live coral with surrounding sand patches. Dominant coral was *Montipora* spp., with *Goniopora*, *Platygyra*, *Porites*, and *Acropora* plates and faviids present. Hydroids, large barrel sponges and algae patches are also present.
3	CR & SG	Ashburton Island	286705	7611075	4.1	East side of Ashburton Island. Large bommies with up to 75% live hard coral cover. *Acropora*, *Porites*, faviids. Coarse sand and silt areas with moderately dense beds of seagrass. Low diversity of coral.
4	FF	Brewis Reef East	286437	7621988	12.3	East of Brewis Reef, South west of Thevenard Island. Sponge and fan garden. Gorgonian fans, sea whips, barrel, vase, encrusting and digitated sponges, hydroids and bryozoans. Red coralline algal tufts with coarse sand and shell fragment patches.
5	MA & CR	Thevenard Island West	288492	7624016	5.7	Flat pavement algae dominated. Occasional outcrop with 2–10% coral cover. Small individual corals including *Pocillopora* and *Turbinaria* spp. Occasional digitated and laminar sponges with solitary ascidians.
6	CR	Paroo Shoals	293805	7614023	4.5	Patches of high coral cover (up to 50–75%) and a diverse community were found on the ridge on the western edge of the shoal, dominated by either corymbose and tabulate *Acropora* spp. or by *Montipora* spp.
7	CR, MA & FF	Saladin Shoal	295913	7613337	6.3	Moderate to high live hard coral cover (up to 50% in places), with patches of sand and silt with coarse shell fragments. One large >2 m *Porites* bommie. Plateau of algae-dominated sand. Abundance of filter feeders (ascidians/sponges).
8	CR	End of Wheatstone Shipping Channel	298328	7617464	6.4	Outcrop at end of shipping channel. Two distinct steep-faced outcrops with 50–75% hard coral cover on top (~5 m). Feature is ~20 m in length. Dominant coral cover encrusting *Montipora* spp. with faviids, *Mycedium* sp. and juvenile *Turbinaria*. Numerous *Nephthea* spp. with occasional digitated sponges.

9	CR	Hastings Shoal	298803	7613488	7.6	Areas of 50–75% hard coral cover on western side of the shoal at depth of 3 m LAT. The coral community was dominated by *Montipora*, with many *Acropora* spp. and faviids also present. The remainder of the shoal was comprised of coral rubble (mainly branching *Acropora* spp.).
10	CR	North West Ward Reef	299018	7610106	3.9	Reef. Large outcrop with east-west orientation on sand and silt pavement. Outcrop has 50–75% healthy hard coral cover, dominated by encrusting *Montipora*, with tabular and digitated *Acropora* spp. sub-dominant. *Platygyra* spp. and faviids also present.
11	CR	Ward Reef	300410	7608868	3.9	Reef. Outcrops dominated by *Acropora* plates, with sub-dominant encrusting *Montipora* spp. Occasional large *Porites* bommies, *Platygyra*, faviids, and *Lobophyllia*. Coral cover 50–75% in places.
12	CR	Ward Reef	301120	7609196	6.4	Ward Reef, east side. Diverse and abundant live hard coral cover reef (~90% cover) with very little damage and dead coral present from storm damage (typically *Acropora* spp.) with patches of silt. *Montipora*, *Lobophyllia*, *Platygyra*, *Turbinaria*, and *Porites* spp.
13	CR	Gorgon Patch	300859	7615993	7.1	Gorgon Patch. Steep-walled reef with up to 80% hard live coral cover in middle of shoal. Corals include *Montipora*, *Acropora*, *Platygyra*, *Turbinaria*, *Porites* and *Nephthea* spp. Patches of algae, with barrel and digitate sponges and gorgonians.
14	CR, MA & FF	Weeks Shoal	302245	7618926	4.6	Flat-topped reef with steep walls, with >75% live hard coral cover in patches including *Montipora*, *Turbinaria*, *Acropora* and faviids. Colonial ascidians, algal patches and gorgonians also present.
15	CR	Unnamed shoal to NE of Koolinda Patch	304144	7615544	3.2	Shoal east northeast of Koolinda Patch, southwest of Direction Island. Large reef with 50-75% live hard coral cover patches on the top. Dominant coral was tabular *Acropora* with *Lobophyllia*, faviids and *Turbinaria* present.
16	CR	Direction Island	307430	7617732	5.6	Direction Island, east northeast edge. Up to 100% hard live coral cover in very healthy condition, with occasional small patch of algae. *Montipora*, *Acropora*, *Pocillopora*, *Turbinaria*, faviids, *Lobophyllia*, *Goniopora* and *Porites* spp. all present.
17	CR & MA	NE Twin Island	314029	7620738	3	Reef with occasional large *Porites* bommies (2–4m). Patches of 25-50% healthy hard coral cover, with overall 10–25%. Hard substrate predominantly covered with fine foliose algae. *Porites* spp. were dominant coral. Edge of hard substrate supports greatest coverage of coral.

18	FF & CR	West middle Mangrove Is	326341	7624763	7.5	Dominated by sponges and ascidians. Hard, raised pavement with sand silt veneer. Sparse corals (2–10%) on hard substrate including young *Turbinaria*, tabular *Acropora*, occasional *Goniopora*, *Platygyra*, *Favia* and faviids. Very sparse algae present. Digitate, laminar and vase sponges.
19	SG	East Glennie Patches	283533	7608755	5.5	Rippled coarse sand. Very large and dense meadow of *Halophila spinulosa* and possible *H. ovalis* of 25-50%. Transect develops into bare substrate before returning to dense patches. Possible dugong grazing paths in substrate.
20	MA	Thevenard Island South	294521	7622970	1.9	Southeast Thevenard Island. Algal-dominated rock platform (*Sargassum* and *Halimeda* spp. dominant).
21	SG	Nearshore NE of Onslow	310515	7609475		Dense seagrass nearshore between Onslow and Coolgra Point
22	SG	SW of Coolgra Point	314624	7612352	5.3	Undulating substrate with fine sand and silt and fine shell fragments. Sparse bioturbation with occasional larger hole. Short tufting algae. Seagrass cover 10–25% (with patches of 25–50%) of *Halophila spinulosa*, *H. decipiens* and unidentified thin-bladed seagrass.
23	SG	Coolgra Point	317246	7614478	3	Sand rippled with patches of dense seagrass (*Halophila* spp 40–60% in places with occasional *H. spinulosa*).
24	SG & MA	SW Twin Island	313878	7618776	4.3	SW Twin Island – south side. Dense seagrass beds (up to 75% cover in places) of *H. decipiens*. Algae-dominated sand veneer patches on presumed rock platform with <5% live hard coral cover. One large *Porites* bommie (~3 m) with *Montipora* spp.
25	SG	SE of Direction Island	307170	7613858	8.5	South of Direction Island. Sand with fine shell fragments. Moderate patches of seagrass of up to 25%, including *H. spinulosa* and *H. decipiens* and also the green alga *Caulerpa* sp. Digitate and laminar sponges and solitary ascidians.
26	SG	West Glennie Patches	282228	7607307	5.5	Rippled coarse sand. Dense patch (~25 m in diameter) of *H. spinulosa* and *H. decipiens* of 25–50%. Transect develops into bare substrate before returning to dense patches. Possible dugong grazing paths in substrate. One sea pen. No observable bioturbation.

27	CR	SW of Gorgon Patch	300094	7615177	5	Outcrop next to shipping channel. Two distinct steep-faced outcrops, with 25–50% hard coral cover on top (~5 m). Feature is ~20 m in length. Dominant coral cover encrusting *Montipora*, with *Pocillopora*, tabular *Acropora*, faviids, juvenile *Turbinaria*, and *Tubastrea* spp. Numerous *Nephthea* sp.
28	CR & MA	NW of Direction Island	304867	7618549	11.5	Northwest of Direction Island, very steep-walled reef from 13–4 m depth. Reef with up to 50% live coral cover and algae-dominated in areas. *Montipora*, *Lobophyllia*, *Acropora* and occasional *Porites* bommies (~2 m).
29	CR	North Herald Reef	315773	7623395	4	Herald Reef – north side in northerly direction. Rock outcrops covered with macroalgae, <10% coral coverage - juvenile *Turbinaria*, tabulate *Acropora*, *Lobophyllia* , and encrusting *Porites* spp.
30	CR	Nares Rock	323379	7629437	5	Nares Rock, northwest of Twin Islands. Steep-walled reef dominated by encrusting *Montipora*. *Porites*, tabulate *Acropora* and *Lobophyllia* spp. 25% coverage. Coral density increases on southern edge of reef. Dense coral cover on top of reef (25–50% cover). Large rock outcrops on edge of reef with 25–50% cover. Encrusting *Montipora* dominated, also *Lobophyllia* spp.
31	CR & MA	Airlie Island	307006	7640697	5.7	Algae-dominated on outcrops on presumed hard platform with patches of fine sand.
32	CR & MA	Taunton Reef	315570	7642531	4.6	Sand and fine shell fragments and coral rubble substrate over presumed reef outcrop. Occasional pavement outcrops supporting macroalgae (*Asparagopsis* sp.) (2–10%) and sparse corals including *Porites*, faviids, tabular *Acropora*, *Lobophyllia* and *Turbinaria* spp. (2–10% in patches) with occasional *Porites* bommies.

*****CR = Subtidal coral communities on biogenic reefs. SG = Subtidal seagrass communities, MA = Subtidal macro algal communities, FF = Sessile benthic filter feeder communities, REC = recreational/aesthetic

Wheatstone Project
Draft Dredging and Spoil Disposal Management Plan

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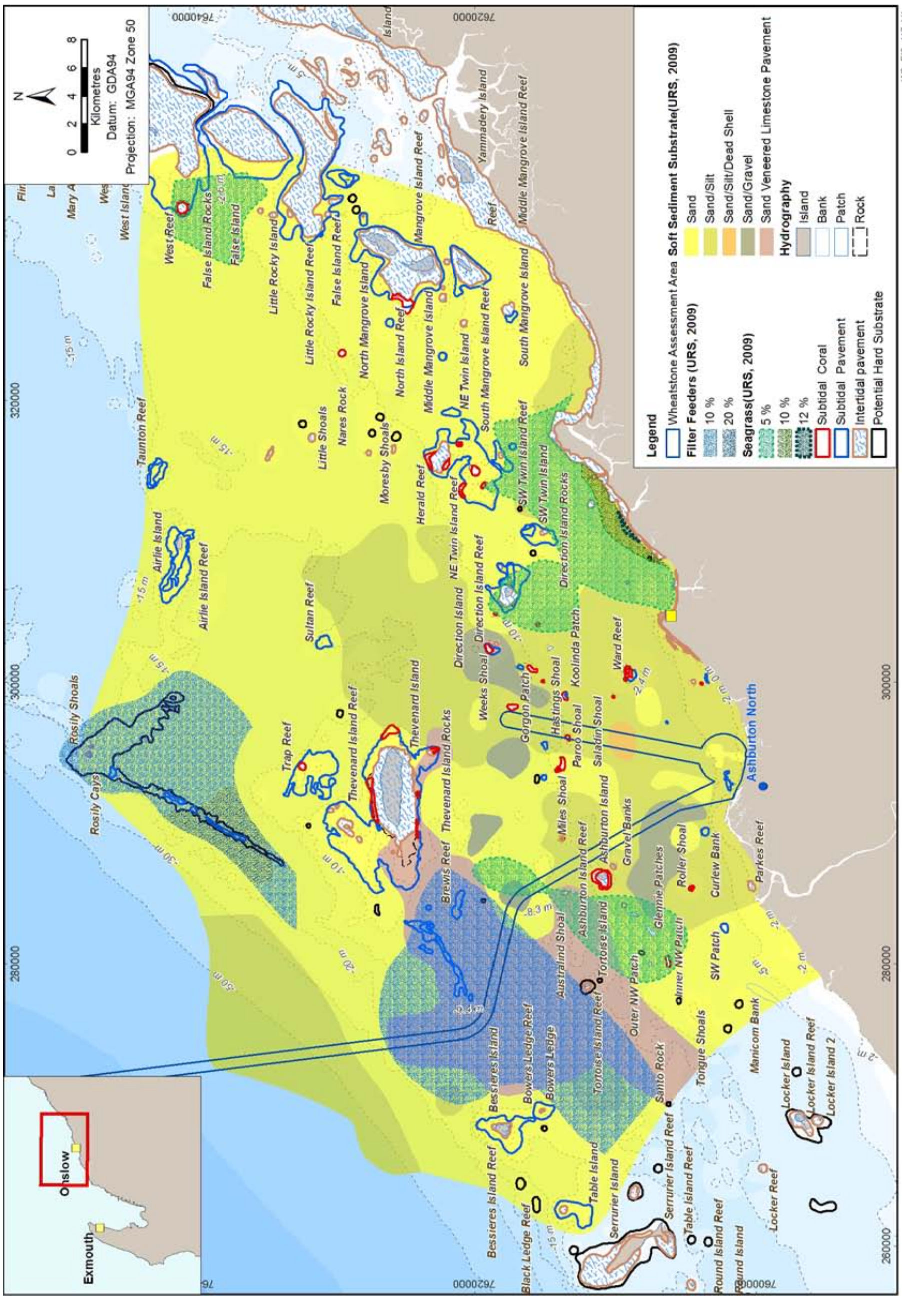

Figure 6-1: Marine Habitat Map

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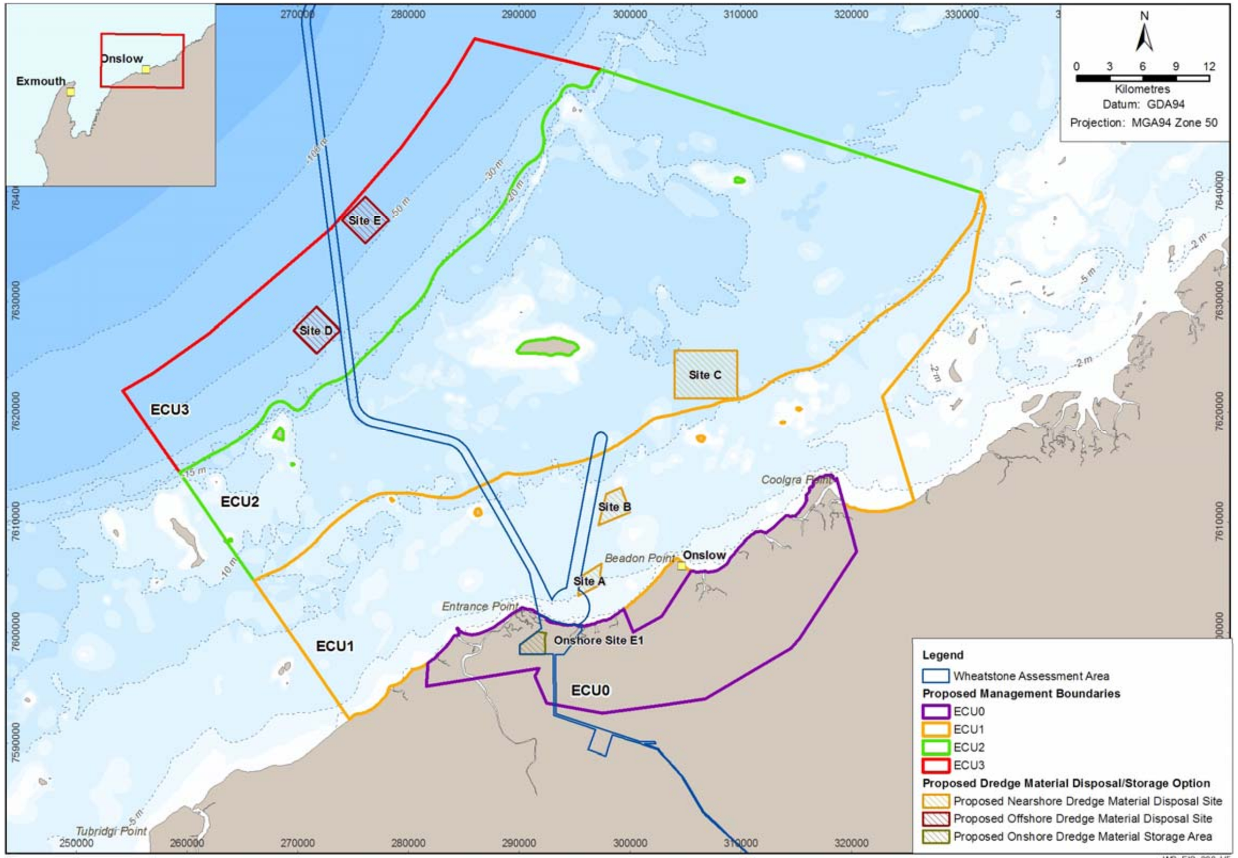

Figure 6-2: Ecosystem Units defined for the Wheatstone Project

6.5.1.1 Hard Coral

In the immediate vicinity of the Project Area, coral communities are in low abundance, restricted to a small number located on the fringes of the platforms that surround the offshore islands.

Field survey results within the vicinity of the proposed Project Area indicate that hard coral density varied between 30 and 70% live coral cover (MScience 2009a). However, sites were selected in areas of highest coral cover and therefore these results are not representative of the entire Project Area. The higher cover areas were dominated by spreading corals such as plate *Montipora* and tabulate *Acropora* spp. A gradient in coral communities was evident from inshore to offshore reefs, with the inshore zone dominated by *Montipora* spp. and the offshore zone dominated by *Acropora* spp. A transition zone between the inshore and offshore zones was evident and consisted of mixed community types with abundant *Montipora* corals but other corals, including *Acropora,* were found to be dominant. A relationship between coral cover and diversity was found with diversity decreasing as coral cover increased, as many sites were dominated by a cover of plate *Montipora* corals.

6.5.1.2 Seagrass

The abundance and distribution of tropical seagrass species can vary greatly due to seasonal changes in water quality (turbidity, light penetration) and conditions (wave action, temperature). Seagrasses are important primary producers but their sparse distribution in the Pilbara Nearshore bioregion means that they make only a small contribution to benthic primary production when compared to mangroves, macroalgae and corals (URS 2009a).

No known meadows of perennial seagrass genera, such as *Thalassodendron* or *Enhalus* spp., occur in the nearshore Project Area. The area is characterised by ephemeral species such as *Halophila* spp. Paling (1990) surveyed subtidal areas off Onslow and found seagrass was absent from most sites. He noted only 'rare' patches of *Halophila decipiens*. Around the islands offshore from Onslow, species of a number of genera (e.g. *Halophila*, *Halodule* and *Syringodium*) are known to occur on the shallow intertidal platforms and in the lee of small reefs, while *Thalassodendron* occurs sparsely distributed in the shallow macroalgal meadows that occur to the west of Thevenard Island (URS 2009a). Seagrasses recorded in surveys of the Project Area were sparsely distributed (when encountered), occurring in small patches.

6.5.1.3 Macroalgae

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

6.5.1.4 Sponge and Whip Gardens

Sessile filter feeders (including soft corals, sponges and ascidians) are common on the sand veneered pavement that dominates the inner shelf and consequently are one of the largest sessile benthic communities present.

6.5.1.5 Intertidal Habitats

Two major types of BPPH are recognised in the intertidal marine areas, namely mangroves (and associated high tidal mud flat) and algal mats.

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

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

- bioturbated mudflats, devoid of macro-vegetation
- samphire flats, dominated by halophytic shrubs but with some crab burrows.

6.5.2 Marine Fauna

6.5.2.1 Overview

Fourteen threatened marine fauna species occur, or could occur, in the nearshore or offshore Project Areas. These include one bird, four marine mammals, six reptiles and three sharks/rays as shown in **Table 6-2**.

In addition to these species, a number of migratory marine mammals and birds that are also protected under the *EPBC Act (Cth)* may occur in the Project Area including cetacean species (whales and dolphins), the dugong, migratory seabirds and wetland birds.

Table 6-2: Threatened Marine Fauna Potentially Inhabiting the Project Area

Scientific Name	Common Name	*EPBC Act (Cth)* Conservation Status	*Wildlife Conservation Act* Status
Birds			
Macronectes giganteus	southern giant petrel	Endangered	Rare
Mammals			
Balaenoptera musculus	blue whale	Endangered	Rare
Balaenoptera musculus brevicauda	pygmy blue whale	Endangered	
Eubalaena australis	southern right whale	Endangered	Rare
Megaptera novaeangliae	humpback whale	Vulnerable	Rare
Reptiles			
Caretta caretta	loggerhead turtle	Endangered	
Chelonia mydas	green turtle	Vulnerable	Rare
Dermochelys coriacea	leatherback turtle	Vulnerable	Rare
Eretmochelys imbricata	hawksbill turtle	Vulnerable	Rare
Natator depressus	flatback turtle	Vulnerable	Rare
Crocodylus porosus	saltwater crocodile	Protected	
Fish			
Rhincodon typus	whale shark	Vulnerable	
Pristis zijsron	green sawfish	Vulnerable	Rare
Pristis clavata	dwarf sawfish	Vulnerable	Rare

6.5.2.2 Marine Turtles

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

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

Juvenile green turtles were observed around the islands. These animals are likely to be residents at their foraging grounds. Foraging green turtles are likely to be found in seagrass and algal habitats near the Project Area and may also utilise coastal mangrove habitats (Pendoley Environmental 2009). A total of 1,091 turtles were sighted during the aerial surveys from mid-May to late December, off the west Pilbara conducted by CWR (2009).

6.5.2.3 Marine Mammals

The Pilbara region supports migratory, transient and resident marine mammals such as whales, dolphins and dugongs, all of which are EPBC listed. Nine species of migratory cetaceans, including blue whales (*Balaenoptera musculus*), humpback whales (*Megaptera novaeangliae*), pygmy blue whales (*Balaenoptera musculus brevicauda*), Bryde's whales (*Balaenoptera edeni*) and minke whales (*Balaenoptera acutorostrata*), occur in the Project Area.

Humpback whales are known to move through the region on their northern and southern migrations to and from the Kimberley between June and October. Aerial surveys beginning in May 2009 found northbound humpback whales were concentrated seaward of Thevenard Island and over the continental slope, on average 49 km offshore (CWR 2009). The southbound migration found whales on average 36 km offshore with cows and calves predominantly resting inshore of the 50 m isobath. The data indicate that the area does not have the same importance for resting as Exmouth Gulf or for calving as Camden Sound.

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

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

Dugongs (*Dugong dugon*) are found within the region and within the Project Area. Dugongs tend to occur in wide shallow bays, mangrove channels and in the lee of large inshore islands. Shallow waters such as tidal banks and estuaries have also been reported as sites for calving (Oceanwise 2005). While dugongs are found in the Project Area, it is not considered to be a favoured habitat due to the lack of extensive seagrass habitats and limited open water. From the available aerial survey data, it is expected that at least some dugongs are resident in the area year-round but with seasonal variation in densities (CWR 2010). Dugongs were predominantly sighted in the south-western portion of the study area (i.e. towards Exmouth Gulf) and in water depths less than 10 m. This is suggestive of a link to the known populations and possibly to food sources in that area (CWR 2009). Dugongs were often sighted over or near to known areas of seagrass and macroalgae, as identified during benthic surveys of the area (URS 2009a).

6.5.2.4 Migratory Waterbirds

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

6.5.2.5 Introduced Marine Species

The National Introduced Marine Pests Coordination Group (NIMPCG 2006) has developed a target list of 55 pest species of concern to Australia. None of these species have been recorded in the Wheatstone Project Area, or elsewhere in the Pilbara Nearshore or Pilbara Offshore bioregions (Huisman *et al.* 2008).

One introduced marine species, the barnacle *Megabalanus tintinnabulum*, has been recorded in Onslow (Huisman et al. 2008). This species is not considered a “pest” and has been recorded at several other WA ports.

6.6 Social and Economic Environment

to be checked against ERMP corresponding chapter

The land and sea area surrounding the proposed Project Area has a number of uses and values, including commercial, heritage, environmental conservation, and recreational. The following map provides an overview of existing land uses falling within and around the boundaries of the proposed Project Area.

6.6.1 Sea Use Values

6.6.1.1 Commercial Fisheries

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

- Onslow and Nickel Bay Prawn Managed Fisheries (ONPMF);
- Pilbara Managed Trap Fishery;
- North Coast Blue Swimmer Fishery; and
- Pearl Oyster Managed Fishery.

The ONPMF is a combination of three areas and four associated Size Management Fish Grounds (SMFG) totalling 39 748 km^2. Construction of the proposed Project, including dredging a material offloading facility and construction of an LNG and condensate jetty, would most directly affect Area 1, which also includes the Ashburton SMFG.

6.6.1.2 Pearling

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

6.6.1.3 Oil and Gas Production Facilities

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

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

6.6.2 Recreational Values

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

7.0 SEDIMENT PLUME MODELLING AND DEVELOPMENT OF IMPACT ZONES

This section is based on the draft preliminary modelling results and will require updating prior to report finalisation. The results presented should not be taken as complete or correct. They are presented here to show what the plan will contain after finalisation. For further details on the plume modelling to date, the reader is referred to the relevant draft modelling reports

7.1 Impact Zones

Impact zones have been developed based on the recommended approach of the DEC's Marine Ecosystem Branch (MEB), which uses four categories of classification. A description of the impact zones is provided in **Table 7-1**. Refer to the EIS/ERMP document prepared for the Wheatstone Project for further details on the establishment of these impact zones.

Table 7-1: Definition of Impact Zones

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% loss close to the channel and <1% loss at the extremes). Mortality will occur within the area, but will not include all individuals. The outer border will be drawn so that no mortality will be predicted to occur immediately outside of this zone.
Zone of 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. This area would be suitable for locating a reference site.

7.2 Tolerance Limits

Tolerance limits for both turbidity and sedimentation rates have been established for various receptors including hard coral, seagrass and recreational values. Tolerance limits have been established for both the nearshore (ECU1) and offshore waters (ECU2) to reflect the different natural turbidity climate of these areas (refer to **Section 6.5.1** for description of the four major Ecosystem Units ECUs) (DHI, 2010).

The tolerance limits and the process followed to establish these limits are detailed in the EIS/ERMP document and its technical appendices.

7.3 Sediment Plume Modelling

7.3.1 Modelled Scenarios

7.3.1.1 Overview

The modelling provides predictions of turbidity and sedimentation patterns associated with the proposed dredging and dredge material disposal. Sediment plume modelling has considered two climatic conditions (strong and representative drift), three seasons (summer, winter and transitional periods) and two spill estimates (realistic and worst case) for each of seven combined dredge scenarios, covering the full range of dredging equipment and dredged material placement sites. This gives a total of 84 different scenarios (i.e., 2 release rates x 6 climate scenarios x 7 dredging scenarios) that have been modelled, which are expected to cover the full spectrum of variability in terms of potential sediment plume impacts on sensitive receptors.

7.3.1.2 Dredging Scenarios

The dredging scenarios that have been modelled are (DHI 2010):

Dredging Scenario 1

- Nearshore dredging in the temporary access channel by CSD pumping to placement Site A.

Dredging Scenario 2

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

Dredging Scenario 3

- Nearshore dredging in the MOF basin by CSD and pumping dredged material to hopper barges located at the -3 m LAT contour for placement at Site C.
- Offshore dredging by the 5,000 m^3 TSHD in section 4 of the PLF approach channel and placement of dredge material at site C.

Dredging Scenario 4

- Nearshore dredging in the PLF basin, of weak rock, by 10,000 m^3 TSHD, with placement to Site C.
- Offshore dredging in the PLF approach channel, of sand, by 10,000 m^3 capacity TSHD with placement at Site C.

Dredging Scenario 5

- Nearshore dredging of sand in the PLF basin by 10,000 m^3 TSHD with placement at Site C.
- Offshore dredging in the PLF approach channel in weak rock by 10,000 m^3 TSHD with placement at Site C.
-

Dredging Scenario 6

- Offshore dredging of sand and weak rock in the PLF approach channel by 10,000 m^3 TSHD with placement of dredged material at Site C.

Dredge Scenario 7

- Offshore dredging of sand in the PLF approach channel by 10,000 m^3 TSHD with placement of dredged material at Site C.

Dredge Scenario 7A

An additional dredge scenario was investigated which incorporated dredge spill (i.e. no overflow) restrictions along parts of the channel (**Figure 7-1**) in order to reduce potential impacts at nearby sensitive receptor locations such as Ashburton Island.

- 10,000 m^3 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 avoid overflow in "no overflow" zone.

The modelling for scenario 7A, assumes that for each dredge cycle, the TSHD starts dredging at the centre of the "no overflow" zone within Section 2. It takes 25 minutes, corresponding to a sailing distance of 1.5 km for a speed of 1 m/s (app. 2 knots) before overflow starts. The dredge continues dredging for another 3 km with overflow. The dredge travels towards south and north, respectively, on alternate trips. This leads to a 3 km section with no overflow along with 3 km with overflow on each side, i.e. the total channel section being dredged is 9 km.

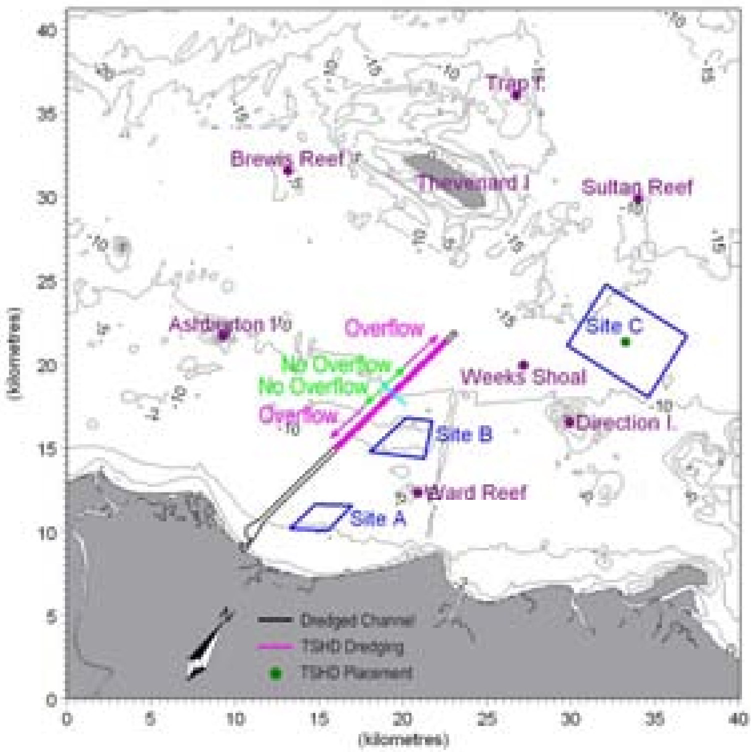

Figure 7-1: Dredging Scenario 7A Incorporating No-release Zone (green) Along the Channel

7.3.1.3 Climatic Scenarios

The Wheatstone area has dominant summer and winter conditions with wind-driven net currents that cause the sediment plumes to travel in a predominant direction. Due to the variable climatic component, a number of scenarios with best estimates of "representative" and "strong" conditions are required to develop an estimate of possible impacts. There is also significant variability throughout the "calm" seasonal period occurring in April and May, therefore there are two representative calm periods to capture this variability. The six climatic scenarios, based on real wind data, are presented in **Table 7-2.** The most complete wind records available for the Project Area are from 2006 and 2007 and comparison to previous years indicate that these two years followed fairly typical patterns, although 2006 encompassed cyclonic events and 2007 had higher than average winds in January. The wind records from 2007 were selected for modelling purposes.

Table 7-2: 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

7.3.1.4 Sediment Spill

In order to capture the uncertainty during the impact assessment stage of the Project regarding the rate of sediment spill from the various dredging, onshore material placement and disposal activities, upper and lower bound estimates have been developed for each spill source simulated in the model. These are referred to as 'High Spill' and 'Low Spill' scenarios in this report, with the High Spill scenarios considered to be a conservative "worst case" over-estimate of likely sediment release rates, and the Low Spill scenarios considered to be realistic estimate of "most probable" sediment release from the proposed program.

The difference between the high and low spill rates for each scenario is documented in DHI (2010a).

7.3.2 Modelling Results

The detailed modelling results for each scenario are presented in DHI (2010) and discussed in EIS/ERMP documentation. The results are presented within this plan to provide context for the management strategies presented in **Section 8.0** and the monitoring program presented in **Section 9.0**.

Combining the realistic scenarios discussed above, 42 scenarios in total, illustrates the highest level of impact across the scenarios for each given location in the Project Area. These combined plots are presented in **Figure 7-2**. Note that these represent the maximum areas of impact arising from the use of conservative "worst case" assumptions. While the scenarios do not provide continuous coverage along the entire extent of the dredging area, it is possible to manually interpolate across the small gaps between scenarios in order to determine indicative impact zones for the full dredging period.

The Indicative Zones of Impact (IZI) are illustrated for dredging and dredge placement impacts on turbidity (indicated as suspended solids concentration - SSC) and rates of sedimentation. For SSC, the IZI are quite similar for corals and seagrass. However, the Zones of Partial and Total Mortality are slightly larger for corals, reflecting their greater sensitivity to SSC impacts compared to seagrass (**Figure 7-2; Figure 7-4**). For sedimentation, the coral Zones of Impact are much more localised than for SSC, and the sedimentation impact zones for seagrass are particularly localised to the immediate vicinity of the channel and placement grounds and do not impact on areas of more abundant seagrass (**Figure 7-3; Figure 7-5**).

As indicated in the results presented above, most of the sensitive coral and seagrass receptors are not located in the near vicinity of the dredging area, and are generally outside of the Zone of Partial or Total Mortality. For corals, only Saladin Shoal falls within the Zone of Total Mortality, and only Paroo Shoal, Hastings Shoal and the End-of-Channel Shoal fall within the Zone of Partial Mortality. For seagrass, only the seagrass area northwest of Ashburton Island and small areas immediately east of Onslow and west of Coolgra Point fall within the Partial Mortality Zone, with no seagrass areas falling within the Total Mortality Zone. These results are consistent with findings from previous Pilbara dredging campaigns, in which ecologically important impacts are largely restricted to areas within 500 m of the dredged channel or disposal ground footprint (Stoddart and Anstee 2005).

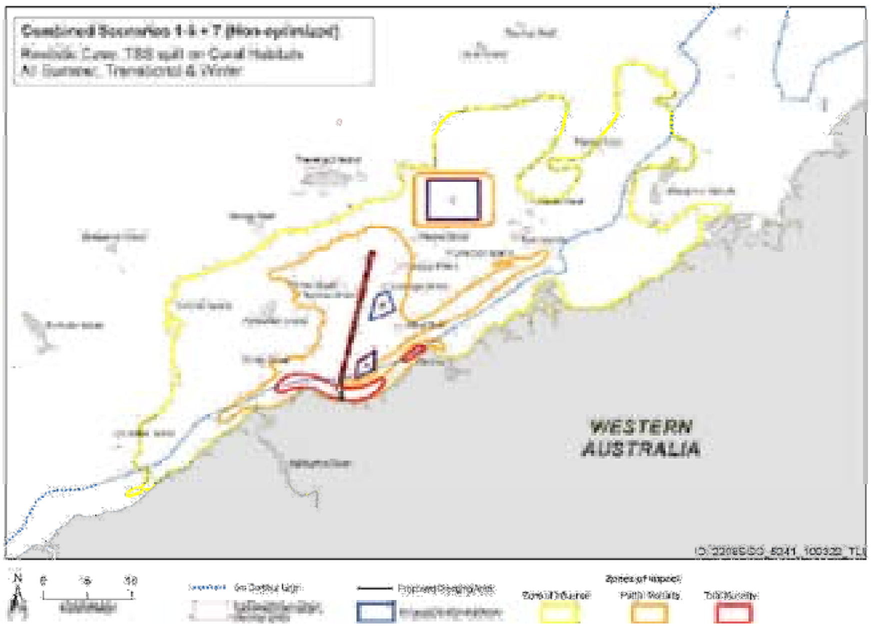

Figure 7-2: All Seasons Indicative Zones of Impact on Coral Habitats from Increased Turbidity (SSC)

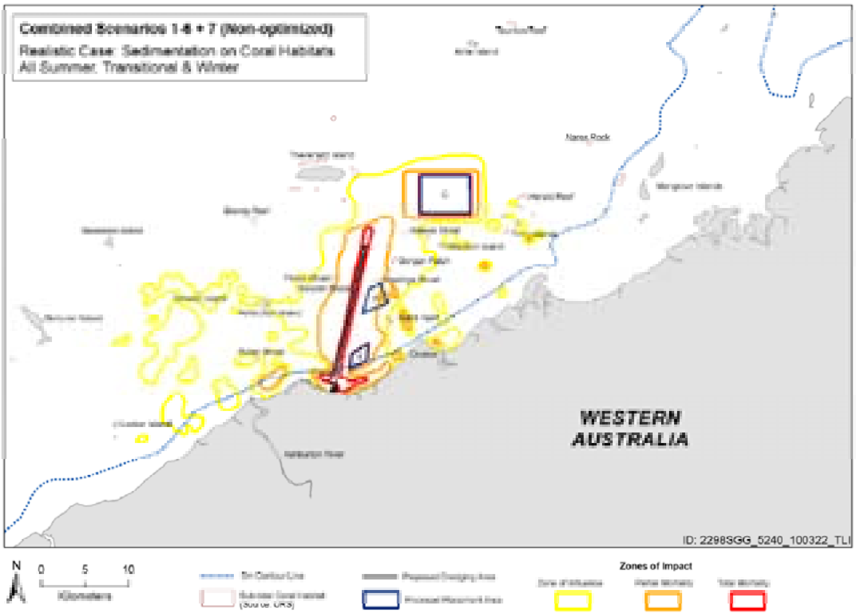

Figure 7-3: All Season Indicative Zones of Impact on Coral Habitats from Increased Sedimentation

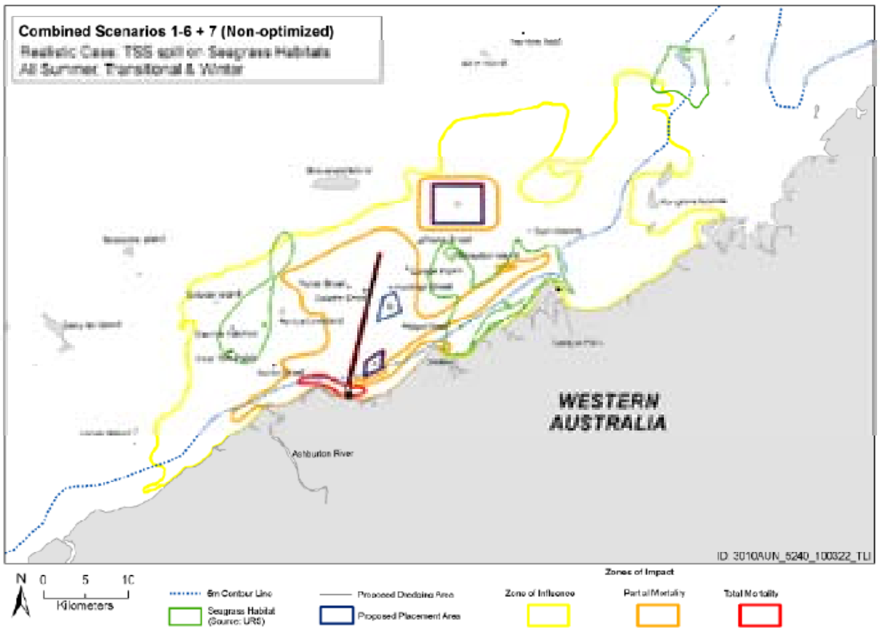

Figure 7-4: All Season Indicative Zones of Impact on Seagrass Habitats from Increased Turbidity (SSC)

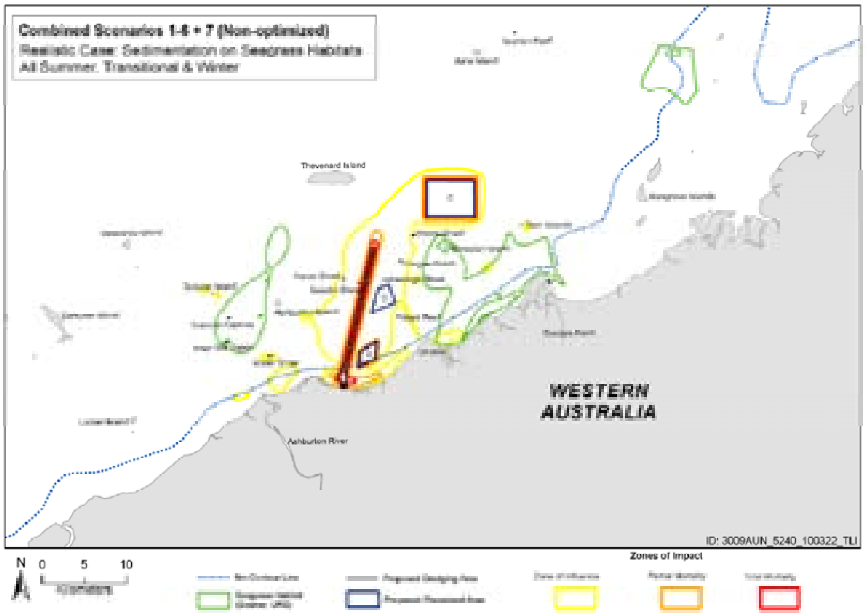

Figure 7-5: All Season Indicative Zones of Impact on Seagrass Habitats from Increased Sedimentation

Modelling predicts that the base case of non-optimised dredging may result in loss of 30% of coral communities that occur to the east of the navigation channel and 17.5% of those that occur to the west. These losses are likely to be reversible in the long term, but are considered irreversible for the impact assessment based on the five-year time frame specified for recovery in EAG 3. To reduce the scale of impacts on the coral shoals which occur within the partial impact zone, two restricted overflow zones will be established for the dredging program to protect the coral shoals on the 10 m isobath and to protect Ward Reef, as illustrated in **Figure 7-1.** Modelling of the Optimised Scenario 7A predicts a substantial reduction in the zone of partial mortality for corals and a minor reduction of impact on seagrasses and macroalgae (**Figure 7-6**). Chevron has therefore committed to adopting and ensuring that the dredging contractor implements the recommended “restricted overflow” zones. The predicted loss of BPPH from the optimised dredging scenario 7A is presented in **Table 7-3**.

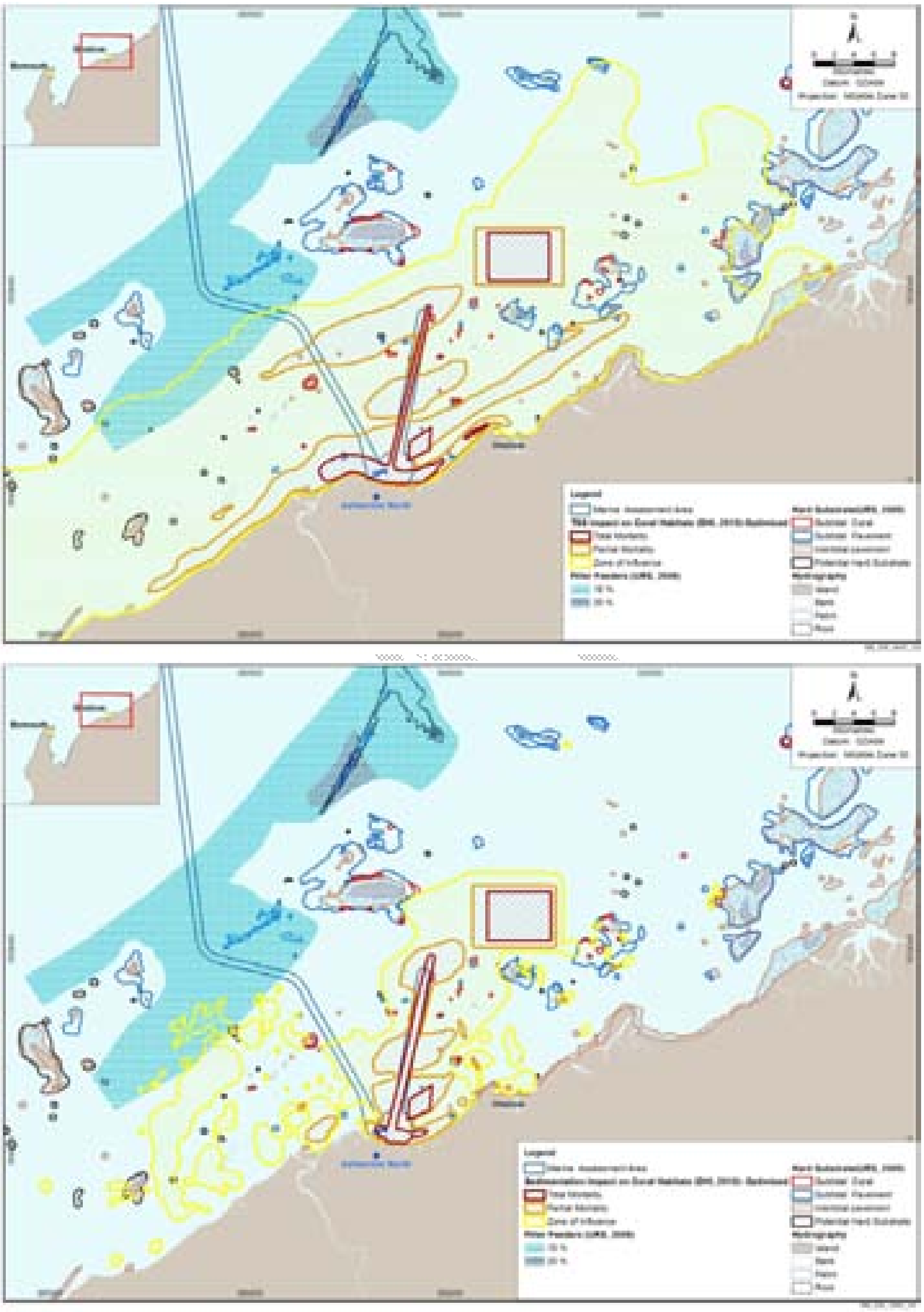

Figure 7-6: Optimised Scenario (1-6+7A): IZI Arising from Exceedance of Coral SSC (Top) and Sedimentation (Bottom) Tolerance Limits Overlain on Distribution of Coral and Filter Feeder Habitats

Table 7-3: Subtidal BPPH Loss Assessment Resulting From Exceedance 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
LAU 1A Corals east of channel	Corals	205	30 NW Ward, West of Beadon Pt, "End-of-channel Shoal.	0	**7.3%**
LAU 1B Corals west of channel	Corals	132	8 Saladin	0	**3%**
LAU 1C Sediments east of channel	Seagrass	10,151	2,570	0	**12.6%**
	Macroalgae	11,425	730	0	**3 %**
LAU 1D Sediments west of channel	Seagrass	3,430	102	0	**1.5%**
	Macroalgae	11,239	1,234	250	**7.7%**
LAU2G Sediments west of channel	Seagrass	1,451	291	0	**10%**
	Macroalgae	2,585	1,291	0	**25%**

Table duplicated from Chapter 8 of the EIS/ERMP

8.0 ENVIRONMENTAL MANAGEMENT

The management and mitigation measures presented within this section are conceptual and are to be confirmed by the project stakeholders prior to the

8.1 Water Quality and Benthic Primary Producer Habitat Management

8.1.1 Background

8.1.1.1 Overview

The management of BPPH with regards to potential impacts from elevated turbidity and sedimentation rates resulting from the dredging activities will focus on the management of hard corals (as representative subtidal BPPH) and mangroves.

Water quality will be monitored to provide an early warning of potential impacts to BPPH. Water quality will also be managed to meet the objectives of the Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006) as listed in **Table 1-1.**

8.1.2 Management of Subtidal BPPH

As described in **Section 6.5**, subtidal BPPH that may potentially be affected by the dredging and dredge material management activities include hard corals, seagrass and macroalgae. Of these, hard corals are considered to be the most sensitive to the impacts of excessive turbidity caused by the dredging and placement activities and will be used in dredge monitoring as indicators of any potential impacts to subtidal BPPH.

The management of potential impacts on hard corals from elevated turbidity and sedimentation levels resulting from the dredging and dredge material placement will be managed primarily through a tiered, responsive management approach that involves the collection of data on water quality to serve as an early warning of potential impacts on BPPH and collection of data on coral health, which are assessed against management trigger levels. The responsive monitoring and management approach includes:

- water quality monitoring;
- sedimentation monitoring; and
- receptor monitoring (coral health).

The aim of the responsive monitoring and management program will be to assess any potential impacts on water quality or hard coral communities and, in the event of unacceptable impacts, to implement a management response to minimise the risk of exceeding the limits of acceptable net hard coral loss. The limits of acceptable net coral loss for each zone described in **Section 7.0** are shown in **Table 8-1**.

Table 8-1: Limits of Acceptable Net Hard Coral Loss

Zone	Limit of Acceptable Net Coral Loss (%)
Zone of Permanent Loss (Total Mortality)	100%
Zone of Partial Loss (Partial Mortality)	50%
Zone of Influence (Visual, no ecological effect)	0%

In addition to the responsive management approach, additional monitoring and analysis is likely to be undertaken to develop predictive links between water quality and coral health to allow for refinement, where appropriate, of early warning criteria.

8.1.2.1 Responsive Monitoring and Management Approach

The responsive monitoring and management approach involves the collection of data on water quality which are assessed against early warning criteria, and coral health, which are in turn assessed against management trigger levels (**Table 8-2**). Early warning water quality criteria will be developed based on conservative levels, below the thresholds at which impacts to corals would be expected. Hard coral management triggers will be developed based on precautionary criteria aimed at preventing impacts on hard coral communities that exceed approved limits (**Figure 8-1**). These criteria and triggers will enable a tiered, responsive management structure to be implemented in the event that water quality or coral health monitoring indicates that unacceptable impacts are likely to be occurring (**Figure 8-1**). The tiered approach involves increasing levels of management as each trigger level is reached, with the aim of managing potential impacts before they reach the limits of acceptable hard coral loss.

Water quality data will be used primarily as an early warning to enable the implementation of additional or more frequent coral health monitoring aimed at recording any potential impacts of altered water quality on hard coral communities.

Water quality early warning criteria will be used to trigger additional or more frequent coral health monitoring in the Zone of Influence. Since it is predicted that altered water quality within the Zones of Total Mortality and Partial Mortality will have impacts on coral health, it is not practical to establish early warning water quality criteria for these zones.

Water quality early warning criteria within the Zone of Influence are likely to be based on the ranges of water quality characteristics experienced by BPP naturally. These will be established from baseline water quality monitoring as well as from information on BPP thresholds to altered water quality as determined through examination of the literature and experience in previous dredging projects in the region. Preliminary early warning criteria will be established prior to the commencement of dredging operations. It is likely that these criteria will be revised if water quality and coral health data become available during the dredging program and predictive relationships can be established.

Table 8-2: Example Coral Health and Water Quality Management Trigger Criteria

Zone	Level 1	Level 2	Level 3
Zone of Total Mortality (Permanent Loss)	N/A	N/A	N/A
Zone of Partial Mortality (Partial Loss)	>20% average[1] net[2] detectable coral mortality	>30% average[1] net[2] detectable coral mortality	>40% average[1] net[2] detectable coral mortality
Zone of Influence (Visual, no ecological effect)	Water quality criteria[3] exceeded for <HOLD> period of time	Water quality criteria[3] exceeded for <HOLD> period of time	Average[1] net[2] detectable coral mortality

[1]Average refers to the average mortality of corals across a number of sites (may include contingency sites) in the vicinity of the water quality exceedance.
[2] Net refers to the difference between levels of mortality recorded at the potential impact monitoring site and reference sites, to enable differentiation of potential dredging impacts from natural variation.
[3]Water quality criteria (turbidity) will be established prior to dredging using the full baseline water quality data set combined with existing information on coral tolerance thresholds to altered turbidity.

Sedimentation rates will be monitored at representative locations where sensitive receptors are located to assist in interpretation of potential impacts on receptors. However, since natural rates of acretion and removal of sediments are dynamic in north-western Western Australia and accurate measurements of sedimentation are not yet achievable with current technology (see **Section 9.2.2**), sedimentation data will not be formally assessed against management triggers.

8.1.2.2 Predictive Links Monitoring

The relationship between water quality and coral health is poorly understood for this region. As such, water quality trigger criteria used to manage potential impacts of dredging and dredge material placement activities on coral health are based loosely on a combination of background data and published information. The relationship between water quality and coral health will be investigated during the dredging program (following methods outlined in **Section 9.3**) and predictive relationships will be developed (where possible). This will be achieved through an ongoing analysis of water quality and coral health data from all responsive monitoring sites as well as additional sites located in areas where impacts are likely to occur (e.g. within the Zone of Total Mortality). Where predictive links can be developed between water quality and coral health, it may be possible to refine trigger values used in the responsive monitoring and management approach in order to more accurately manage potential impacts on sensitive receptors.

8.1.2.3 Impact Monitoring

Following the requirements of Environmental Assessment Guideline No.3 (EPA 2009) an assessment of BPPH is required prior to and following development activities to provide an estimate of the areal extent of BPPH loss that is attributable to the development. The Impact Monitoring program will be used to calculate the areal loss of BPPH attributed to both direct and indirect impacts of dredging and dredge material placement management activities, and to confirm whether the extent of loss exceeds predicted and approved limits (as described in

Table 8-1). Where BPP have been lost due to dredging and dredge material placement activities, but BPPH remains intact, Impact Monitoring will also assess the likelihood of recovery of lost BPP communities. The Impact Monitoring program is likely to involve the collection of data on a range of key subtidal BPPH types and associated BPP communities within the Project Area before and after development activities as per the methods outlined in **Section 9.4.**

Management Area:	**Management of Subtidal BPPH (Hard Coral)**
Performance Objective:	To comply with the draft Outcome-Based Condition XX as follows: *Draft ONLY at this stage* *"The Proponent will manage its dredging and dredge material placement activities, to prevent, as far as practicable, Project attributable losses of marine benthic primary producer habitats and communities so as not to exceed the levels of acceptable loss predicted in* ***Table 8.1****. Within this 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 organisms (including soft corals, macroalgae and seagrasses)."*
Management:	The water quality and BPPH management framework is described below and illustrated in **Figure 8-1**. **<u>Overview</u>** The management of water quality and associated potential impacts on sensitive BPPH will be managed via: ♦ Preventive management including: o General preventive management measures to be applied whenever practicable during the dredging and dredge material management activities. ♦ Responsive monitoring and management, including: o Continuous water quality monitoring within representative areas where hard coral communities occur. o Coral health monitoring within the Zone of Partial Loss, with an associated tiered management response. **<u>Preventative Monitoring and Management</u>** *<u>General Preventive Management</u>* ♦ TSHDs will be fitted with a turbidity reducing valve within the overflow pipe. ♦ Diffusers will be utilised during offshore dredge material placement via the CSD at placement Site A. ♦ Where reasonably practicable the works will be managed to optimise the under-keel clearance of the TSHD to reduce sediment re-suspension via propeller wash. ♦ During sediment transport by the TSHD and barges, the level of the overflow pipe will be raised to its highest point to ensure minimum spillage. ♦ Hopper doors on the TSHD and barges will be maintained to ensure minimum loss of sediment during transport. ♦ Well-maintained and properly calibrated dredging equipment will be utilised. ♦ Hopper dewatering will be confined to areas away from sensitive receptors where reasonably practical. ♦ A restriction of overflow from the TSHD should occur in the Restricted Overflow Areas (**Figure 8-2**) when sensitive receptors are at risk. The areas will vary depending on conditions and dredging operations. ♦ Impacts on BPPH will be limited by limiting anchoring by construction vessels within established 'no anchoring areas'.

The following mitigation measures will be implemented in the design and operation of the Dredge Material Placement Area (also refer to CEMP for mitigation measures related to construction activities):

- Discharge of decant water from the onshore reception area will be via two controlled points which will include the use of weir boxes to control water height. A target discharge quality of 250 mg/l will apply, however, this is likely to be refined based on feedback information from monitoring programs.
- Dredged material will be contained in a bunded area to prevent unconfined release of seawater and sediments.
- The placement of material into the sites will promote trapping of fines in the settled material and reduce the amounts of fines in suspension.
- Drainage of slurry water from the onshore placement area will be to the south away from the mangrove systems, therefore managing the potential impact from rising groundwater levels.
- 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.
- Onshore placement area bunds will be designed to withstand erosion during inundation events.
- Discharge of decant water from the onshore placement area will be pumped via a pipeline to the nearshore outfall location and not to mangrove systems within the Ashburton Delta.
- Water levels within the bunded area will be managed to avoid overtopping of the bunds, particularly during extreme rainfall events.

Responsive Monitoring and Management Procedures

Responsive monitoring and associated tiered responsive management will be implemented to manage any potential impacts that increased turbidity may have on sensitive BPPH. Responsive monitoring will consist of (**Figure 8-1**):

- Water quality and coral health monitoring to be carried out throughout the dredging program and following completion of dredging.
- Monitoring of decant water discharged from the onshore dredge material placement area to be assessed against discharge criteria (<250 mg/l TSS).
- Groundwater monitoring in the vicinity of the onshore dredge material placement area to detect an alteration of groundwater conditions that may indicate a potential impact on the Ashburton Delta system.

A tiered management response program associated with water quality and coral health monitoring will include assessment of monitoring data against trigger criteria (as per **Figure 8-1**), with trigger criteria established to minimise impacts on BPPH.

Water Quality Monitoring – Decant Water from Onshore Placement Area

Turbidity (NTU), pH, temperature, DO and conductivity are likely to be measured in the potential onshore dredge material placement area sump prior to decant water being pumped to the marine outfall. It is likely that these parameters will be measured in real-time on a daily basis at the point(s) of discharge either manually or using an in-situ data logger.

Any exceedance of water quality parameters within the sump would prompt an examination of the exceeding parameter at the closest monitoring sites to the marine outfall location, or manual examination of the parameter at a location between the discharge point and sensitive receptors.

Water Quality Monitoring – Sensitive Receptors

Continuous water quality monitoring in representative areas where key sensitive receptors are located will be undertaken throughout the duration of the dredging and dredge material placement works. Continuous water quality monitoring is likely to be achieved through the use of *in-situ* water quality data logging instruments. Refer to **Section 9.2.1** for further details of the water quality monitoring program. The results of the water quality monitoring will be:

- Used in the analysis of any observed impacts on BPP.
- Used in development of predictive relationships between water quality and coral health (**Section 9.3**).
- Compared to water quality trigger levels (**Section 9.2.1**), with an exceedance triggering contingency coral health monitoring in the Zone of Influence.

Coral Health Monitoring and Responsive Management

Coral health monitoring will consist of:

- Monitoring of coral health at X <Hold> sites within the Zone of Partial Mortality and a subset of X<Hold> reference sites.
- Monitoring of coral health at X <Hold> sites within the Zone of Influence and X<Hold> reference sites.
- Contingency monitoring at X <Hold> sites within the Zone of Influence and X<Hold> reference sites every XX

  frequency to be agreed

  if early warning water quality criteria are exceeded.

Refer to **Section 9.3** for further details of the coral health monitoring program.

The coral health trigger levels that will be applied are provided in **Table 8-2** Further details on the establishment of these trigger levels are provided in **Section 8.1.2.1**.

Potential Responsive Management Measures

The following measures will be considered for implementation in the event that any Level 1, 2 or 3 coral health management trigger is exceeded (as per **Figure 8-1**). It should be noted that the selection of the most appropriate management measure will be made based on the impact observed, including its temporal and spatial scale, metocean conditions, and the planned future dredging operations. Management measures that may be considered include:

- Apply tidal or seasonal windows for dredging sections of the dredging area.
- Redefine the zones in the channel where overflow by the TSHD is allowed.
- Move dredging operation to another location or temporarily cease in dredging activities.
- Reduce or stop overflow.
- Reduce or modify the production of the CSD.
- Increase the minimum under keel clearance for the TSHD when dredging in areas where propeller wash is a significant source of turbidity.
- Optimise disposal based on met-ocean conditions and location of affected BPPH.
- Reduce operations.
- Temporarily cease discharge from the reclamation area.

Monitoring:	♦ Responsive Monitoring (**Section 9.2**) ♦ Predictive Links Monitoring (**Section 9.3**) ♦ Impact Monitoring (**Section 9.4**)
Reporting:	♦ Monthly Monitoring Reports to the DEC (**Section 8.0**)
Risk Assessment	♦ Refer to **Appendix A** for the Risk Assessment Table. The Residual Risk rating for impacts on BPPH from the indirect impacts of the dredging and dredge material management activities is high.

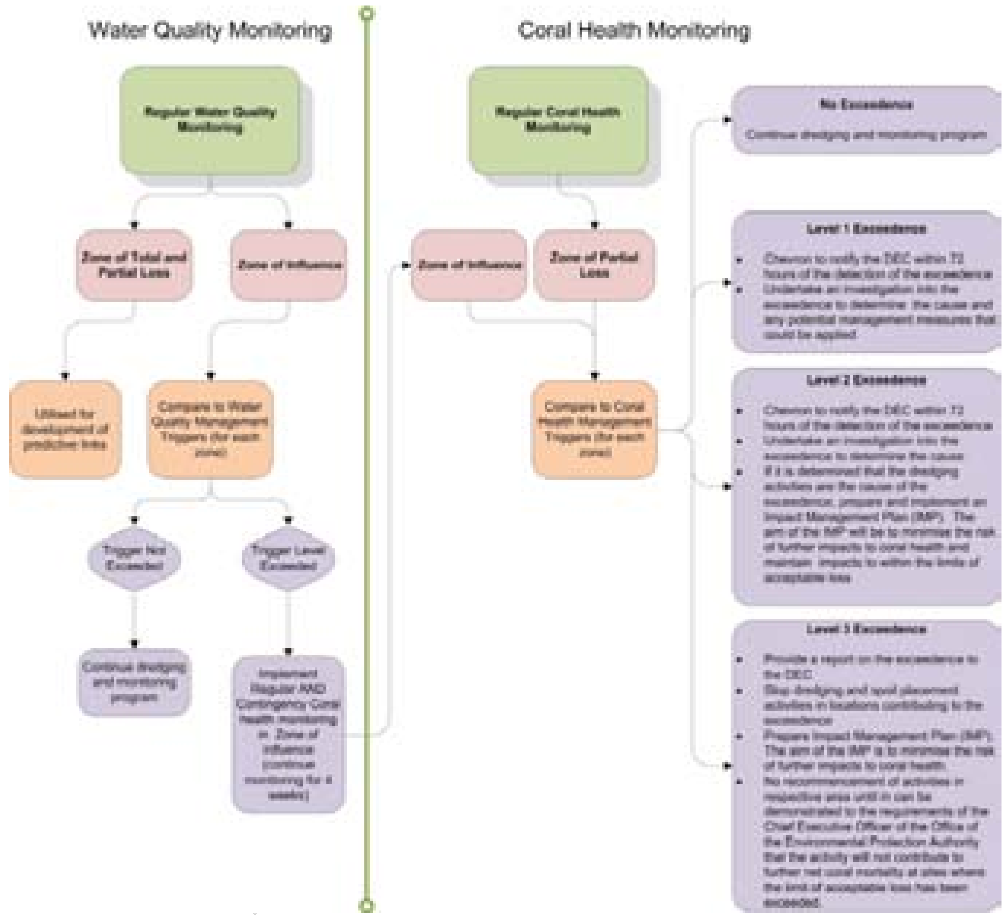

Figure 8-1: Responsive Monitoring and Management Procedure

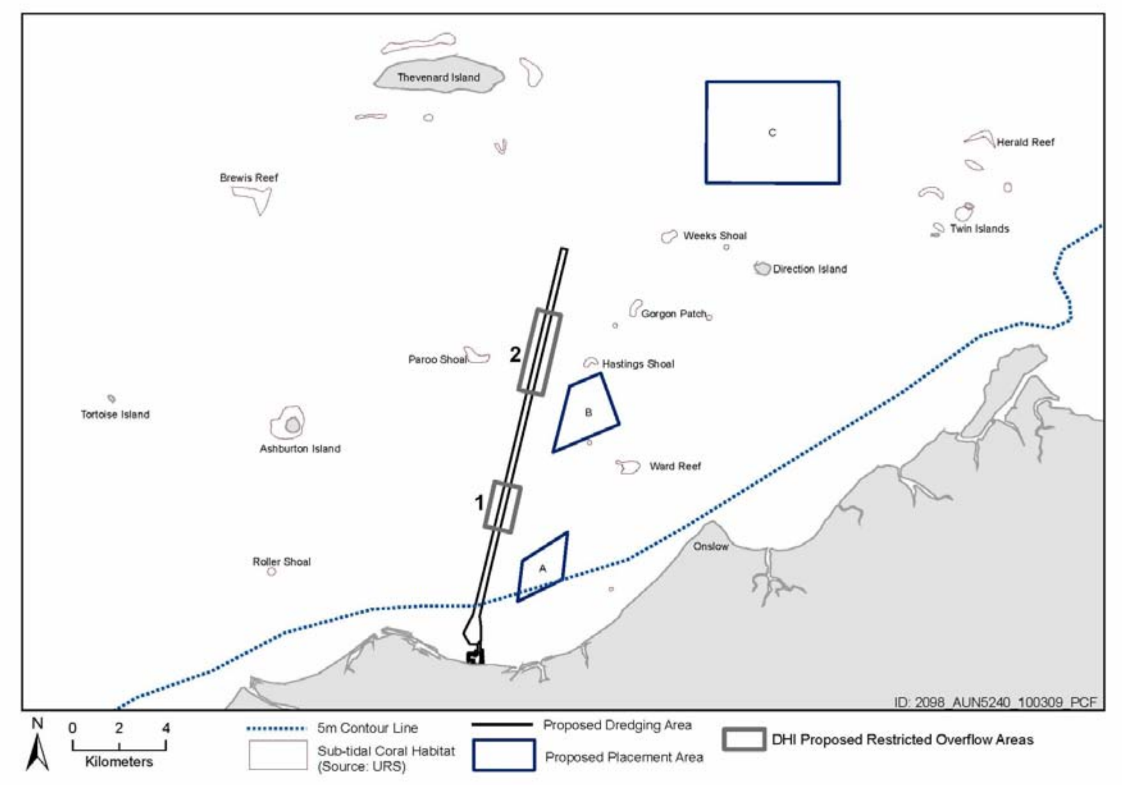

Figure 8-2: Trailing Suction Hopper Dredge (TSHD) Restricted Overflow Areas.

Figure is an example only as the areas will be moveable up and down the channel based on environmental conditions and dredging activities. Area 1: this restricted overflow area is required to protect Ward Reef during summer, and Roller Shoal during winter, though it could possibly be relaxed during the calm transitional periods. Area 2: this restricted overflow area is required to protect Hastings Shoal, Gorgon Patch and Weeks Shoal (and to a lesser extent Direction Island) during summer, and Paroo Shoal during winter and calm transitional periods.

8.1.3 Management of Mangroves

Management Area:	**Benthic Primary Producer Habitat (Mangroves) Management**
Performance Objective:	To comply with Outcome-Based Condition #XXX as follows: draft only, to be updated *"The Proponent will manage its construction and operation activities to prevent, as far as practicable, a demonstrable reduction in mangrove habitat aerial extent as a result of Project attributable impacts, within the East Ashburton Delta and Hooley Creek – Four Mile Creek systems. This will ensure:* ♦ *Not more than 5% long-term loss of mangrove habitat (as shown in Figure 2.1) 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* *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 East Ashburton Delta and Hooley Creek – Four Mile Creek systems.*

Management:	**Preventative Management**
	♦ Prior to the commencement of works, all personnel will be required to understand their environmental responsibilities in relation to the management of mangrove habitat.
	♦ Personnel with responsibilities in specific environmental practices will be adequately trained to enable effective implementation of work instructions and procedures.
	Responsive Monitoring and Management
	A comprehensive mangrove monitoring programme (**Section 9.5**) will be designed and implemented on the basis of the potential for change to mangrove health and mangrove habitat condition as a result of Project activities. Such changes are related, but not limited to:
	♦ Seepage impacts arising from the potential placement of dredge material onshore.
	♦ Alteration of groundwater conditions caused by onshore placement of material that may indicate a potential impact on the Ashburton Delta system.
	♦ Alteration of sedimentation/erosion patterns in mangrove areas as a result of:
	  ♦ modification of coastal processes;
	  ♦ movement of dredge plume into mangrove habitat;
	  ♦ liberation of sediment from cut/fill activities (e.g. during the reclamation of tidal flat areas on the west side of the Hooley Creek west arm);
	  ♦ potential movement of offshore-placed dredge material; and
	  ♦ potential movement of sediment during cyclone events.
	♦ leaks and spills of hydrocarbons or chemicals.
	♦ modification to tidal flows and tidal flat hydrology from the impoundment of the upper reaches of Hooley Creek (west arm) and some of the adjacent high tidal mud flats.
	♦ increased airborne dust.
	Dredging and dredge material placement activities will also be managed so as to minimise indirect impacts on mangrove estuarine condition, particularly within the Ashburton Delta system as per the Outcome-Based Condition. However, potential risk of indirect impacts of dredging and dredge material

	placement activities on this estuarine habitat are low due to the short duration that dredging activities will occur in close proximity to the estuary. The only potential for indirect impacts are when dredging operations are occurring at or close to the proposed MOF, and such temporary impacts are unlikely to have any significant impacts upon the estuary. Therefore, management of potential indirect impacts to the condition of this estuarine habitat through altered water quality or sedimentation will be adequately covered through the management of water quality outlined in **Section 8.1.2.** The monitoring program will be carried out on a quarterly basis and will include: ♦ Surveying the areal extent of mangroves loss to provide clear spatial delineation of the extent of direct and indirect impacts on mangroves for comparison against baseline mangrove habitat distribution. ♦ Monitoring of early warning indicators of change in mangrove health and mangrove habitat condition cover based on the cause and effect pathways for physical and biological stressors, associated with the implementation of the proposal, on mangroves and the key processes maintaining mangroves. Quantitative monitoring measures may include: mangrove tree species composition and tree density; mangrove tree health (canopy density and/or tree condition data); groundwater/soilwater salinity and water table depths; sediment heights and ground levels; and hydrocarbon and heavy metals concentrations in mangrove sediments and selected mangrove fauna. In the event that monitoring indicates that the loss of mangroves exceeds the allowable limits prescribed in Ministerial Conditions, Chevron will: 1) report such findings to the Chief Executive Officer of the EPA within 21 days of receipt of an internal monitoring report confirming such findings. 2) provide evidence which allows determination of the cause of the mangrove habitat decline.
Monitoring:	♦ Mangrove Ecosystem Monitoring Program (**Section 9.5**).
Reporting:	♦ Annual Mangrove monitoring reports.
Risk Assessment	♦ Refer to **Appendix A** for the Risk Assessment Table.

8.2 Marine Fauna Management

8.2.1 Background

8.2.1.1 Marine Mammals

Refer to **Section 6.5.2.3** for details on marine mammals that may be present within the Project Area. The management of marine mammals will focus on the species most likely to be sighted (humpback whales and dugongs) and will primarily involve observation and avoidance measures to minimise the risk of vessel interaction with these species. Note that with respect to dolphins, their mobility and intelligence means the risk of impact is negligible, and the observation and avoidance procedure will not apply.

8.2.1.2 Turtles

Refer to **Section 6.5.2.2** for details on turtle species that may be present within the Project Area. The management of turtles will primarily involve measures to minimise the risk of entrapment/entrainment of the turtles within the dragheads of the TSHD.

8.2.2 Management: Humpback Whales and Dugongs

Management Area:	**Marine Fauna Management (Humpback Whales, Dugongs and Turtles)**
Performance Objective:	To comply with Outcome based Ministerial Condition XX as follows: *"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.* *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."*
Management:	Impacts to marine fauna (humpback whales, dugongs and marine turtles) from increased turbidity and sedimentation (e.g. direct behavioural impacts or indirect impacts through alteration of foraging habitats) are managed via **Section 8.1**. ♦ Prior to commencement of dredging and dredge material placement, selected crew will receive training in marine fauna observations. ♦ Personnel trained in marine fauna observations will be used to monitor key activities. ♦ All Project vessels will keep a log of observed in-water incidents or reportings of injured/dead marine fauna. ♦ Any deaths of marine fauna listed under Section 14(2)(ba) of the *Wildlife Conservation Act (1950)* will be reported to the DEC. <u>Striking impact on Humpback Whales and Dugongs</u> ♦ Humpback whale and dugong observations and response procedures including application of 300 m observation zone and 100 m exclusion zone will be implemented during dredging and dredge material disposal works as outlined in **Figure 8-3.** ♦ Dolphins' mobility and intelligence mean they are more likely to move out of the dredge area more quickly and therefore dolphin sightings within the 500 m observation zone or 100 m exclusion zone will not trigger a 'do not commence' or 'stop dredging' response. Dolphin sightings will be managed on a case by case basis depending on the dolphins' location relevant to specific dredge equipment. ♦ The presence of cetaceans/dugongs in or near exclusion zones established for key dredging and construction activities will be recorded. ♦ All sightings of humpback whales or dugongs that result in management measure being implemented will be recorded. ♦ A trained crew member will maintain a watch, during daylight hours, for humpback whales and dugongs while any dredge is on route to and from the dredge area to disposal grounds. If sighted, direction/speed will be adjusted to avoid impact (within the safety constraints of the vessel). ♦ Management of cetacean interactions will be in accordance with the requirements for cetacean interactions specified under Part 8 of the EPBC Regulations 2000 (Cth) and the Australian National Guidelines for Whale and Dolphin Watching. <u>Entrainment impacts on Marine Turtles</u> ♦ When operating with less than 5 m under-keel clearance, the dredge will initially move slowly through the area before commencing dredging so that the noise and vibration alerts marine turtles in the vicinity and encourages them to leave. This will only be applied on dredging in new areas and not once the work area has been established.

	♦ When initiating dredging, suction through dragheads will be initiated just long enough to prime the pumps, prior to the dragheads engaging the seabed. ♦ Dredge pumps will be stopped as soon as possible after completion of dredging and where practical the draghead will remain within 4 m of the seabed until the dredge pump is stopped. <u>Workforce recreational impacts on Marine Turtles</u> ♦ 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.
Monitoring:	♦ Water quality monitoring (**Section 9.2**). ♦ Humpback whale, dugong and marine turtle observations throughout the works.
Reporting:	♦ Humpback whale, dugong and marine turtle sightings resulting in management measures being implemented will be recorded. ♦ Marine mammal injury or mortality incidents will be reported to the DEC and DEWHA.
Risk Assessment :	Refer to **Appendix A**. The Residual Risk rating for impacts on marine fauna is Low.

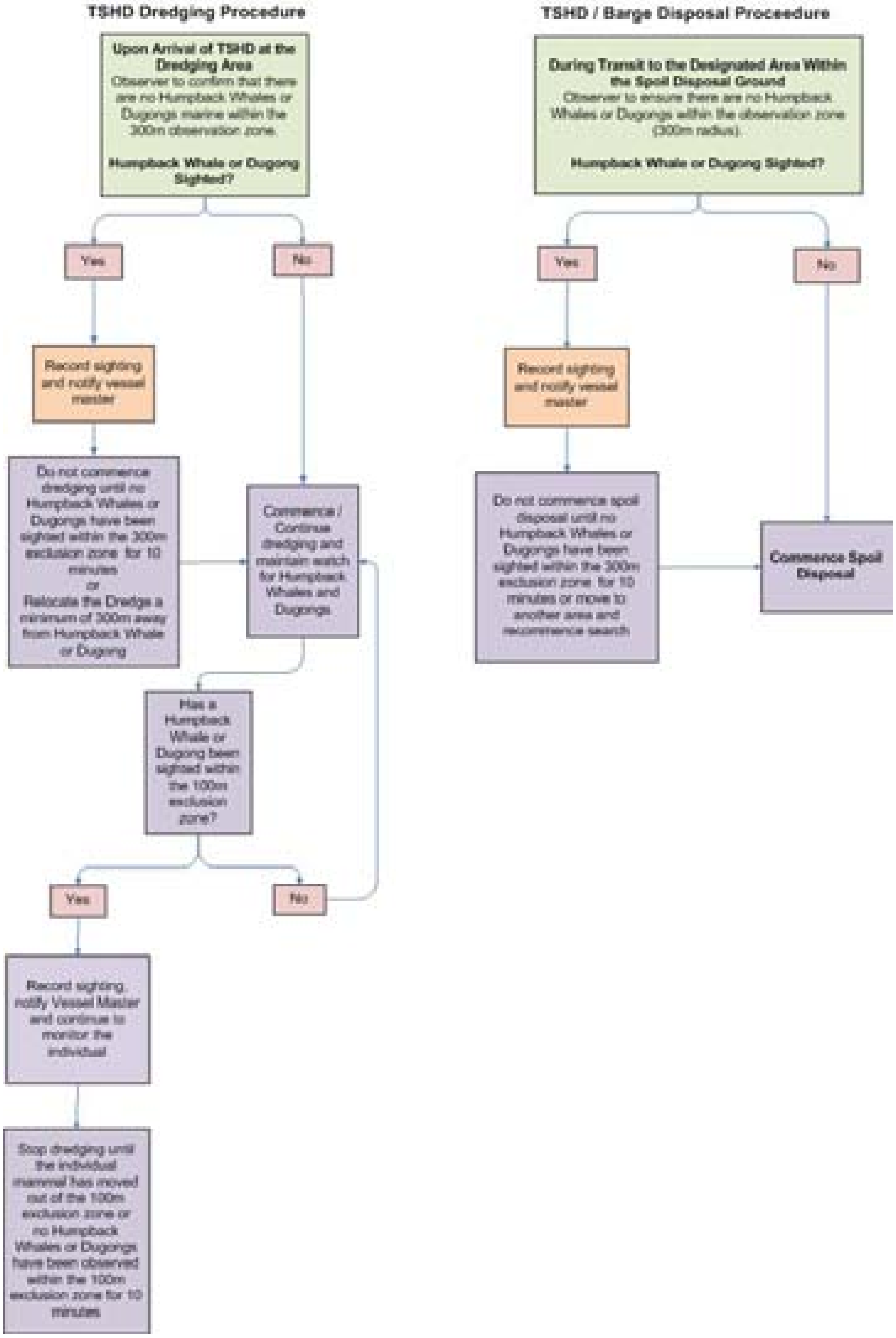

Figure 8-3: Humpback Whale and Dugong Interaction Procedures

8.3 Introduced Marine Pest Management

8.3.1 Background

Introduced marine pests are biota that are translocated into water outside of their natural distribution ranges, settle and survive in the new area and subsequently form a component of the habitat into which they spread and compete for space and resources with naturally occurring species.

As construction vessels are generally mobilised to Western Australian dredging projects from areas outside of the applicable bioregion, they present a key risk pathway as a vector for the introduction of marine pests. Common high risk niche areas capable of translocating invasive marine species on dredge vessels and dredge associated vessels include:

- ballast tanks
- vessel hull and external niches (e.g. propellers, thrusters)
- internal seawater systems(e.g. seachests and seawater strainers)
- immersible equipment including dredge equipment (trailing pipes, dragheads and anchors) and
- ballast water and sediments.

8.3.2 Management: Introduced Marine Pests

Management Area:	**Introduced Marine Pests (IMP) Management**
Performance Objective:	To comply with Outcome Based Ministerial Condition XX as follows: "*The proponent will manage the dredging and dredge material management works so as to prevent the introduction to and establishment of marine pests in the waters adjacent to the proposal'*
Management:	<u>Mobilisation Procedure</u> The primary focus for the management of introduced marine pests (IMP) will be to reduce the risk of IMP introduction by construction vessels prior to their mobilisation to the project. To achieve this, the construction vessel mobilisation procedure, where reasonably practicable, shall be implemented as follows: ♦ All construction vessels will be subjected to a risk assessment to determine if the vessel presents a low, uncertain or high risk vector for IMP. The risk assessment will be based on the vessel's origin, recent history and vessel maintenance since the previous fouling control coating application (FCC) and whether it will be undertaking a direct sail from its point of origin. ♦ All construction vessels determined to be uncertain or high risk will be subjected to a pre-mobilisation inspection and will not be mobilised until the vessel is assessed as being a low risk. In the event that IMP are identified on the vessel during the pre-mobilisation inspection, the vessel will undergo treatment and re-inspection to the satisfaction of the DoF. ♦ Those vessels which do not mobilise immediately and directly to the operational area may be subject to additional risk assessments and management requirements which may include arrival inspection within 48 hours of arrival on site . ♦ Vessel inspections will be undertaken as detailed in **Section 9.6.** ♦ The Revised Coordinating Committee for Introduced Marine Pest Emergencies (CCIMPE) Trigger List (2006) will be used as the basis for the identification of an invasive marine species. However, inspection and management response may be undertaken with respect to unlisted

	species. ♦ All dredges will comply with the Australian Quarantine regulations 2000 and will comply with the AQIS mandatory ballast water requirements. Contingency Management In the event that IMP are identified on the construction vessel during the arrival inspection or at any time while the construction vessel is on site: ♦ The DoF and DEC will be notified. ♦ The construction vessel will be moved offshore as soon as practicably possible. Within vessel operating constraints, the construction vessel should be moved to offshore waters greater than 12 nm/50 m depth. ♦ The construction vessel will not be permitted to return to site until it has undergone treatment and re-inspection to confirm that the vessel is a low risk. The mobilisation procedure described above will be required to be followed including the mandatory arrival inspection with 48 hours of arrival on site. ♦ A detailed response plan including monitoring and control measures will be developed and implemented. This plan will aim to determine if the identified species has become established and if measures to control the species are required.
Monitoring:	♦ Pre-mobilisation and arrival IMP inspections as required (**Section 9.6**). ♦ Monitoring program to determine establishment of IMP to be developed in the event that invasive marine pests are identified during construction vessel inspections.
Reporting:	Specific details of the requirements of these reports are included in **Section 8.0** of the EIS/ERMP. ♦ Construction vessel risk assessment provided to DoF/DEC prior to mobilisation of vessel. ♦ Vessel inspection checklist provided to DoF/DEC of any construction vessel inspection. ♦ Pre-mobilisation "Assessment Report" for all construction vessels, including results of risk assessment, vessel history and IMP inspection results to the DoF/DEC. ♦ Incident report to be provided to the DoF/DEC in the event that IMP are identified on a construction vessel within Western Australian State Waters. ♦ Report requirements associated with the IMP response plan will be determined.
Risk Assessment :	*Pending Risk Assessment Finalisation*

8.4 Management of Potential Acid Sulphate Soils (PASS)

Information presented to be confirmed with terrestrial team

8.4.1 Background

Potential acid sulphate soils (PASS) require dredging and disposal as part of the development of the MOF. Oxidation of PASS material has the potential to impact on soil and water quality and may release sulphuric acid and heavy metals into the marine environment.

8.4.2 Management: Potential Acid Sulphate Soils

Management Area:	**Management of Potential Acid Sulphate Soils (PASS)**
Performance Objective:	To comply with Outcome Based Ministerial Condition XX as follows: "*The proponent will manage the onshore dredge material management works so as to meet the overall water quality criteria in accordance with the State Water Quality Management Guidelines (SWQMG) and the Pilbara Water Quality Management Guidelines (PWQMG)"*
Management:	The primary measure for the management of PASS material is likely to be the disposal of all such material at a nearshore dredge material placement area. To achieve this objective, PASS material would be dredged using the CSD and pumped directly to the nearshore placement site. This method would ensure that the PASS material does not oxidise, thus significantly reducing the risk of adverse impacts occurring. While the risk is considered minimal, there is potential for some minor amounts of PASS material to be placed within the onshore placement area if this option is utilized. A PASS monitoring program will be implemented and will include: ♦ Monitoring of pH of the placement area discharge waters. ♦ Monitoring of the material within the placement area to determine if actual acid sulphate soil conditions have developed. Monitoring results will be compared against the Department of Environment and Conservation (2009) action criteria for acid sulphate soils (ASS). Where the action criteria are reached or exceeded: ♦ Management of disturbed PASS will occur utilising best management practice methods (e.g. targeted lime dosing), as outlined in the Construction Environmental Management Plan (CEMP). ♦ Monitoring of pH in the receiving environment will occur.
Monitoring:	♦ Monitoring of pH in onshore placement area soils and discharge waters. ♦ Monitoring of pH in receiving environment waters in the event of an exceedance.
Reporting:	♦ Exceedance of DEC action criteria will be reported to the DEC.
Risk Assessment:	Refer to **Appendix A**. The Residual Risk rating for impacts from the dredging of PASS is Low.

8.5 Dredge Material Placement Area Management

8.5.1 Background

The nearshore and offshore dredge material placement areas that will be utilised are shown in **Figure 4-3**. The management of environmental impacts associated with the onshore placement of dredged material are covered in **Section 8.1** (Water Quality and Benthic Primary Producer Habitat Management) and **Section 8.4** (Potential Acid Sulphate Soil Management).

The requirements with respect to the management of the dredge material placement area and offshore dredge material disposal activities will be specified in the Sea Dumping Permit (SDP).

8.5.2 Management: Dredge Material Placement Area

Management Area:	**Dredge Material Placement Area Management**
Performance Objective:	To undertake the dredging and dredge material management activities in accordance with the requirements of the SDP.

Management:	Compliance with the requirements of SDP including:
	♦ Establish by Differential Global Positioning System (DGPS) that immediately prior to dredge material placement, the vessel is within the approved dredge material placement area.
	♦ Any dredge used in connection with the disposal activities and any associated towing vessels must comply with the relevant state, national or international standards with respect to seaworthiness, safety and environmental requirements, or any rules or conditions laid down by the certifying classification society, and be capable of disposing dredged material at the dredge material placement locations in accordance with the SDP.
	♦ Marine mammal management procedures as detailed in **Section 8.2** will be followed during dredge material placement activities.
	♦ Records comprising either weekly plotting sheets or a certified extract of the ship's log will be retained (for verification and auditing purpose), which detail:
	    ♦ the times and dates of when each dredge material placement run is commenced and finished;
	    ♦ the position (as determined by DGPS) of the vessel at the beginning and end of each dredge material placement run, with the inclusion of the path of each dredge material placement run; and
	    ♦ the volume of dredge material (in cubic metres) moved to the placement area and quantity in dry tonnes for the specified operational period. These quantities will be compared with the total amount permitted under the SDP.

Monitoring:	A bathymetric survey of the dredge material placement areas will be undertaken: ♦ Prior to the commencement of dredging. ♦ Within two months of the completion of all dredge material placement activities authorised under the SDP.
Reporting:	♦ Within two months of the final bathymetric survey a digital copy of each of the bathymetric surveys will be provided to the Royal Australian Navy

	hydrographer. ♦ To facilitate annual reporting to the International Maritime Organisation (IMO), the proponent will report to the DEWHA by 31st January each year, including on the day of the expiry of the SDP or completion of all dredging under the SDP, information as specified in Schedule 2 of the SDP.
Risk Assessment:	Not applicable

8.6 Waste Management

8.6.1 Background

The unintentional or uncontrolled release of waste material (solid, liquid, hazardous and sewage wastes) can adversely impact on the marine environment. The discharge of wastes into the marine environment is regulated by the *Protection of the Sea* (*Prevention of Pollution from Ships) Act 1983 (Cth*) which is based on the MARPOL 73/78 Convention Annex IV (sewage) and Annex V (Garbage) to which Australia is a signatory.

The management of wastes will be undertaken in accordance with the Wheatstone Project Waste Management Plan (WMP).

8.6.2 Management: Waste Management

Management Area:	**Waste Management**
Performance Objective:	Minimise the risk of impact on the marine environment as a result of waste materials generated by the dredging and dredge material management activities
Management:	♦ Implementation of Wheatstone Project WMP. ♦ Adherence to the requirements of the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (Cth)* and MARPOL 73/78 Convention Annex IV (sewage) and Annex V (Garbage).
Monitoring:	Not Applicable.
Reporting:	As per the Wheatstone Project WMP.
Risk Assessment:	Refer to **Appendix A** for the Risk Assessment Table. The Residual Risk rating for impacts of waste from the dredging and dredge material management activities is Low.

8.7 Hydrocarbon Management

8.7.1 Background

The operation of vessels engaged in the dredge program and in support of the program requires adherence to a number of standards in relation to effective minimisation of the risk of hydrocarbon spills and the mitigation of spills into the marine environment.

Hydrocarbons (including diesel fuel, hydraulic oils, engine oils, greases and lubricants) are used and handled everyday during the dredging operations. The accidental release of these substances presents a potential risk to the environment. The main potential sources of release of hydrocarbons into the marine environment are:

- grease
- diesel spills during refuelling (bunkering)
- hydraulic oil spills due to equipment failure (e.g. burst hydraulic hose)
- incorrect storage and handling of hydrocarbons
- release of oily bilge waters
- contaminated deck wash.

8.7.2 Management: Hydrocarbons

Management Area:	**Hydrocarbon Management**
Performance Objective:	Minimise the risk of impacts to the marine environment as a result of accidental spills of hydrocarbons from dredging and support vessels.

Management:	♦ Hazardous material storage areas will be designed to handle the volumes and operating conditions specifically required for each substance, including product identification, transportation, storage, control and loss prevention (e.g. bunding and drainage).
	♦ Industry standards, port authority and pollution prevention regulations will be adhered to during refuelling, transfer, storage and handling of hazardous materials (e.g. bunding, level gauges, overflow protection, drainage systems and hardstands).
	♦ Hazardous materials (including hazardous waste) will be stored in appropriately labelled drums or tanks. Complete up to date list of MSDSs will be available and stored with relevant products.
	♦ The hydraulic oil system will be of a high quality, well maintained and regularly inspected.
	♦ The main hydraulic system on each dredging vessel will be equipped with standard low pressure alarms and shut down systems to minimise hydrocarbon loss in the event of a burst hydraulic hose.
	♦ Detailed refuelling procedures will be developed by the dredge contractor prior to commencement of work on site and will include the following requirements:
	  ♦ Fuel transfer to occur in accordance with port authority and pollution regulations;
	  ♦ Specific safety boundaries used when refuelling;
	  ♦ Requirement of refuelling to be undertaken in fair weather conditions to reduce risk of spills;
	  ♦ Requirement for open communication channels to be maintained during refuelling;
	  ♦ Instructions for visual monitoring; and
	  ♦ Emergency response procedures.
	♦ Personnel involved with refuelling or fuel transfer will be trained in their

	roles, functions and responsibility, including emergency response prior to engaging in refuelling or fuel transfer.
	♦ All vessels greater than 400 gross tonnage will have bilge oil/water separators that comply with the requirements of Annex I of MARPOL 73/78 and Part II of the *Protection of the Sea (Prevention of Pollution from Ships) Act 1993* (Cth) to ensure that oil concentrations in discharges are less than 15 ppm.
	♦ Drainage from decks and work areas with potential for oil, grease or hydrocarbon contamination will be collected and processed through an oil/water separator and managed according to International Oil Pollution Prevention (IOPP) procedures prior to discharge or stored for onshore placement.
	♦ Sufficient and appropriate equipment, materials and resources will be available to:
	  ♦ prevent spills to marine environment from working machinery (e.g. spill trays, one-way valves or other spill prevention features);
	  ♦ respond to spills to the marine environment; and
	  ♦ respond to spills to ground (on board vessels).
	♦ The dredge contractor will comply with and align spill response preparedness with the Chevron Oil Spill Contingency Plan (OSCP).
	♦ All relevant personnel will be trained in spill response and reporting.
	♦ All vessels will have a current International Oil Pollution Prevention Certificate (IOPP) issued by the State in which the vessel is registered and an approved Shipboard Oil Pollution Emergency Plan (SOPEP).
	♦ If vessel does not have an existing approved SOPEP the vessel will prepare a vessel specific Spill Contingency Plan (SCP) that bridges to the Chevron OSCP to ensure an effective, integrated response to any spill.
	♦ Onboard spills will be contained and cleaned up immediately and will not be washed overboard. Product MSDSs will be adhered to during clean-up.

Monitoring:	♦ Audits of each vessel hydrocarbon handling procedures and equipment including spill kits will be undertaken on a regular ongoing basis.
Reporting:	♦ Spills will be documented and reported in accordance with the Chevron Incident Reporting Procedure.
Risk Assessment:	Refer to **Appendix A** for the risk assessment table.

9.0 MONITORING AND INSPECTION PROGRAMS

9.1 Overview

Monitoring programs detailed below are conceptual at this stage and are under development. Further details of monitoring programs will be provided in later revisions of the DSDMP.

Monitoring and inspection programs will consist of the following elements:

- Responsive monitoring;
- Predictive links monitoring;
- Impact monitoring;
- Mangrove ecosystem monitoring; and
- Introduced marine pest inspections.

Potential impacts of dredging and dredge material placement activities on water quality and BPPH will be managed through a responsive monitoring program, consisting of data collection on water quality and the health of hard corals.

Predictive links assessments will be undertaken to potentially assist in the understanding of the relationship between water quality and coral health and to enable, where possible, a refinement of water quality early warning criteria.

BPPH Loss Assessment Monitoring will be undertaken to investigate whether losses of BPPH and associated BPP communities are due to dredging and dredge material placement activities are within approved limits (as per Table X)

table of approved losses to be included upon finalisation of Outcome Based Condition

Impact monitoring will also assess the nature of these losses or changes in BPP communities, and the potential for recovery of any changes. BPP communities will be monitored prior to, and following the completion of dredging activities.

Mangrove ecosystem monitoring will be undertaken to assess and manage potential impacts to the mangrove area. The primary function of the monitoring will be to assess any impacts from the dredging operations. If onshore placement occurs, monitoring will occur adjacent to the Onshore Material Placement Area to examine potential impacts from the onshore placement (such as local alteration of the water table) and discharge of excess water used in the pumping of dredge material to the reception area. However, regardless of whether onshore placement occurs, mangrove monitoring will be undertaken to examine potential impacts of construction activities, as per the CEMP.

9.2 Responsive Monitoring and Management

Throughout the dredging and dredge material management period, monitoring will be undertaken to assess ongoing potential impacts of the dredging and dredge material management activities on water quality and coral health. Responsive monitoring will consist of the collection of data on water quality and coral health to be formally assessed against management triggers as outlined in **Section 8.1**. Responsive monitoring will also be reliant upon data collected during the baseline period in order to establish trigger values that are based on background data.

This section outlines the monitoring and measures that may be undertaken as part of a responsive monitoring strategy.

9.2.1 Water Quality Monitoring

9.2.1.1 Objectives and Approach

The key objective of the water quality component of the responsive monitoring program is to provide an early warning of potential impacts on hard coral communities due to suspension of sediments caused by dredging, offshore dredge material disposal and discharge of excess water generated through the potential onshore placement of material.

Continuous water quality monitoring is likely to be undertaken at sites where sensitive receptors have been identified and may be potentially impacted by dredging or dredge material management activities. Where possible, water quality monitoring sites are likely to include those used for baseline studies to allow the use of site-specific baseline data against which to monitor potential changes due to dredging and disposal activities.

Water quality data collected from sites located within the Zone of Influence will provide an early warning of potential impacts on coral communities within this zone. Since no coral mortality is expected to occur (nor likely to be approved) within the Zone of Influence, water quality data from these sites can be assessed against management trigger criteria. An exceedance of trigger criteria would prompt contingency measures, such as additional coral health monitoring, in order to closely monitor and avoid potential impacts to coral health within this zone.

It is predicted that water quality within the Zones of Total Mortality and Partial Mortality will be altered to an extent where corals will suffer mortality. Therefore, it is not considered appropriate that water quality criteria be established for these zones (as opposed to the Zone of Influence, where no impacts on coral health are predicted, or likely to be allowed under Ministerial Conditions, and for which formal triggers will be established). However, water quality data from these zones will be useful for developing predictive relationships between water quality and coral health where coral impacts are observed to occur, and for refinement of management trigger criteria that are used to manage water quality within the Zone of Influence (see predictive links monitoring, **Section 9.3**).

Excess water generated by the pumping of dredge material to the onshore material placement area, if used, is likely to be monitored in real-time at the point of discharge to avoid potential impacts to the receiving environment caused by physical and chemical processes that may occur during the pumping of material and settlement within the onshore material placement area. An exceedance of water quality parameters at the point of discharge would lead to an examination of water quality at or before monitoring sites where sensitive receptors have been identified.

9.2.1.2 Parameters

Key water quality parameters that may be measured and used in the management of dredging and offshore dredge material management activities are turbidity (measured in nephelometric turbidity units - NTU) and light climate (photosynthetically active radiation – PAR). Turbidity provides an indirect measure of the alteration of the light climate received by BPP communities as a result of the suspension of sediments caused by dredging or dredge material disposal. The quanta of light received by BPP, measured in PAR, is a more direct measure of changes in water quality that may affect BPP. However, this measure must also be combined with turbidity data in order to relate changes in light climate to the suspension of sediments caused by dredging or disposal activities.

Temperature may also be measured at monitoring sites where hard coral communities occur in order to document any natural thermal anomalies that may cause impacts on coral health (bleaching). These data will assist in differentiating impacts from natural thermal anomalies from potential impacts caused by dredging or dredge material management activities.

Water quality parameters that may be measured in order to manage potential impacts of the discharge of excess water from the potential onshore dredge material placement area include: turbidity (NTU); pH; temperature; dissolved oxygen (DO); and salinity (conductivity). Turbidity is likely to be altered by the pumping and placement of dredge material to the onshore dredge material placement area, which will result in the suspension of sediments. The pH of excess water may be significantly lowered if acid sulphate soils (ASS) form within the onshore dredge material placement area. If discharged into the receiving environment, waters of lowered pH may be detrimental to biological receptors.

The settlement and ponding of water within the dredge material placement area may potentially result in heating of the excess water through solar radiation and high air temperatures. This may have subsequent effects on DO levels within excess water. Additionally, the ponding of excess water may cause an increase in evaporation rates which may lead to increased salinity (measured as conductivity). Any extreme alteration of these parameters may affect biological receptors when excess water is discharged from the onshore dredge material placement area into the receiving environment.

9.2.1.3 Data Collection

Water quality data are likely to be collected continuously at representative sites where sensitive BPP receptors are located.

Turbidity and light data are likely to be collected using *in-situ* loggers which will record the turbidity regime and light received by BPPH at representative sites on a daily basis.

Water temperature will not be affected by dredging and offshore dredge material disposal, but there have been recorded instances in the Pilbara region of changes in coral health, including bleaching and partial morality, due to natural thermal anomalies (MScience 2008). Therefore, it is likely that temperature would be recorded at all monitoring sites where hard coral BPP are located, in order to differentiate potential dredging and dredge material disposal impacts on coral health from natural thermal events.

Turbidity, pH, temperature, DO and salinity are likely to be measured in the potential onshore dredge material placement area sump prior to decant water being pumped to the marine outfall. It is likely that these parameters will be measured in real-time on a daily basis at the point(s) of discharge either manually or using an *in-situ* data logger. Any exceedance of water quality parameters within the sump would prompt an examination of the exceeding parameter at the closest monitoring sites to the marine outfall location, or using a manually-operated probe to measure the parameter at a location between the discharge point and sensitive receptors.

Measurements of metocean conditions will also be available for use in the interpretation of changes in water quality and coral health. These measurements would be used to identify important influences on dredging activities or causes of observed exceedances and may include parameters such as current direction or wave height.

9.2.1.4 Analysis and Reporting

All data will be subjected to rigorous quality assurance and quality control (QA/QC) procedures. Due to issues with bio-fouling of equipment, a regular maintenance schedule is likely to be implemented and all loggers likely to be retrieved, downloaded, cleaned and redeployed or replaced as necessary on a fortnightly basis (where possible) to maintain the quality of data collected. Prior to the analysis of water quality data to review potential exceedance of trigger levels, a preliminary check of data integrity is likely to be undertaken and anomalous data removed using an objective function, following guidance outlined in ANZECC and ARMCANZ (2000).

Water quality data collected within the Zone of Influence will be assessed against water quality management trigger criteria. Data from the Zone of Influence can also be compared against reference site data to determine whether the exceedance was due to natural variation or potential dredging impacts. Exceedances of water quality criteria that are attributed to dredging or disposal activities will be reported as soon as possible,

timeframe to be determined

to enable the rapid implementation of management measures aimed at mitigating subsequent impacts to coral communities.

9.2.2 Sedimentation Monitoring

9.2.2.1 Objectives and Approach

The main objective of monitoring sedimentation rates is to assist in understanding potential impacts of dredging and dredge material management activities on sedimentation regimes at monitoring sites, and to infer potential impacts on sensitive BPP receptors. Based on observations in other large-scale dredging programs, it is likely that there will be sedimentation impacts on BPPH in areas within close proximity to dredging or dredge material placement activities. Therefore, sedimentation monitoring will provide evidence of whether potential impacts within these areas were caused by dredging or other factors.

There are no formal management triggers associated with sedimentation monitoring. Due to the highly dynamic sedimentation regimes that occur in the Pilbara region through the influence of tidal currents and waves, data on gross sedimentation rates collected using sediment traps are likely to only provide broad estimates of sedimentation and may not accurately portray the actual accumulation of sediments and potential impacts on BPP communities. In this regard, data on net sedimentation rates would be more useful for management purposes. However, instruments that measure net sedimentation rates are still in early development and known systems are unreliable. Therefore, data collected by these instruments would not be suitable for management purposes. Sedimentation monitoring will therefore be used only to provide a broad understanding of potential changes in sedimentation regimes caused by dredging and dredge material disposal activities.

9.2.2.2 Data Collection

To monitor gross sedimentation rates, it is likely that sediment traps will be deployed at a selection of monitoring sites where sedimentation impacts are most likely (e.g. in the Zones of High and Moderate Impact). These traps will be retrieved and emptied on a routine basis during responsive monitoring and sediment will be sent to a laboratory for analysis of total sediment weight and particle size distribution (PSD). If instruments become available during the dredging program that accurately measure net sedimentation rates, then it is possible that these instruments may substitute sediment traps or be added to the program.

9.2.2.3 Reporting and Analysis

Organic and inorganic fractions of the particulate matter in the traps can be measured in the laboratory to assess whether the majority of the sediment is organic (not dredge-related) or inorganic (possibly dredge-related). Seasonally or when required, PSD analysis can be undertaken on the material within the sediment traps to relate sedimentation data to material suspended by dredging and dredge material disposal activities. Data will be summarised and reported together with water quality monitoring data at monthly intervals.

9.2.3 Coral Health Monitoring

9.2.3.1 Objectives and Approach

The objectives of coral health monitoring are to detect potential changes in coral health that are a result of dredging and placement activities and allow for potential impacts to be managed within approved limits. To achieve these objectives, coral health data are likely to be routinely collected from sites within the Zones of Partial Mortality and Influence and compared against management trigger criteria, an exceedance of which would prompt the implementation of management measures to limit further impacts. Since it is predicted that all hard corals within the Zone of Total Mortality will be lost, coral health data collected within from the zone will not be assessed against management trigger criteria.

Coral monitoring is likely to be carried out at routine sites on a XXXX basis,

frequency to be agreed

depending on the zone and management implications. It is possible that the frequency of routine coral health monitoring may be reduced (in consultation with regulatory authorities) if predictive relationships between water quality and coral health can be developed and water quality criteria can be used reliably and with sufficient precaution to trigger more frequent coral health monitoring if required.

Contingency coral health monitoring (including more frequent monitoring or monitoring of additional sites) may be implemented in the event of an exceedance of water quality criteria, through the processes detailed in **Section 9.2.1**. The aim of this monitoring would be to provide a more rapid response in the event of impacts on coral health through more frequent monitoring, or to provide greater power to detect changes through the monitoring of additional (contingency) sites.

9.2.3.2 Parameters

The key coral health parameter that is likely to be monitored and used to trigger a management response is coral mortality (either partial or whole-colony mortality). Coral mortality estimates derived from repeated measurements of tagged coral colonies generally yield precise data with high level of power to detect small changes.

Other qualitative parameters that are likely to be measured to provide diagnostic information to interpret changes in coral communities include:

- health (colour intensity)/level of bleaching;
- mucus production; and
- sediment cover.

However, since the assessment of these parameters can be subjective and there are no clear relationships established in the literature between these parameters and subsequent levels of mortality due to dredging impacts, data collected on these parameters will not be formally assessed against management trigger criteria.

Data collection

Coral health monitoring is likely to consist of a combination of qualitative and quantitative measures. At each monitoring site, coral colonies are likely to be inspected and photographed. The number of colonies to be assessed at each monitoring site will be determined through power analyses of baseline data. The species targeted for monitoring at each site may be selected on the basis of their dominance, an initial appraisal of health, and that their size will be conducive to photography and analysis. A pilot study will be undertaken to determine if it is possible to obtain an appropriate level of power for detecting change in coral health using diver-less monitoring methods, and if so, these methods may be adopted in preference to diver-based methods.

Quantitative Indicators – Coral Mortality

Coral mortality can be recorded where there is no live tissue and subsequent algal growth or sediment accumulation has occurred. Coral bleaching will be recorded where there is still live tissue and that tissue is bleached white.

Coral mortality is likely to be assessed by analysing each coral photo with Coral Point Counter with Excel Extensions (CPCe) (Kohler & Gill 2006). This software was developed by NOVA South Eastern University (Boca Raton, Florida) in conjunction with the U.S. National Oceanographic and Atmospheric Administration (NOAA) and is used to estimate percentage cover mortality. This application aids in estimating the percentage of living coral tissue within each photographed colony. Measures on individual colonies can then be grouped to assess potential changes in coral condition on 'reef' and regional scales over time.

Qualitative Measures

A general qualitative visual assessment of coral health will also be undertaken on each coral colony by a trained observer before the colony is photographed to provide contextual information for changes that may be observed in later digital analysis. This may involve the assessment of the production of mucus (presence/absence), sediment presence/absence, evidence of bleaching and any other evidence of sub-lethal stress. Each colony may be compared to a reference photograph taken prior to dredging (baseline), to make a qualitative assessment of an adverse change in coral health.

9.3 Predictive Links Monitoring

9.3.1 Objectives and Approach

The key objectives of predictive links monitoring are to:

- Examine the relationship between water quality and coral health to allow for refinement, where appropriate, of management trigger criteria.
- Verify the threshold values used to interrogate the sediment plume model and predict impacts on corals.

The relationship between water quality and coral health is poorly understood for this region. As such, water quality trigger criteria used to manage water quality impacts on coral health, and coral tolerance thresholds used to interrogate sediment plume modelling and predict impacts, are based loosely on a combination of background data and published information. In order to refine thresholds and triggers and more accurately manage potential impacts on corals it is critical to investigate the relationship between water quality and coral health during the dredging program. Data will be examined throughout the dredging program to develop predictive relationships (where possible) between water quality and impacts on coral health. The development of these predictive relationships can then be used to refine trigger criteria for the responsive monitoring approach.

9.3.2 Parameters

Key parameters likely to be investigated in predictive links monitoring include: turbidity (measured in NTU); sedimentation and coral mortality (whole colony and partial mortality); and coral sub-lethal health indicators such as colour intensity and mucus production, as described under the responsive monitoring program (**Section 9.2**).

9.3.3 Data collection

The majority of data collection required to meet this objective will be obtained through the responsive monitoring program (**Section 9.2**). All data collected from monitoring sites during the responsive monitoring program will be examined. In addition, water quality and coral health data will be collected on a regular basis,

frequency to be agreed

from sites located within the Zone of Total Mortality in close proximity to dredging and disposal operations (when logistical and safety constraints permit). These sites are likely to provide valuable data on the relationship between water quality and coral health as they are located in areas where coral mortality is likely to occur as a result of dredging activities. Data collection methods for these sites will follow those described under the responsive monitoring programs (**Section 9.2**).

In addition to water quality and coral health data, information on metocean conditions will also be accessed and used in the interpretation of relationships between water quality and coral health.

9.3.4 Analysis and reporting

Data will be examined mainly through regression analysis. Any potential refinement of trigger criteria will be carried out in consultation with regulatory authorities.

9.4 Impact Monitoring

9.4.1 Objectives and Approach

The objectives of Impact Monitoring are to:

- Calculate the areal loss of BPPH attributed to both direct and indirect impacts of dredging and dredge material placement activities.
- Confirm whether the extent of loss exceeds predicted and approved limits (as described in Table X.X

  table of approved losses to be included upon finalisation of Outcome Based Condition

- Where BPP have been lost due to dredging and dredge material disposal activities, but BPPH remains intact, assess the likelihood of recovery of BPP communities.

Following the requirements of Environmental Assessment Guideline No.3 (EPA 2009), an assessment of BPPH is required prior to and following development activities to provide an estimate of the areal extent of BPPH loss that is attributable to the development.

The Subtidal BPPH Loss Assessment program will involve the collection of data on potential changes in hard coral BPPH (as a representative indicator of other BPPH) within the Project Area before and following the completion of development activities. Hard corals are considered to be a sensitive indicator of the impacts of dredging on other BPP types (EPA 2009) and changes in these communities are more easily measured than other BPP types that may be naturally temporally dynamic (such as small, ephemeral seagrasses and macroalgae) and where it is difficult to distinguish potential dredging impacts from natural changes.

Potential losses to mangrove communities from development impacts will be assessed separately.

The most statistically powerful assessment of changes in BPPH is likely to be achieved through the collection of data at multiple times prior to the development (during baseline conditions) and at multiple times post-development, at both impact and control locations (Multiple Before-After-Control-Impact approach; Underwood 1991).

9.4.2 Data collection

9.4.2.1 Hard Coral BPPH

Hard corals are located predominately on the fringes of the platforms that surround offshore islands, where they occur in coverage of up to 70%. Coral cover in other areas, particularly closer to dredging operations, is generally patchy and of low coverage.

Data on the loss of hard corals are likely to be collected through a combination of two approaches: i) through the extrapolation of hard coral health data from responsive monitoring sites, collected prior to, during and immediately following dredging and disposal activities; and/or ii) through the collection of additional data on coral loss using towed video or other non-diver methods that incorporate a wider spatial coverage and range of species (including soft coral species).

Hard coral mortality data obtained through the responsive monitoring program can be extrapolated to reflect losses for a wider area. This involves comparing mortality estimates prior to and post-dredging activities at monitoring sites within the Zones of Total Mortality, Partial Mortality and calibrating these losses against natural mortality observed at reference sites during the dredging program. By multiplying the level of coral mortality within each zone by the level of coral cover within that zone, mortality estimates from tagged colonies may be scaled up to reflect losses for the entire zone. However, these calculations assume that the tagged colonies are representative of the entire coral community.

A more representative approach that may be undertaken in addition to, or replacement of, the above method includes estimating the loss of hard corals within each zone through an assessment of coral mortality along representative transects within each zone. Transects would be surveyed multiple times prior to dredging, where possible during dredging, and post-dredging.

Transects may be assessed using remote methods such as towed video, a remotely operated vehicle (ROV) or automated underwater vehicle (AUV), or by divers, with a preference for non-diver methods if sufficient statistical power can be achieved. Each of these methods would include the collection of data using high resolution video or still images that can be digitally analysed to quantify coral cover and levels of mortality. Data on additional parameters, such as sediment and algal cover, may also be collected along transects to help interpret observed changes in coral mortality.

9.4.3 Analysis and Reporting

Data on hard coral BPPH loss will be extracted from video footage of frame grabs or from digital still photographs, using an analysis program such as Coral Point Count with Excel extensions (CPCe; Kohler et al. 2006).

Data on the loss of BPPH recorded along transects within each zone will be multiplied by the average percent cover of BPP and the areal extent of the BPPH type within each zone to determine the overall area of loss. Areal loss of BPPH within each zone will also be calibrated, using reference site data, to remove the effects of natural losses.

Power analysis will be carried out on initial datasets collected during the baseline period to gauge the natural variability of indicators measured and to determine the number of transects required within each zone to examine potential dredging impacts.

A report on the baseline condition of subtidal BPPH report will be compiled. A final report will also be produced that details any changes in BPPH pre- versus post-dredging activities.

9.5 Mangrove Ecosystem Monitoring

9.5.1 Objectives and Approach

A comprehensive mangrove monitoring program will be designed and implemented on the basis of the potential for change to mangrove health and mangrove habitat condition as a result of Project activities. The objective of the mangrove monitoring programme will be to detect impacts on mangroves and/or the onset of changes to the processes and conditions required for mangrove survival, so that attempts to mitigate such changes can be made as effectively as possible (i.e. provide for mangrove protection). To achieve this, focus will be placed on parameters that are readily detectable and these will be linked to the main processes responsible for maintenance of mangrove systems and survival of mangroves.

9.5.2 Parameters

Parameters related to mangrove health and mangrove habitat condition and distribution may 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, measured using standard surveying techniques;
- hydrocarbon and heavy metal concentration in mangrove sediments and selected mangrove-dependent fauna;
- diversity and abundance of mangrove-dependent fauna; and
- mapping of mangrove habitat distribution and coastline movements.

9.5.3 Data Collection

Baseline monitoring would be undertaken prior to construction activities that may impact on mangrove habitat. The programme would establish monitoring sites immediately adjacent to the Project Area (e.g. Hooley Creek and the eastern most section of the Ashburton Delta) and at 'control' sites, distant from the likely zone of impact.

9.6 Introduced Marine Pests (IMP) – Inspections

9.6.1 Overview

The dredge vessels' mobilisation procedure requires a pre-mobilisation inspection of any vessel considered to be an uncertain or high risk vector for IMP. The risk assessment for vessels will be undertaken as per the form contained in Appendix XXX.

to be developed

9.6.2 Inspection Requirements

IMP inspections will be undertaken by a suitably qualified person with experience in the identification of IMP and in the inspection of construction vessels. All inspections will be undertaken either in 'dry dock' or via 'in water' inspection, with sufficient visibility.

The Revised Coordinating Committee for Introduced Marine Pest Emergencies (CCIMPE) Trigger List (2006) will be used as the basis for the identification of a marine species as an invasive pest, noting the potential presence of other unlisted species, demonstrating invasive characteristics or otherwise of concern. Other species not currently on these lists that are commonly accepted to have the potential to become invasive in some environments will be considered accordingly.

Inspections to examine the occurrence or risk of IMP will involve:

- an inspection of the vessel hull including the external niche areas
- an inspection of the internal niches including accessible ballast tanks, bilge spaces, anchor chain/cables locker, internal seawater systems
- an inspection of the topside wet areas including immersible equipment/dredge equipment (trailing pipes, dragheads and anchors).

Each of these items will be visually inspected and video/photographs will be taken of all niche areas and any species of concern. The ballast water logs will also be inspected to confirm compliance with the AQIS Mandatory Ballast Water Requirements.

In the event that a known or suspected IMP of concern are identified, a photograph or video image showing the species will be taken, including the full extent of the fouling clearly visible and a sample will be taken and sent for expert taxonomic identification. The contingency management measures presented in **Section 8.3** will be implemented when suspected IMP are identified and will not be dependent on the taxonomic identification due to the time required for taxonomic study.

9.6.3 Reporting

An inspection checklist will be completed for each inspection. This checklist, including a statement from the inspector providing an assessment on the status of the vessel in terms of risk, will be forwarded to the DEC and DoF prior to the commencement of the vessel's operation. An inspection report detailing the risk assessment, ballast water records and the results of the inspection will be provided to DEC and DoF**.**

10.0 REPORTING, REVIEWS AND CORRECTIVE ACTIONS

to be populated once all management approaches agreed

11.0 REFERENCES

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Appendix A Risk Assesement outcomes

<To be included upon finalisation of the DSDMP, refer to the EIS/ERMP for risk assessment outcomes>

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Appendix T1

Draft Coastal Processes Management Plan

Tables

Figures

Photographs

Table 1.1: Commitments Register.

No.	Reference	Commitment	Method
Mangrove Habitat			
1	Section 8.2	Sand management system: Encompassing some degree of sediment collection and distribution for the west and east sides of the MOF	Design
2	Section 8.2	Sand management system: To provide sediment management that limits adverse effects of downdrift erosion to the east of the MOF	Mitigation
3	Section 8.2	Sand management system: An ability to adapt the sand management system to respond to cyclonic events	Design
4	Section 8.2	Monitoring: Beach profile monitoring	Reporting
5	Section 8.2	Monitoring: Hooley Creek channels (east and west) cross-section monitoring	Reporting
6	Section 8.2	Reporting: Annual coastal processes monitoring report.	Reporting
Coastal Dune Habitat Management			
7	Section 8.3	Monitoring: Site inspection of beach and entrance bar condition between Ashburton River delta and Beadon Creek	Reporting
Coastal Recreational Value Management			
8	Section 8.4	Monitoring: Site inspection of coastal recreational value condition between Ashburton River delta and Beadon Creek	Reporting
9	Section 8.4	Monitoring: Community liaison to provide feedback on impacts to recreational values	Reporting
Coastal Protection (Onslow Seawall) Management			
10	Section 8.5	Management: Seawall maintenance programmes may be implemented where deterioration is deemed to be attributable to the presence of nearshore infrastructure	Reporting
11	Section 8.5	Monitoring: Site inspection of beach and seawall condition between Beadon Point and Beadon Creek	Reporting
Heritage Management			
12	Section 8.6	Monitoring: Site inspection of important heritage (geological, European and indigenous) locations to assess condition and potential threats from coastal processes	Reporting

1.0 INTRODUCTION

1.1 Background

Chevron Australia Pty Ltd (Chevron) proposes to construct and operate a multi-train liquefied natural gas (LNG) and domestic gas (Domgas) plant 12 km southwest of Onslow on the Pilbara coast. The LNG and Domgas plant will initially process gas from fields located approximately 200 km offshore from Onslow in the West Carnarvon Basin and other yet-to-be determined gas fields. The Wheatstone Project is referred to as the Project and the Ashburton North Strategic Industrial Area (Ashburton North SIA) is the proposed site for the LNG and Domgas plant. The Project will require the installation of gas gathering, export and processing facilities in Commonwealth and State Waters and on land. The LNG plant will have a maximum capacity of 25 million tonnes per annum (MTPA) of LNG.

The Project has been referred to the State Environmental Protection Authority (EPA) and the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) and, subsequently, an Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP) document was prepared for the Project. The EIS/ERMP will be assessed under the State process that is accredited under the bilateral agreement with the Commonwealth government. Therefore the EIS/ERMP has been prepared to meet both the EPA *Guidelines for Preparing a Public Environmental Review/Environmental Review and Management Programme* (EPA 2009a) and the DEWHA *Guidelines for the Content of a Draft Environmental Review and Management Programme/Environmental Impact Statement* (DEWHA 2008). The document will be assessed in parallel, by both departments.

Onshore infrastructure will be located adjacent to the Ashburton River delta and the Hooley Creek tidal system. Nearshore construction requirements include breakwaters across a sandy coastline for the placement of a materials offloading facility (MOF) and a product loading facility (PLF), a dredged navigation channel and approximately five proposed dredge material placement sites. Chevron have developed this Draft Coastal Processes Management Plan (Draft CPMP) to manage the interruption of natural coastal processes adjacent to the Project, and to comply with various EPA guidelines pertaining to benthic primary producer habitat (BPPH).

1.2 Purpose and Scope

The purpose of this Draft CPMP is to identify potential changes to coastal processes associated with construction of nearshore and onshore 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 MOF 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.

This Draft CPMP provides an outcome based approach to coastal management of the potential environmental impacts of the Project.

On completion of the approvals process, this Draft CPMP will be finalised. The finalised CPMP will also address any relevant requirements of the State Ministerial Conditions and Commonwealth approvals decisions (Section 11.0). The finalised CPMP will also be made publicly available.

1.3 Draft CPMP Structure

The Draft CPMP includes a description of the following:

- the location and scope of the works focussing on aspects that will potentially affect coastal processes;
- an overview of the existing environment of the Project area, including issues and sensitivities particular to the location and works;
- potential environmental risks from both planned operations and unexpected events;
- the environmental performance objectives, standards and criteria that will be used to measure environmental performance during implementation of this Draft CPMP;
- the management implementation strategy required to achieve the environmental performance objectives of this Draft CPMP; and
- a system for documenting, monitoring and reviewing the success of the implementation strategy to facilitate ongoing improvement of environmental performance.

The Draft CPMP is structured as follows:

- Section 2 describes the activity to be undertaken and aspects that may cause deterioration to natural costal processes.
- Section 3 describes the receiving environment, both physical and biological.
- Section 4 details potential environmental impacts that may be caused by construction and operation in the area.
- Section 5 details the environmental management structure that will be implemented and explains management and mitigation strategies to be implemented to manage or reduce environmental impact.
- Section 6 describes the roles and responsibilities of Project personnel in implementing the Draft CPMP.
- Section 7 explains training and education that Project personnel may need to undertake in order to successfully implement the Draft CPMP.
- Section 8 details the monitoring, inspection, review and mitigation programmes that are to be completed.
- Section 9 details the various stakeholders that have been consulted, or will be consulted in the development and finalisation of the Draft CPMP.
- Section 10 contains the proposed environmental commitments relating to coastal processes management and will include the relevant final Ministerial Conditions handed down by the Minister once the EIS/ERMP has been assessed and approved.

1.4 Chevron ABU Policy 530

The Chevron Australasia Business Unit (ABU) has stated its commitment to achieving Operational Excellence (OE) in ABU Policy 530. The Chevron ABU strives to achieve OE through the implementation of the ABU Operational Excellence Management System (OEMS). Further details regarding this policy can be found on Chevrons website at www.chevronaustralia.com. Chevron is committed to implementing the Project in accordance with ABU Policy 530.

1.5 Legislation and Guidelines

Commonwealth and State legislation pertinent to the activities described by this Draft CPMP includes, but is not limited to, the following Acts and Regulations (and relevant amendments):

- State Legislation
  - *Wildlife Conservation Act 1950*
  - Wildlife Conservation Regulations 1970
  - *Environmental Protection Act 1986*
  - Environmental Protection Regulations 1987
  - *Conservation and Land Management Act 1994*
  - *Pollution of Waters by Oil and Noxious Substances Act 1987*
  - Pollution of Waters by Oil and Noxious Substances Regulations 1993
  - *Conservation and Land Management Act 1994*
  - *Fish Resources Management Act 1994*
  - *Jetties Act 1926*
  - *Marine and Harbours Act 1981*
  - *Offshore Petroleum and Greenhouse Gas Storage Act 2006*
  - *Shipping and Pilotage Act 1967*
- Commonwealth Legislation
  - *Environment Protection and Biodiversity Conservation Act 1999*
  - *Environment Protection (Sea Dumping) Act 1981*
  - Environment Protection (Sea Dumping) Regulations 1983
  - Australian Ballast Water Management Requirements 2001
  - Australian Quarantine Regulations 2000
  - *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*
  - *Marine Act 1982*
  - Navigable Waters Regulations 1958
  - Port and Harbour Regulations 1966

In addition, the EPAs *Environmental Assessment Guideline No. 3: Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment* (EAG No. 3) (EPA 2009b) relates indirectly to the activities described in this Draft CPMP and has been considered in development of the management measures. The EPAs *Guidance Statement No. 1 - Guidance Statement for Protection of Tropical Arid Zone Mangroves Along the Pilbara Coastline* (GS No. 1) (EPA 2001) also relates indirectly the coastal processes and has also been considered.

Coastal processes fall into the legislative domain of the Department of Planning (previously DPI) *State Coastal Planning Policy - SPP No. 2.6* (WAPC 2003) and the Department of Transport (DoT) (previously DPI) *Coastal Protection Policy for Western Australia* (DPI 2006). 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 coastal impacts with respect to habitat will be considered within the environmental approvals process through the *Environmental Protection Act 1986* (EP Act (WA)).

The Ashburton North Strategic Industrial Area (Ashburton North SIA) is an industrial development that is demonstrably dependent on a foreshore location (SPP 2.6 – Schedule 1 G) therefore it is unlikely that coastal setback requirements would apply. However, the objectives set out in the SPP 2.6 are addressed in the Draft CPMP. 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;
- 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 2003).

The Coastal Protection Policy (DPI 2006) does not have a firm legislative basis, as it relies upon interpretation of the *Jetties Act 1926*. However, it provides detailed interpretation of the State Coastal Planning Policy SPP 2.6 (WAPC 2003) and gives a clear policy context for DoT advice to the EPA, which is often sought for port development projects. Relevant State Government policies for coastal management that provide guidance to Proponents include:

- Statement of Planning Policy No. 2.6: State Coastal Planning Policy (SPP 2.6)
- Coastal Protection Policy for Western Australia (CPPWA).
- Development Control Policy 1.8: Canal Estates and other Artificial Waterway Developments
- State Planning Policy No. 3.4: Natural Hazards & Disasters.

The Coastal Protection Policy (DPI 2006: 7-8) 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.

Sand bypassing of maritime developments is identified in the CPPWA and is addressed in the Draft CPMP, in recognition that the natural supply of littoral sand is a resource shared by the community.

1.6 APPEA Code of Environmental Practice

The Australian Petroleum Production and Exploration Association (APPEA) Code of Environmental Practice (2008) has been developed as a guide for gas production operations in Australia. Specific requirements of the APPEA Code relevant to the activities described in this Draft CPMP include:

- compliance with applicable laws, regulations, standards and guidelines and, in their absence, adopting the best practicable means to manage adverse environmental impacts;
- providing adequate training to enable employees and contractors to adopt environmentally responsible work practices;
- developing emergency plans and procedures so that incidents can be responded to in a timely and effective manner;
- developing and maintaining management systems to identify, control and monitor risks;
- identifying elements of the environment with natural, cultural, scientific or other significance which require avoidance or special protection procedures;
- identifying and addressing special impacts from construction and installation techniques;
- minimising air emissions and water discharges;
- managing all waste materials generated and chemicals utilised in the construction and commissioning phase in accordance with site waste and chemicals management plans and relevant regulations.

1.7 Hierarchy of Documentation

This Draft CPMP will be implemented for the Project via the Chevron ABU OEMS. The OEMS is the standardised approach that applies across the ABU in order to continuously improve the management of safety, health, environment, reliability and efficiency to achieve world-class performance. Implementation of the OEMS enables the Chevron

ABU to integrate its OE objectives, processes, procedures, values and behaviours into the daily operations of Chevron personnel, and contractors working under Chevrons operational control supervision. The OEMS is designed to be consistent with, and in some respects, go beyond ISO 14001-2004: Environmental Management Systems – Requirements with Guidance for Use (ISO 2004). Key elements of Chevrons Environmental Management Programme can be viewed below (Figure 1.1).

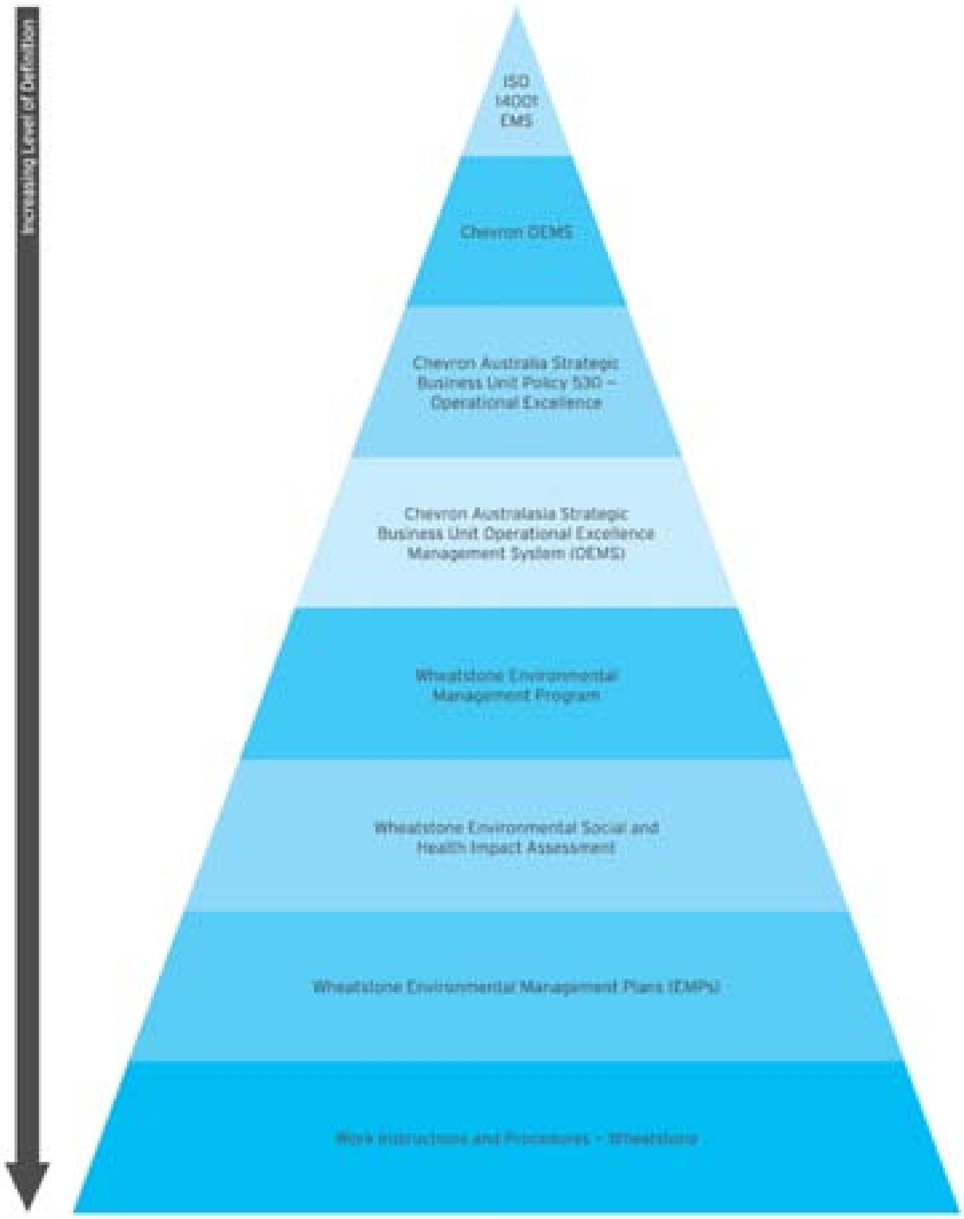

Figure 1.1: Key Elements of the Wheatstone Environmental Management Programme.

2.0 DESCRIPTION OF THE ACTIVITY

2.1 Location

The Project will involve collection of gas from several Petroleum Titles, approximately 225 km north of Onslow. Gas from third party suppliers will also be processed at the Project facility to achieve the projected output of 25 MTPA.

The Ashburton North SIA is located approximately 12 km south-west of Onslow. Figure 2.1 shows the location of the offshore and onshore components of the Project. The nearshore and onshore areas of the Project assessed for environmental impact are shown in Figure 2.2. All marine nearshore facilities will be contained within these areas (Figure 2.3).

The Ashburton North SIA is proposed as a multi-user precinct and will potentially be shared by other industrial developments. The Dampier Port Authority (DPA) will eventually operate and maintain nearshore infrastructure, including the MOF. This Draft CPMP does not take into consideration the impacts of other developments and facilities that are operated by third parties.

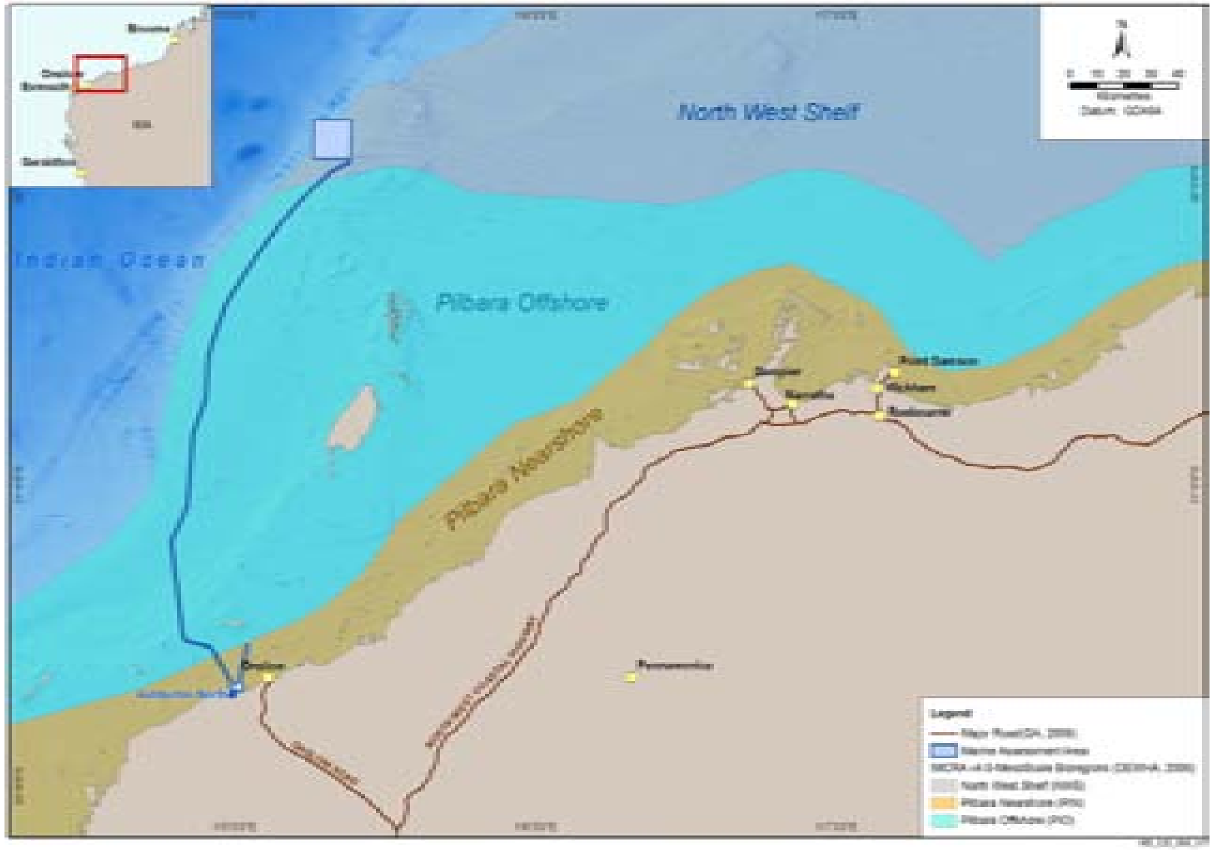

Figure 2.1: Location of the Wheatstone Project

Figure 2.2: Wheatstone Project assessment areas

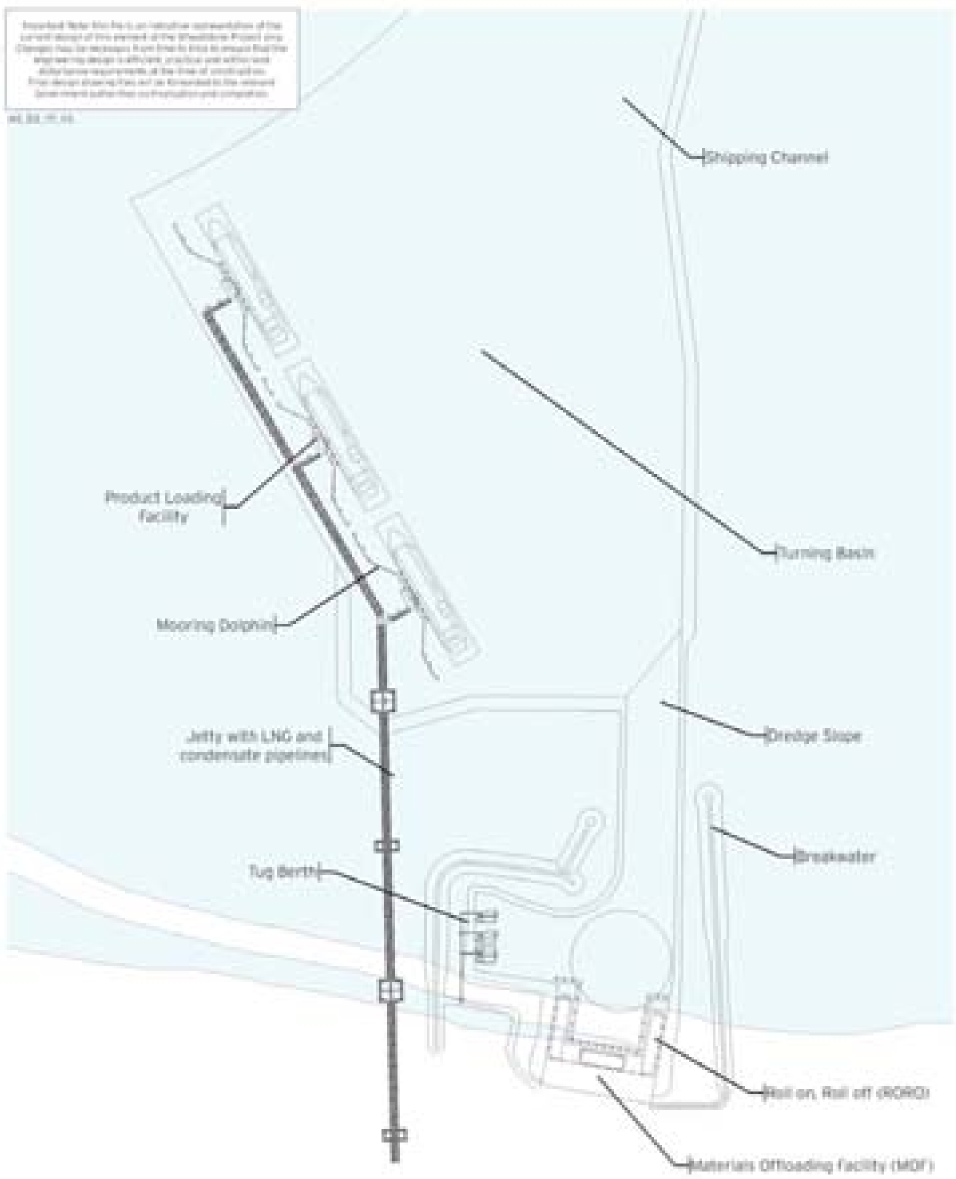

Figure 2.3: Conceptual design of the Projects nearshore infrastructure

2.2 Works Overview

The Project requires construction of the MOF breakwaters across a sandy coastline, which is expected to trap littoral material on the updrift side of the breakwaters (west of the MOF) and potentially cause downdrift beach erosion (east of the MOF). This will require ongoing coastal processes management during the design, construction and operation phases.

The following construction activities may also influence coastal processes and are addressed in the Draft CPMP:

- capital dredging of the MOF and PLF with marine access channel, the navigation channel and the turning basin, and the placement of dredged material;
- maintenance dredging over the anticipated 25 years of planned operation;
- installation of the MOF;
- installation of the PLF;
- trunkline shore crossings;
- construction of onshore infrastructure affecting the stability of the Hooley Creek lagoon system entrance;
- access road construction.

Layout of the proposed nearshore infrastructure is shown in Figure 2.3. Construction works are expected to be undertaken over a four-year period.

2.2.1 Capital Dredging

Capital dredging will be required for the temporary access channel, and the MOF and PLF with marine access channel. Dredging of approximately 45 Mm^3 of material is required with a variety of dredging plant. Five dredge material placement sites have been proposed (Figure 2.4). A temporary access channel is required early on in the works to deliver equipment and supplies to the site through the MOF. This channel will eventually be incorporated into the MOF and PLF marine access channel. Material will be dredged using a combination of hopper and cutting suction dredge.

2.2.2 MOF Breakwaters

The MOF breakwaters are to be constructed immediately west of Hooley Creek and will extend offshore to an approximate water depth of -2.5 m below lowest astronomic tide (LAT) (Figure 2.3). The western breakwater is located near the location where a sand spit extending from the Ashburton River delta welded to the shoreline in 2005, whilst the eastern breakwater is located immediately west of the Hooley Creek tidal complex. The breakwaters are expected to be concrete armoured structures with an impermeable core. Dredging of the MOF and marine access channel will be undertaken using a combination of hopper and cutter suction dredge and the dredged material will be placed in one of five dredge material placement grounds.

2.2.3 PLF

The PLF is expected to be a permeable structure with relatively wide spacing between pile bents, thus preventing capture of littoral material (Photograph 2.1; Damara WA 2010). The pile configuration for the access trestle and the PLF is likely to be pile bents of 36” diameter piles at a spacing of approximately 24 m (Bechtel 2009). Temporary works associated with construction of the PLF and the shoreline abutment may influence coastal processes and are briefly considered in this Draft CPMP with regards to the proposed monitoring programme (survey profiles around these structures are included).

Photograph 2.1: An example of wide spaced pile bents (Onslow Salt jetty).

2.2.4 Trunkline Shore Crossing

The trunkline shore crossing will be constructed beneath the coastal area using micro-tunnelling which will have minimal impact on coastal processes. However, temporary works associated with this tunnelling and construction of nearshore structures may capture littoral materials, and would require further revision of the Draft CPMP.

2.2.5 Borrow Area Excavation

It is proposed that a number of onshore sites be excavated for use as borrow areas to supply construction material (Borrow Areas 1 – 4; Figure 2.5). A number of potential geological heritage features are located within the proposed borrow area areas. While it is unlikely that changes in coastal proccess will impact on these features, due to their distance from the coast, it is probable that excavation will disturb these features.

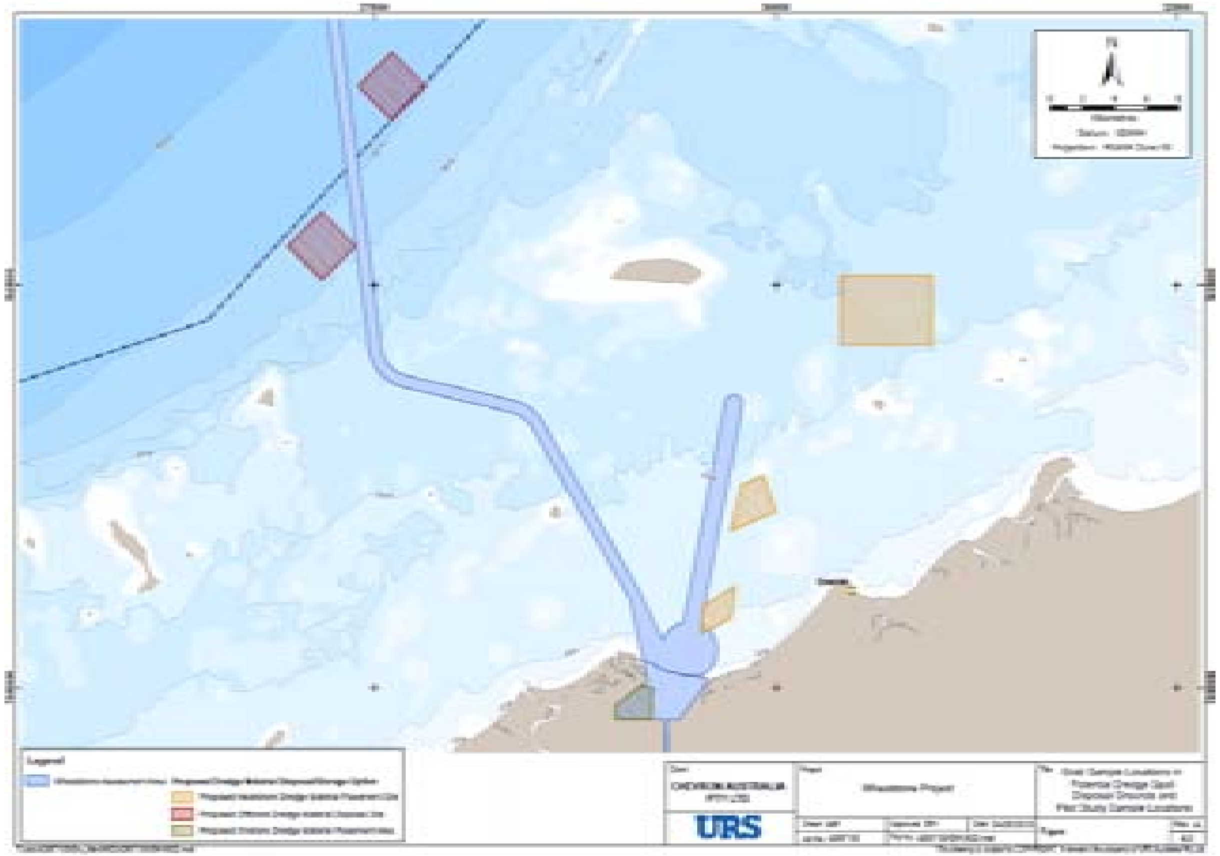

Figure 2.4: Proposed nearshore and offshore dredge material placement sites (A – E)

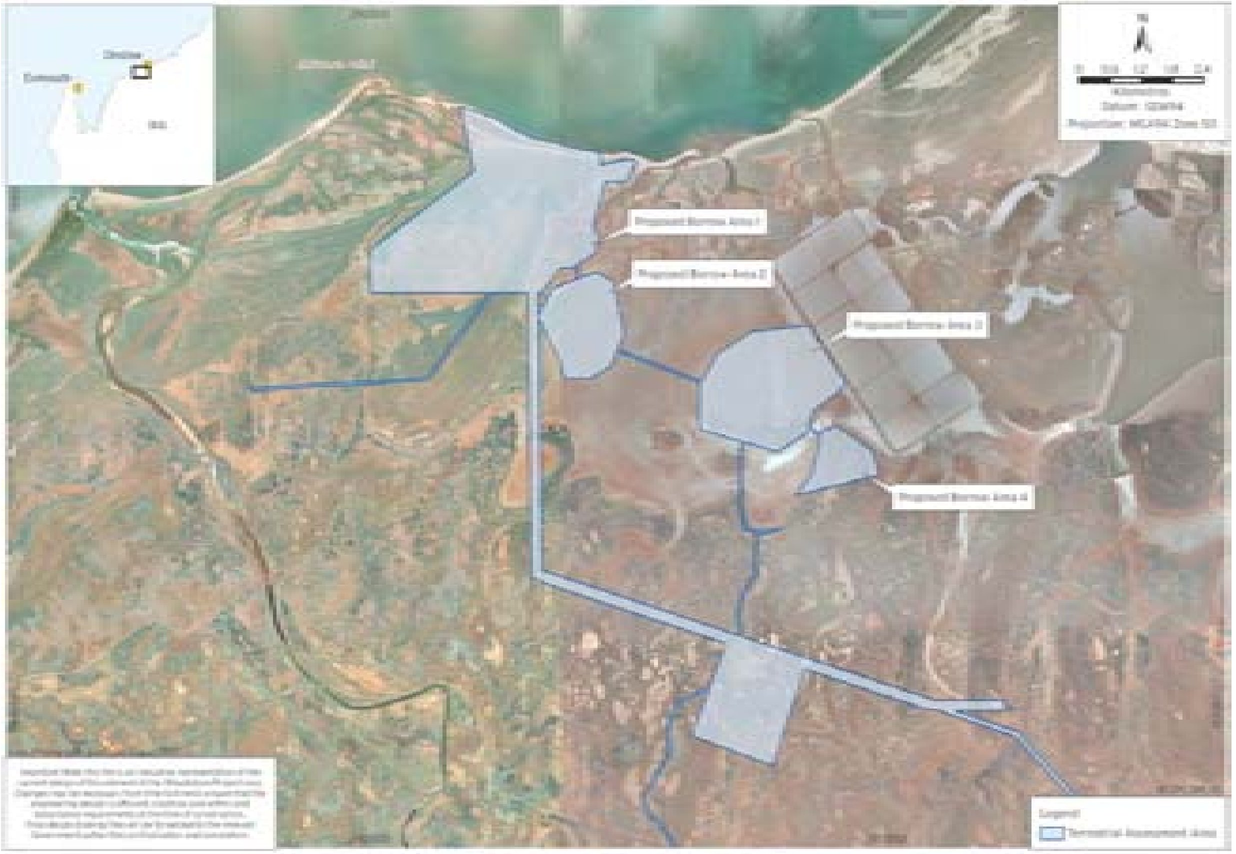

Figure 2.5: Proposed borrow area locations (Borrow Area 1 – 4).

2.2.6 Access Road

A road is proposed to provide access to the Ashburton North SIA. The road will be built up to no more than 5 m Australian height datum (AHD). Hydrodynamics of the floodplain are likely to change as a result and may cause an extension of downstream channels due to flow focusing.

There is a slight risk that the tendency for increased channel formation may result in an increased quantity of breakout runoff from the Ashburton River through the Hooley Creek system. The likelihood of this occurring is very low; however the consequences (both for the Project and for the environment) are high. Such an event would require extension of the channel structure across the Hooley Creek lagoon system.

2.3 Timing and Duration of Key Stages of the Proposed Operation

Finalised timelines for key stages of the proposed Project will be included in future revisions of this Draft CPMP, following consultation with regulatory agencies and prior to release for Public Review.

3.0 RECEIVING ENVIRONMENT

3.1 Overview

The onshore and nearshore infrastructure associated with the Project is located in the Shire of Ashburton, in the southwest of the Pilbara Region of Western Australia. Characterisation of the regional and local nearshore environment has been undertaken as part of the EIS/ERMP prepared for the Project. This information has been summarised below to provide context for the proposed management strategies and monitoring programmes detailed in this Draft CPMP.

3.2 Physical Environment

3.2.1 Regional Geology

In brief, the regional geology surrounding the Project site is characterised by a complex geologic framework of lithified Pleistocene and older landforms. The terrestrial landscape is dominated by partially lithified and unconsolidated alluvial sediments, overlain by sediments of marine origin and reworked alluvial sands closer to shore. These sediments, in turn, overlay older Pleistocene sedimentary structures, particularly along the beach and in the nearshore waters.

The coastal context of the Project area is characterised by:

- A north-northwest facing coastline that forms part of a West Pilbara coastal compartment from Tubridgi Point to Cape Preston.
- A single sediment cell extending over 70 km, approximately from Tubridgi Point to Coolgra Point. Distinguishing geomorphologic features of this sediment cell include the active delta and tidal creeks of the Ashburton River, long sandy beaches and dunes perforated by tidal creek networks, as well as island chains running almost parallel to shore.
    - Adjacent to the Project site, the western sector of this sediment cell (Tubridgi Point to Entrance Point) is characterised by sediment reworked by erosion processes due to a net eastward drift.
    - The eastern sector of this sediment cell (Entrance Point to Coolgra Point), is characterised by sediment largely of fluvial origin reworked as eastward migrating chenier spits, with sediment reworked by erosion processes due to a net eastward drift. Material is also derived from Holocene transgression of shelf sediments and reworked beach and dune material.
- Underlying coastal limestone that emerges above the intertidal zone irregularly.
- Occasional evidence of tsunami or cyclonic washover behind foredunes.

The complex and dynamic coastal geomorphology of the Project site, and in particular the Ashburton River delta, needs to be emphasised in terms of the challenges it presents in predicting the likely coastal response to the Project.

3.2.2 Soils & Landforms

The Project is located in the Exmouth and Ashburton soil-landscape provinces, as described by Tille (2006). The Exmouth Province generally comprises alluvial plains or sandplains with coastal flats and dunes, and some ranges and stony plains, on sedimentary rocks of the Carnarvon Basin. The Ashburton Province is located to the southeast of the Exmouth Province. It comprises a mosaic of hilly terrain and stony plains with rugged ranges, hills, ridges and plateaux above sedimentary rocks of the Ashburton, Edmund and Collier Basins. Soils are varied within these provinces and generally comprise:

- sandplains and dunes dominated by deep red sands and deep sandy duplexes;
- red/brown non cracking clays, hard cracking clays and deep red sandy duplexes on the alluvial plains and floodplains, along with some red loamy earths;
- tidal soils on the coastal flats;
- coastal dunes of calcareous deep sands and deep red sands;
- calcareous shallow loams, red loamy earths and stony soils on the Cape Range and other limestone hills;
- red deep sands on the undulating sandy plains to the south;
- stony soils in the hilly terrain;
- red shallow loams, red/brown non-cracking clays, loamy earths and deep sandy duplexes on the stony plains;
- red loamy earths and red/brown hardpan shallow loams, deep red sands and shallow sandy duplexes along the hardpan wash plains;
- deep red sands and sandy duplexes on the sandplains;
- red loamy earths, calcareous loamy earths and deep red sands on alluvial plains;
- calcareous shallow loams on the calcrete plains.

3.2.3 Coastal Geomorphology

A complex geological framework determines the coastal geomorphology of the western Pilbara. The sub-region lies north of the Gascoyne sub-basin and on the Peedamullah Shelf (Geological Survey of Western Australia 2007). Partially lithified and unconsolidated alluvial sediments dominate the terrestrial landscape in the vicinity of Onslow and the Project site. Close to shore, these are overlain in places by sediments of marine origin, including shelly sands and reworked alluvial sands. Some of the sands are of recent Holocene origin and overlie older Pleistocene sedimentary structures (Semeniuk 1993).

3.2.4 Landform Components

Four sets of landform components comprise the coastal area of the wider Ashburton River delta. These include: the active deltaic complex of the Ashburton River; the Saddle Hill dune ridge and back-barrier flats; the Onslow mudflats and tidal creeks (Hooley Creek); and the active sandy beaches and associated coastal dunes. These landform components are summarised below.

Ashburton River Delta & Beaches

The Ashburton River delta and beaches are characterised by:

- deposition of sediment at the coast from the Precambrian hinterland over a geologically long period, forming a riverine plain with up to 25 m deep unconsolidated material;

- development of a suite of coalescing river deltas with the deltaic plain consisting of overlapping and inter-fingering delta lobes against a north west facing rocky shore;
- an asymmetry to the delta, with the river feeding chenier spits on the eastern side of its mouth (a feature of coastal environments subject to strong littoral transport along the lower swash zone of sandy beaches);
- a switching of the main channel to the west some time since the 1920s.

Entrance Point delta is a geologically controlled cuspate foreland with its asymmetrical shape apparently determined by a limestone pavement (an older deltaic landform comprising the main body of the feature), as well as by wave diffraction around offshore structures such as Curlew Bank, Roller Shoal and Ashburton Island.

The Ashburton River delta is immediately adjacent to and updrift of the Project site. The cheniers and sand spits of the foreland constitute a substantial store of sediment that is unstable and could easily be remobilised by fluctuation in the intensity of fluvio-marine processes. This has implications for channel siltation and coastal response.

Onslow Mudflats and Tidal Creeks - Hooley Creek

The Hooley Creek system is characterised by:

- palaeochannels, tidal creeks, mudflats and residual mounds comprising the natural landforms of the Onslow mudflats;
- water flow through the tidal creeks providing a major exchange of sediment between the nearshore marine and terrestrial areas;
- headwaters displaying morphologies ranging from erosional to depositional, changing from headwater gullying and erosion in the west to headwater fans and deposition in the east;
- palaeochannels with potential for reactivation due to avulsion of the main channel of the Ashburton River;
- an entrance bar configuration subject to deflation during cyclonic events, channel switching and rebuilding.

The Hooley Creek system is immediately adjacent to and downdrift of the Project site. It is likely to be the area with the most active coastal response to the Project.

Sandy Beaches and Dunes

The Ashburton River and its offshore shoals are the major sources of sediment moved eastwards along the beaches to the offshore shoals in the vicinity of the Mangrove Islands and Barrow Island. Disruption of the littoral pathway due to breakwater construction is therefore likely to have downdrift effects on the coast, particularly the stability of Sunset Beach and Beadon Point. Conversely, the littoral drift is reversible during extreme cyclonic events, driving strong onshore winds and high seas from the north, and this is likely to affect sedimentation in the vicinity of engineered works crossing the shore. Beaches nearby and eastwards of Four Mile Creek have been examined for these reasons, as well as for their potential indication of coastal change.

Four Mile Creek

The entrance to Four Mile Creek is about 2 km east of the current entrance to Hooley Creek and Eastern Creek (and about 4 miles west of Onslow). The creek entrance is orientated to the west with a wide entrance shoal on the eastern shore and a spit about

200m long. Relatively high coastal dunes back this coastline. The orientation of the coastline becomes more northwest towards the Onslow Salt Jetty and Beadon Point.

Dunes at the entrance to Four Mile Creek were reportedly eroded during Cyclone Vance with new, modest relief dunes colonised by spinifex evident. Dunes further east towards Beadon Point are high and wide with established vegetation. There are large shell deposits along the active beach face at least to a depth of 0.2m on the beach to the east of the creek entrance. Beach material is visibly coarser than beaches to the east.

Beadon Point

Beadon Point is immediately west of Onslow and the site of the most recent ocean timber jetty, since dilapidated. The Onslow Salt jetty is approximately 1 km southwest of Beadon Point, and the edge of Onslow town site is located approximately 400 m to the southeast.

On its western side, Beadon Point is backed by high dunes fronted by a deep swale and lower secondary dune. The beach southeast of the Point is very narrow and steep, with small rock groynes apparent, suggesting the beach has previously experienced erosion. Onslow town site is protected from erosion by a long revetment seawall and adjacent beach. The depth of the toe of this seawall is uncertain and is likely to be dependent upon the sand level at the toe of the seawall. The section of the seawall closest to the Point and protecting the local memorial, is in poor condition with rubble apparent along the toe. Wide sub-tidal shoals and possibly reefs are evident offshore at lower tides but were largely inundated during May 2009 when the inspection took place.

Beadon Creek

Beadon Creek is about 2.5 km southeast of Beadon Point at the site of the local boat harbour. A 500 m long breakwater trains the western side of the creek. The eastern side of the creek remains untrained with an entrance bar encroaching westward. There is a north-facing concave sandy beach with modest relief dunes between Onslow town site and Beadon Creek.

3.2.5 Coastal Processes

Net alongshore sediment transport from Onslow to Dampier is generally considered to be from west to east. This is based upon offshore wave climate, prevailing winds, the orientation of tidal creek entrances, accretive features on the west side of rocky headlands and the drift paths of modelled circulation across the North West Shelf (Pearce *et al*. 2003). Transport reversal during winter, or under cyclonic action, is expected due to inter-annual variability of onshore and offshore breezes. It is noted that off-shelf suspended sediment transport is generally in the opposite direction to alongshore transport, moving from east to west (Margvelashvili *et al*. 2006).

Local shoreline movements in the vicinity of the Project were examined using photogrammetric analysis of historical aerial imagery from 1963, 1973, 1986, 1993, 2001, 2004, 2007 and 2009 (Damara WA 2010). Despite very high variability of forcing conditions, historic photographs show that the Ashburton coast has generally maintained a similar shoreline position for decades, with only local features experiencing significant change. The characteristic behaviour of constrained dynamic zones is developed by the geologic framework underpinning much of the Pilbara coast, with rocky features providing strong structural control over shoreline position (Semeniuk 1996).

The following is noted:

- The shoreline has generally prograded since the earliest photography in 1963. It is possible that the 1963 position is the result of an eroded shore, following a severe cyclone in January 1961, with some evidence of deflation of coastal dunes.
- The shoreline generally prograded by 1973 and thereafter retained a similar position, with foredune vegetation growth consistent with rebuilding of dunes by natural processes.
- General accretion of the ebb delta either side of the present entrance to the Ashburton River over the period 1963 to 2009.
- Erosion of the beach and dune system west of Entrance point. As this was the site of the previous main channel for the Ashburton River, it historically had a high sediment supply. Since the main entrance shifted to the west, the supply reduced greatly and the previously deposited material subsequently eroded.
- Accretion east of Entrance Point, manifested as an eastward migration of the bar systems at Entrance Point and the East Ashburton delta, with cycles of deflation and rebuilding evident.
- Accretion of the Hooley Creek entrance bar system, with cycles of deflation and rebuilding evident.
- Relative stability of the beaches between Hooley Creek and Beadon Point between 1973 and 2009.
- Accretion at Beadon Creek following construction of the boat harbour and training wall in 1968.

Despite very high variability of forcing conditions, historical photographs show that the Ashburton coast has generally maintained a similar shoreline position for decades; only local features have experienced major geomorphological change, including the deltas, cheniers and spits at the mouths of tidal creeks. This characteristic behaviour is developed by the geologic framework underpinning much of the Pilbara coast, with rocky features providing strong structural control over shoreline position (Semeniuk 1996). In this situation, coastal dynamics are appropriately interpreted using a source-sink conceptual framework that is applicable to a largely controlled or engineered coast.

3.2.6 Coastal Change

A broad indication of the recent geologic development of coastal landforms in the Ashburton River delta was made in Damara WA (2010) through radiocarbon dating, particularly those in the highly active chenier foreland plain comprising the eastern delta of the Ashburton River. Information of ages of the various coastal features (wrack deposits and fossilised coral reef) can be found in Damara WA (2010).

3.2.7 Sediment Transport Rates

The interruption to sediment transport rates provided by Project infrastructure, particularly by the MOF breakwaters, influences the coastal response and the level of intervention required to manage adverse environmental impacts.

Methods for determining sediment transport rates include aerial photographic analysis, field inspections, shoreline movement plans and photogrammetry, empirical modelling (e.g. CERC formulae), numerical modelling, suspended sediment measurements, sediment traps and analysis of similar entrance channels (Seymour 1989; Pranzini and Wetzel 2008). There have been several environmental and engineering studies for the Project area where sediment transport characteristics have been estimated for various aspects of the Project (DHI 2008; Damara WA 2010; LWI 2009; DHI 2010).

Cyclonic Conditions

Extreme wind, wave, surge and rainfall conditions potentially associated with tropical cyclones determine that they may significantly affect the Ashburton-Onslow coast. Shoreline movement plans indicate that during Tropical Cyclone (TC) Vance, the majority of the beaches between Ashburton River and Beadon Creek experienced erosion in the order of 20 m. More significant changes occurred at the entrance to drainage networks, with destabilisation of the sand spit at Hooley Creek and release of a significant quantity of fluvial material from the mouth of the Ashburton River.

The effects of a single cyclone, however severe, do not provide an indication of the range of potential cyclonic impacts, which are highly dependent upon the cyclone system path, interaction with tides and the coastal configuration at the time of the cyclone. Consequently, although limited movement of Ashburton River delta occurred during TC Vance, there is potential for large volumes of sediment in the delta and its cheniers to be remobilised under cyclonic conditions. This material may move towards the Project site during the cyclone event, or be deposited in a position that enhances ongoing sedimentation under ambient conditions.

In summary, further work is required to determine littoral drift rates under cyclonic conditions. Modelling does not currently allow for mobilisation of large volumes of nearshore material due to bar deflation during storm surges or runoff flooding.

A typical pattern of post-cyclone recovery, supported by historic shoreline movements along the Ashburton to Onslow coast, shows rapid recovery of 20-50 per cent of shoreline erosion within 6-12 months. This is followed by gradual recovery of approximately 20 per cent per year of the shoreline erosion with a relative downdrift lag for sections of coast that are interrupted by littoral transport barriers. This lag mechanism potentially provides the greatest threat to recreational value of Onslow Town Beach. Recovery of the eroded vegetation line will occur more slowly. The speed of recovery depends on the severity of erosion, and the capacity for ambient conditions to resupply the location.

These observed patterns of recovery assist with the interpretation of beach monitoring subsequent to a cyclone erosion event.

3.2.8 Meteorological Influences

The Pilbara Region experiences an arid to tropical climate and is influenced by two air masses, the Indian Tropical Maritime air moving in from the west or northwest during summer, and the tropical continental air from inland during winter. A pronounced dry period is typically experienced from August to November (Australian Natural Resource Atlas 2009).

Meteorological data is recorded at a Bureau of Meteorology (BoM) weather station at the Onslow Airport, located approximately 12 km north–east of the Project site. This data has been collected since 1940. Onslow Airport experiences mean daily temperatures during summer ranging from 19 °C to 36 °C with the maximum reaching as high as 49 °C. During winter the mean daily temperatures range between 13 °C and 27 °C with the minimum occasionally dropping as low as 3 °C.

Average yearly evaporation for the Pilbara Region is approximately 3300 mm. Tropical cyclones contribute 40 to 60 per cent of the rainfall in the north, but less than 30 per cent in the southern and eastern parts of the region (Australian Natural Resources Atlas 2009). The average annual rainfall recorded at the BoM weather station at Onslow

Airport is 328 mm. The majority of rain falls between January and June. Rainfall in the region varies significantly from year to year and is dependent on rain bearing low pressure systems, thunderstorm activity and passage of tropical cyclones. Cyclonic events range from storms delivering up to 300 mm of rainfall to milder 30 mm events. Wet years typically receive a large proportion of rainfall from cyclonic events. The Project area is expected to experience similar rainfall patterns.

3.2.9 Oceanographic Influences

Wave action occurring along the North West Shelf is generated from one of the following sources: Southern and Indian Ocean swells; easterly winter swell generated across the Timor Sea; locally generated wind waves; or wind waves generated by tropical cyclones (Pearce *et al*. 2003; RPS Metocean Engineers 2004). It is suggested that Indian Ocean swells increases towards the west and create southwest swells in the Onslow area. However, due to sheltering from the continental landmass, these swell waves have a reduced influence closer to shore. Similarly, Barrow Island and the shoals of the Lowendal and Monte Bello Islands provide shelter from Timor Sea swells. Consequently the nearshore wave climate is strongly influenced by locally generated wind waves and occasional tropical cyclones.

Key water level processes affecting Onslow include tides, cyclonic surges, seasonal ranging and inter-annual mean sea level variations (National Tidal Facility 2000). Tidal forcing contains a range of cycles including semi-diurnal ranging, monthly spring-neap cycle, a bi-annual cycle due to movement of the solar equator, a 4.4 year cycle developed from lunar elliptic motion and 19.6 year cycle developed from lunar nodical motion (Damara WA 2008). With regard to local water level, a mesotidal pattern is observed with a spring tide range of 1.9 m and mixed, mainly semi-diurnal, tides.

3.3 Ecological Environment

With relation to coastal processes, two important ecological habitats have been identified within the Project areas coastal and intertidal environment, including mangrove habitats (as defined in Section 3.3.1) and coastal dune habitat (as defined in Section 3.3.3).

3.3.1 Intertidal Habitats

Mangrove Habitat

Mangroves occur mostly within river mouths and tidal creek systems, where they form a nearly continuous ribbon of vegetation fringing the creek channels. At Hooley Creek, Middle Creek and Four Mile Creek, mangroves are confined to a narrow fringe adjacent to the creek channel that is typically only 10 to 20 m wide. More expansive mangrove areas are found at the Ashburton River delta where a far greater area and diversity of habitats exist, suitable for mangrove colonisation. The relationship between tidal elevation and frequency of tidal inundation establishes salinity gradients across the mangrove zone that influences both the occurrence of the different mangrove species (due to differing salinity tolerance limits) and the mangrove community structure. These mangroves are protected and partly isolated from the sea by barrier spit systems.

Of the mangrove species known to exist in the Pilbara coast (EPA 2001), six occur within the Onslow area (Le Provost Environmental Consulting 1991) and were recorded during the intertidal survey of the Project area (URS 2010a). These species are:

- *Avicennia marina* – white mangrove
- *Rhizophora stylosa* – spotted-leafed red mangrove
- *Bruguiera exaristata* – ribbed mangrove
- *Ceriops australis* – spurred mangrove
- *Aegialitis annulata* – club mangrove
- *Aegiceras corniculatum* – river mangrove.

Within the study area *A. marina* was the most widespread and dominant species, occurring within the majority of mangrove associations. This local dominance reflects the broader regional characteristic of the Pilbara coast (Semeniuk 1993). *R. stylosa* was a secondarily common species occurring mainly in monospecific stands. As with *A. marina*, the species is relatively widespread, occurring from the Kimberley to Exmouth Gulf.

During the intertidal habitat surveys (URS 2010a), five mangrove associations were defined. These include:

- tall dense *A. marina* thickets or low forests fringing the major creek systems and seaward margins;
- low, dense *A. marina* shrubland;
- low, open to very open *A. marina* scrub, typically occurring on the landward margin of the mangrove zone and often integrating with high tidal mud flat habitat;
- mixed, tall *A. marina*/*R. stylosa* thickets, low forest and woodland;
- tall dense *R. stylosa* thickets or low forests.

These associations were consistent with those mapped along the eastern side of Exmouth Gulf by Biota (2005) and provide a regional context for the associations mapped in the Project area.

The EPAs Guidance Statement No. 1 (GS No. 1) identifies areas of arid zone mangroves as being of high conservational significance (EPA 2001). It also sets out the EPAs expectations for the protection of mangroves, while recognising current and potential future development areas.

The guidelines are based on work by V and C Semeniuk Research Group (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.

GS No. 1 describes four types of mangrove management areas and has developed guidelines for each. These 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.

Pilbara Region 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 Ashburton River delta mangrove habitat is identified as being “regionally significant” (Guideline 1), and are therefore considered to have a very high conservation value. The EPAs operational objective for Guideline 1 areas is that no development should take place that would adversely affect the mangrove habitat, the ecological function of these areas, 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.

The Hooley Creek – Four Mile Creek system is classified by GS No. 1 as being governed by Guideline 4. Guideline 4 covers all other mangroves occurring inside designated industrial areas, associated ports or other development and which are not covered by Guideline 3. The EPAs 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.

High-tidal Mud Flats

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

- bioturbated mudflats, devoid of macro-vegetation; and
- samphire flats, dominated by halophytic shrubs but with some crab burrows.

The dwarf desert spike-rush, *Eleocharis papillosa*, was recorded from a single location within these flats (Biota 2009). *E. papillosa* is classified as vulnerable by the EPBC Act (Cth). This species was located within samphire shrub land vegetation within a tidally influenced creek along the Onslow Road. It is likely that the species occurs throughout this particular creek habitat (Biota 2009). There is some potential for samphire vegetation to be affected by changed tidal regimes as a result of the Project. If further investigation shows that this threatened species does occur throughout this vegetation unit, then the severity of the impact of changed tidal regimes will depend on the ability of the species to cope with changed (increased or decreased) inundation. Any vegetation monitoring or management plan needs to be aware affect of changed tidal regimes on this vulnerable species.

Algal Mats

Algal mats are not present in the Ashburton River delta area, however expansive areas of algal mats exist on mud flats in the Hooley Creek – Four Mile Creek system. The algal mats vary from a sheet form to a pustular or crinkled form. In the most commonly observed sheet form, the mat is typically 5 to 10 mm thick. These algal mats are likely to be classified as Category E (Development Areas) by the EPAs EAG No. 3 (EPA 2009b). The EPAs guidance for these areas is that the cumulative loss of BPPH (in this case algal mats) should be no more than 10 per cent of the original extent before any European influences.

3.3.2 Sub-tidal Habitats

The majority of the seafloor in the vicinity of the Project area (between the mainland shore and Thevenard Island) is comprised predominately of bare sand and silts (URS 2010b). BPPH (including coral communities, seagrass meadows and algal beds) within the nearshore Project area is sparsely distributed and is present at discrete locations.

Seagrasses are important primary producers, but their sparse distribution in the Pilbara nearshore bioregion means that they make only a small contribution to benthic primary production when compared to mangroves, macroalgae and corals (URS 2010b). In particular, their sparse distribution in the nearshore Project area means that the Project is unlikely to have a significant impact, especially in terms of total BPPH.

3.3.3 Coastal Dune Habitats

Aside from the occurrence of one specimen of *E. papillosa*, no other EPBC Act (Cth) listed species have been recorded in the Onslow locality or are expected to occur in the habitats present in the survey area (Biota 2009). No species listed as Declared Rare Flora under the Western Australian *Wildlife Conservation Act 1950* were recorded from the survey area, nor are they likely to occur based on the habitats present (Biota 2009). Five Priority flora species were recorded by Biota during the surveys; however *E. papillosa* is the only one of these species that may possibly be affected by changed coastal processes as a result of the Project.

No Threatened Ecological Communities listed under the EPBC Act (Cth) or the *Wildlife Conservation Act 1950* occur in the survey area. No Priority Ecological Communities listed by the DEC occur in the survey area.

Coastal dune habitats are the main terrestrial (supra-tidal) vegetation habitats likely to be affected directly by changed coastal processes as a result of the Project. They are not identified by Biota (2009) as having any degree of conservation significance.

3.4 Coastal Recreational Value

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

3.5 Coastal Protection

3.5.1 Onslow Seawall

The Onslow seawall was constructed in 1958/59 by the Department of Housing and Works (DHW) to provide protection to the town site from coastal erosion (M.P. Rogers and Associates 2002). Drawings indicate the presence of rock beneath the seawall with levels varying from -0.8 m AHD to 0.3 m AHD (DHW 33908-01-01). It is understood the original seawall was largely founded on rock. TC Vance exposed the town seawall and caused severe erosion behind it. Repair works were undertaken by DoT in 2002. Works included repacking of armour, re-establishing a consistent crest level and an extension of the seawall to the south. The design involved founding new works on rock or at levels varying from -1.0 m AHD at the northern end to 0.0 m AHD at the southern end. The works were completed in November 2002 (DPI 1256-06-01). As-constructed drawings are not definitive as to the extent to which the current seawall is founded on rock. Inspection of the seawall in 2009 identified that most of the seawall was in reasonable condition, although the core was being exposed at the northern end of the seawall near the memorial. Nearshore infrastructure-attributable impacts may occur and may compromise the integrity of the seawall due to an alteration of natural coastal processes, however implementation of this Draft CPMP should reduce these impacts.

3.5.2 Onslow Town Beach

Onslow Town Beach is immediately adjacent to the Onslow seawall and provides protection to the toe of the seawall. The beach is an arcuate shape, largely controlled by the sub-tidal rock platform at Beadon Point and the breakwater for the Beadon Creek boat harbour. There also appears to be a reef offshore of Third Street that provides a local control on the beach, and the boat ramp at Cameron Street appears to act as a short groyne. Surveys from 2002 showed the beach adjacent to the northern caravan park was inundated during high tides but gets wider to the south, where the beach is about 50 m wide at mean sea level (DPI 726-48).

3.6 Heritage

3.6.1 Geological & Coastal Impact Features

The significance of the deltaic complex of the Ashburton River include a suite of geologic features and landforms comprising the shoreface, coastal dunes, chenier plains, mudflats, upper deltaic floodplains and palaeochannels. This relates to the degree to which the landforms collectively and individually provide essential life services and/or are recognised by experts within the geological disciplines for inclusion within the Register of the National Estate (Australian Heritage Commission, 1990).

Potential examples in the Ashburton-Onslow region include:

- the chenier plain comprising the eastern delta of the Ashburton River which is remarkable for the rapidity of landform change and its state of preservation
- the last interglacial platform identified through radiometric analyses of embedded coral and shell is intermittent and cut by the Ashburton River. The feature has been observed to extend from Urala Station to Onslow. Such landforms are poorly preserved in Western Australia
- the interglacial shoreline on Urala Station including components of the 120 000+ yr BP landforms backed by coastal dunes. Both have been crossed by younger linear desert dunes
- high level wrack deposits of the 700 year old storm or tsunami that occurred on the western part of the coastal dune ridge. This provides evidence of the low-frequency high-magnitude events affecting the Ashburton River delta.
- old shell taxa provides ancient biogeography of the system and is of considerable potential engineering interest in terms of landscape stability. It contrasts with the younger components of recent chenier development on the eastern delta. The range of species preserved is of considerable scientific biogeographic interest. Additionally,

complexity in the mix of materials and landforms on the modern surface provides evidence of extreme events in the region

In combination, these elements have considerable conservation significance on the basis of geological heritage (Damara WA 2010).

3.6.2 Indigenous Heritage

An estimated 37 per cent of the Onslow population is indigenous to the area, from the Thalanyji, Yindjibarndi and Banyjima language groups. The Thalanyji people are the native title holders of the land in the Onslow area, including the Project site land. The registered midden site Amethyst 07 is within the Project site (Chevron 2009). It is possible that there will be other Indigenous Heritage Sites within the Project area.

There are also several listed middens and artefact scatters in the coastal dunes along Sunset Beach near Onslow which are classified as open sites with location co-ordinates available. These sites appear to be set back more than 100 m from the coastline. One ceremonial site, one mythological site and two camp sites, listed as occurring within the search area, are closed sites. The precise location of the closed sites is unknown.

3.6.3 European Heritage

The Project is approximately 4 km from the Old Onslow town site heritage place (Heritage Council of WA Place 03444). This place is listed on the 'State Register of Heritage Places' and is protected under the *Heritage of Western Australia Act 1990*. The town site was established in 1885 and abandoned in 1925 because of repeated flooding and siltation of the river mouth. The heritage place contains various ruins including the old jail, cemetery and hospital. The site of the old jetty and a section of the old tramway (also part of HWA/03444) are within the Project site (Chevron 2009).

4.0 POTENTIAL ENVIRONMENTAL IMPACTS

An environmental risk assessment has been completed to identify the most significant risks that will represent the focus of environmental management and monitoring (EIS/ERMP: Chapter 8). This assessment assisted in detailing the environmental acceptability of the Project, identifying key areas of risk and developing potential monitoring and management strategies. The risk assessment completed for the EIS/ERMP phase was undertaken in accordance with the principles and guidelines contained in the AS/NZ 4360:2004 – Risk Management and the EPA draft guidelines '*Application of risk-based assessment in EIA*' (EPA 2009c). The process evaluates the likelihood and consequence of environmental impacts occurring as a result of a factors (receptor) exposure to one or more aspects (Project activities) to assess the environmental risk levels.

4.1 Environmental Aspects and Impacts

During the initial scoping risk assessment, aspects of the Project that provide a barrier to alongshore sediment transport, and corresponding downdrift impacts, including changes to the entrance regime of Hooley Creek were identified as high risk. Subsequent studies have also identified potential change to the most eastern barrier spit of the east Ashburton River delta. A range of investigations were proposed including a coastal geomorphology assessment and coastal processes modelling. A second risk assessment for coastal processes was undertaken in August 2009, following a preliminary coastal geomorphology assessment and desktop geological heritage study. The environmental risks associated with the marine infrastructure, capital dredging and onshore works including the access road were assessed. Environmental risks that have been assessed as posing either a medium or high risk have been identified as 'key risks'. Risks have been assessed assuming the application of mitigation and management measures and therefore indicate the residual risk levels posed to each key environmental factor. Mitigation in this instance would be the implementation of a sand management system (potentially including sand bypassing). Sand bypassing is the process of mechanically transferring sediment from one side of a structure (that is impeding sediment movement) to the other to prevent a build-up of sediment on the upstream side and erosion on the downstream side. While impacts to geological heritage may also exist, due to the potential excavation of onshore sites for borrow areas, further field studies need to be undertaken to confirm the existence of these features.

Whilst the scope of the environmental risk assessment did not specifically include social impacts, such as the loss of recreational beach value due to downdrift erosion, these issues are addressed in this Draft CPMP as they are aligned with the environmental objectives of the Project.

4.1.1 Physical Environment

The complex and dynamic coastal geomorphology of the Project site, and in particular the Ashburton River delta, needs to be emphasised in terms of the challenges it presents in predicting the likely coastal response to the Project. However, the proposed MOF breakwaters, turning basin and dredged navigation channel provide an interruption to shoreface sediment transport patterns with the following likely impacts:

- Construction of the proposed MOF basin 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 harbour, with a greater volume accreting on the western side due to the net easterly littoral drift. This accretion will likely 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 potentially cause destabilisation of the outer chenier adjacent to the eastern Ashburton River 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 harbour, modulated by episodic, seasonal and inter-annual fluctuations in the direction of sediment transport. This may be partially mitigated through the sand management system, although the discrete nature of managed works, both spatially and temporally, is likely to affect the coastal dynamics, increasing local shoreline variability.
- The effect of wave sheltering adjacent to Hooley Creek tidal spit will produce a local imbalance in sediment transport and is likely to cause erosion of the spit. Marginal increase in water flow through to Hooley Creek lagoon is anticipated due to the more open entrance, including exposure to greater wave action.
- Deeper waters provided by the dredged channel and shipping basin will provide a trap for any bedload sediment transport passing in either direction.

DHI (2010) modelled nearshore wave and current responses to the MOF and navigation channel for both typical summer and winter conditions. Wave sheltering downdrift of the MOF and navigation channel in summer conditions extends to the entrance of Hooley Creek, about 1.5 km to the east of the MOF. Direct sheltering is not predicted east of Four Mile Creek.

During winter conditions, the modelled wave approach was directly onshore and the shadowing effect of the structures is minimal. However, easterly winds can drive westward transport in winter and would result in sheltering on the western side of the MOF (Damara WA 2010).

Construction and operation at the Ashburton North SIA is likely to modify the hydrodynamics of the Hooley Creek lagoon system, for both coastal and runoff flooding. The ultimate effects of terrestrial operations will be determined by changes to the coastal flooding and runoff catchment areas of the lagoon. In simple terms, runoff flooding opens the lagoon-ocean connection and increases the extent of tidal inundation. After a flood, the channel gradually closes over due to littoral drift, with the minimum cross-section determined by the volume of tidal exchange.

Modelling of runoff flows indicates moderate increases to the lagoon super-elevation during flood events (Chevron 2009). Hence there is increased capacity for the lagoon entrance channel to expand during runoff flooding. This effect may be enhanced by changes at the entrance due to erosion downdrift of the harbour breakwaters.

An expanded lagoon-ocean connection reduces the hydraulic resistance of the flow pathway from the Ashburton River, which is presently only a small breakout from the river channel to the otherwise coastal lagoon. Whilst remote, the capacity for increased channelization of Hooley Creek West provides potential for re-activation of the palaeochannel identified from the Ashburton River towards the Hooley Creek tidal creek complex. Such re-activation would require an extreme flood event, and therefore whilst considered remote, may occur without a corresponding progressive expansion of the tidal creek structure.

4.1.2 Biological Environment

The potential impacts of the Project, due to changes in coastal processes, on the biological environment are generally a direct result of the changes to the physical environment. These include:

- potential loss of regionally significant mangrove habitat due to erosion of the Hooley Creek entrance bar and the east Ashburton River delta chenier spit, or the closure of tidal creek entrances due to the onshore migration of dredged material placed nearshore (Figure 4.1)
- potential loss of coastal dune habitat between the Project site and Beadon Creek due to coastal erosion (Figure 4.1)
- potential changes in the inundation patterns, affecting intertidal habitats (Figure 4.1).

4.1.3 Coastal Recreation Value

Sunrise and Sunset Beaches are highly valued by the people of Onslow. Erosion of these beaches as a result of the Project may impact the recreational value of these beaches. Impacts may include loss of beach width affecting four-wheel driving at higher tides (at Sunset), loss of Onslow Town Beach width (affecting walking values), changes in beach sediments (potentially affecting visual amenity and swimming values), changes at the tidal creek entrances (boating, fishing and crabbing values), and changes to visual amenity (Figure 4.1).

Whilst beach widths can be measured, loss of beach recreational value is more difficult to quantify, both in terms of determining that a perceived loss of recreational value is a result of the Project or justifying that is it unrelated. Management of these potential impacts is addressed in this plan.

4.1.4 Coastal Protection (Onslow Seawall)

Beaches in front of the Onslow seawall, located in front of the town site and downdrift of the Project, are likely to be influenced by the trapping of sand by the MOF. This beach is recognised to have high recreational value, and in turn, could have a secondary impact of the level of protection provided by the Onslow seawall to the Onslow town site. In particular, reduction to beach levels may result in larger waves reaching the seawall during a storm, increasing wave overtopping and, depending upon the extent of underlying rock, compromising the integrity of the seawall (Figure 4.1).

The Onslow seawall provides critical protection for the Onslow town site against erosion and from cyclonic impacts. There may be a need to protect the integrity of the Onslow seawall, as interruption of littoral sediment transport by the MOF breakwaters may reduce the rate at which the beaches to the east recover from storm erosion. As Onslow Town Beach is already relatively narrow, the Onslow seawall is critical for the protection of the developed land immediately behind the seawall.

The sand management system should assist in managing beach levels in front of the Onslow seawall, so that they are maintained within their natural variability, and so a level of protection is provided by the seawall to the town site.

4.1.5 Heritage

Several sites of geological, indigenous and European significance are located near the existing shoreline, or adjacent to coastal dunes, however they are almost exclusively located behind the primary dunes. It is unlikely that these sites will be affected by altered coastal processes, provided that proposed management and mitigation measures are implemented to manage erosion that may develop on the beaches, east of the Project site. Those located eastward may be threatened if severe downdrift erosion occurs (Figure 4.1).

Development and application of the sand management system to prevent a sustained nearshore infrastructure-attributable erosion trend of the shoreline will provide protection to the heritage sites. Notably, actions to preserve the recreational value of the beaches between Four Mile Creek and Beadon Point would also provide protection of coastal heritage sites.

Excavation of several onshore sites for use as borrow areas (Figure 2.5) may result in the loss of several geological heritage features (mainly fossilised coral reef) (Figure 4.2). Mitigation measures will be put in place to manage potential disturbance to geological heritage sites during borrow area excavations.

Figure 4.1: Location of key environmental receptors.

Figure 4.2: Location of potentially impacted geological heritage sites (fossilised coral reef).

5.0 ENVIRONMENTAL MANAGEMENT & MITIGATION OBJECTIVES

The Projects overall environmental objective is to conduct its operations in a manner that manages environmental impacts to as low as reasonably practicable. Relevant environmental impacts, management measures, and performance targets are detailed in the following sections. A series of environmental and social objectives, and associated performance criteria for coastal management has been developed as a result of the environmental risk assessment.

The Projects environmental management objectives for coastal process preservation are to manage Project-attributable impacts to:

- have no loss of regionally significant mangrove habitat in the Ashburton River delta, achieved through sensitive Project design, appropriate construction management and coastal processes management;
- reduce impacts on mangrove habitat in Hooley Creek to as low as reasonably practicable;
- manage the development of a nearshore infrastructure-attributable erosion trend in the mean sea level shoreline position and dune vegetation line between the Project site and Beadon Creek;
- maintain the recreational value of beaches between the Project and Beadon Creek;
- install and operate nearshore infrastructure in a way that does not compromise the integrity and performance of the Onslow seawall;
- manage impacts with relation to heritage;
- construct and operate the Projects infrastructure in a manner that reduces indirect impacts; and
- design and implement monitoring programmes to provide feedback as to the continuity of natural coastal processes.

This section summarises several aspects of coastal processes that may be impacted upon and the measures in place to reduce the potential environmental impacts. For each environmental aspect, a set of objectives, a standard, and criteria has been developed as part of a systematic approach to the management of environmental risks and to assess the environmental performance of the works.

5.1 Sand Management System

The design and implementation of an effective sand management system for the MOF breakwaters is the primary means for achieving performance measures. Monitoring will be undertaken during the design, construction, and operation phases to identify changes to coastal processes resulting from the Project. If required, a sand management system will be developed and implemented to manage the environmental impact of these changes within acceptable limits. This may require management actions prior to and during the construction phase of the Project. Sand management will need to consider:

- potential “near field” coastal response to the Project infrastructure, capturing sediment to either side of the breakwaters
- the interruption to littoral transport caused by the Project infrastructure, expected to cause downdrift erosion to the east of the site

- significant year-to-year variability of sediment transport rates
- potential for significant sediment transport associated with tropical cyclones
- long-term management of sand volumes, as historic accretion has occurred in the vicinity of the Project site
- response times required to manage environmental impacts to within acceptable limits
- approvals required for undertaking mitigation works
- potential benefits of pro-active mitigation measures such as sand nourishment or sand bypassing
- potential synergies with capital and maintenance dredging activities
- the feasibility of various sand management options.

This range of factors, and the existing uncertainty presently associated with the estimated rates of sediment transport require an adaptive sand management system, incorporating extensive beach monitoring to establish the need for any mitigation actions.

Potential requirements for sand management have been identified for four sectors. These include:

- Ashburton River delta, particularly the eastern-most chenier;
- Hooley Creek lagoon,
- Various Onslow beaches, between Hooley Creek and Beadon Point; and
- Onslow Town Beach.

5.1.1 East Ashburton River Delta

Destabilisation of the easternmost chenier may occur due to “near field” erosion shortly after construction (Table 5.1), or through episodic downdrift erosion on the western side of the Project site. This may occur under the influence of a strong reversal in sediment transport, most likely due to a severe tropical cyclone (Table 5.2). The key environmental factor at potential risk is the mangrove system of the east Ashburton River delta, that is presently protected by the chenier. The likelihood of this outcome occurring is considered to be minimal, but the environmental consequence of the outcome occurring is relatively high.

5.1.2 Hooley Creek Lagoon

Changes to the entrance structure of the Hooley Creek lagoon are anticipated to occur as a result of installing Project infrastructure, most significantly due to the effect of downdrift erosion to the east of the MOF breakwaters. Additional change is likely to result at the entrance because the placement of nearshore infrastructure modifies the catchment areas for both coastal and runoff flooding. Erosion of the Hooley Creek spit may directly expose the mangroves to wave action (currently, the presence of a tidal spit provides protection).

A management approach for Hooley Creek lagoon entrance is suggested below (Table 5.3). Due to the potential complexity of entrance behaviour and response, selection of management actions requires careful review of the situation, based upon knowledge gained through the ongoing monitoring programmes. A set of triggers have been provided that identify the need for such a review.

It should be noted that measurements given for average spit width and minimum channel width (Table 5.3) require further refinement via modelling of cyclonic impacts (for spit width) and modelling of choking and other hydrodynamic impacts (for channel width).

5.1.3 Sunset Beach

Downdrift erosion due to the interruption of littoral transport by the MOF breakwaters and channels is likely to occur. Due to the structural control provided by Beadon Point and the relatively low rates of alongshore sediment transport, impacts to Sunset Beach are likely to be gradual, potentially causing slight beach realignment. However, the nature of post-storm recovery of the beach is likely to be changed, as potential loss of sand build-up around Beadon Point will not be balanced by a summer sand feed from the west. The key value potentially affected by these changes is the recreational value offered to the residents of Onslow, who regard the beach resource highly.

A framework for the management of Sunset Beach is outlined in Table 5.4.

5.1.4 Onslow Town Beach

The interruption of littoral transport by the MOF breakwaters and marine access channels is likely to reduce the gradual bypassing that naturally occurs at Beadon Point. While this in its self will not cause erosion of Onslow Town Beach, it is likely to change the nature of post-storm recovery. The key value potentially affected is the recreational value offered to the residents of Onslow, who regard the beach resource highly. The potential effect of erosion on the town shoreline is already mitigated by the existing seawall.

A framework for the management of Onslow Town Beach is outlined in Table 5.5.

Table 5.1: Management of potential near-field erosion.

Timing	♦ During Construction and Operation of nearshore infrastructure
Controls	♦ Design: Breakwater layout and configuration ♦ Provision of suitable nourishment material

	♦ Provision of plant suitable for sand placement
Monitor	♦ A – Rapid assessment (qualitative) ▪ What: beach structure ▪ How: On-ground photo capture ♦ B – Quantitative assessment ▪ What: Chenier width from waterline to waterline (or permanent vegetation line) at spring high tide ▪ How: Physical on-ground surveys
Triggers	♦ A – presence of extensive erosive scarp (>500 m) ♦ B – Average Chenier Width <30 m (non-cyclonic conditions only)
Action	♦ A – undertake Quantitative assessment ♦ B – Assess volume in the "sand trap", potentially located to the west of the main MOF breakwater, to determine further potential for "near-field" erosion. Provide corresponding volume of beach nourishment from external source
Performance Review	♦ Monitor performance of nourished material in the following months. ♦ Assess using Quantitative assessment
Trigger to Review Strategy	♦ If nearshore infrastructure-attributable erosion trend on chenier continues after filling of sand trap, review management strategy
Alternative Actions	♦ Undertake hydrographic survey to identify pathway of sediment loss. ♦ Review "sand trap" performance ♦ Revise (and apply) any change to nourishment requirements

Table 5.2: Management of potential westerly transport events erosion.

Timing	♦ During Construction and Operation of nearshore infrastructure
Controls	♦ Design: Breakwater layout and configuration ♦ Provision of suitable nourishment material

	♦ Provision of plant suitable for sand placement
Monitor	♦ A – Rapid assessment (qualitative) ▪ What: beach structure ▪ How: On-ground photo capture ♦ B – Quantitative assessment ▪ What: Chenier width from waterline to waterline (or permanent vegetation line) at spring high tide ▪ How: Physical on-ground surveys
Triggers	♦ A – presence of extensive erosive scarp (>1000 m) ♦ B – Average Chenier Width <20 m
Action	♦ A – undertake Quantitative assessment ♦ B – Evaluate risk of large-scale chenier destabilisation. If risk is moderate or greater, undertake renourishment to achieve a minimum average chenier width >20 m
Performance Review	♦ Monitor performance of nourished material in the following months. ♦ Assess using Quantitative assessment
Trigger to Review Strategy	♦ If severe erosion is observed on the chenier for any two out of three consecutive years, then strategy to be reviewed
Alternative Actions	♦ Undertake hydrographic survey to identify pathway of sediment loss. ♦ Coastal engineering review of beach monitoring data ♦ Modify breakwater design

Table 5.3: Management of Hooley Creek lagoon entrance.

Timing	♦ During Construction and Operation of nearshore infrastructure
Monitor	♦ What: Hooley Creek spit width at high tide during spring tide and Hooley Creek channel width/depth. ♦ What: Mangrove habitat and spatial area of algal mats

	♦ When: At a to-be-determined frequency. Event-based monitoring (after tropical cyclone impact) as soon as area accessible from Onslow ♦ How: Physical on-ground surveys, and aerial photography/satellite imagery where possible (noting limited accuracy)
Triggers	♦ Average Spit Width: (non-cyclonic) <20 m to absorb cyclonic impact (assuming no significant surge event) ♦ Minimum Channel Width: (behind Hooley Creek spit) 40 m ♦ System recovery after cyclone: <20 % per year (of spit width) after tropical cyclone (based on historical 'natural' recovery time of ~5 years) ♦ Regionally significant mangrove habitat loss: any detectable loss ♦ Algal mat loss: any detectable loss
Action	♦ Determine most appropriate action depending on circumstances, including: cause and rate of change; availability of resources; adaptability of response; extent of community concern and secondary environmental impacts of proposed management action
Performance Review	♦ Generally will require at least 12 months to determine the effectiveness of any strategy to cope with seasonal effects
Alternative Actions	♦ Revegetate ♦ Beach nourishment ♦ Sand management

Table 5.4: Management of Sunset Beach

Timing	♦ During Construction and Operation of nearshore infrastructure
Monitor	♦ What: Beach Width from water line to permanent vegetation line at spring high tide (between Four Mile Creek and Beadon Point) ♦ When: At a to-be-determined frequency. Event-based monitoring (after tropical cyclone impact) as soon as area accessible from Onslow

	♦ How: Physical on-ground surveys, and aerial photography/satellite imagery where possible (noting limited accuracy)
Triggers	♦ Minimum Beach Width: (non-cyclonic) <25 m (5 m for functional use and 20 m buffer for moderate cyclonic event) ♦ Beach Recovery <20 % per year after tropical cyclone (based on historical 'natural' recovery time of ~5 years) ♦ Community concerns/complaints
Action	♦ Determine most appropriate action depending on circumstances, including: cause and rate of change; availability of resources; adaptability of response; extent of community concern and secondary environmental impacts of proposed management action
Performance Review	♦ Generally will require at least 12 months to determine the effectiveness of any strategy to cope with seasonal effects
Trigger to Review Strategy	♦ No evidence of reversing the nearshore infrastructure-attributable erosion trend
Alternative Actions	♦ Sand management ♦ Beach nourishment

Table 5.5: Management of Onslow Town Beach.

Timing	♦ During Construction and Operation of nearshore infrastructure
Controls	♦ Onslow Town Beach seawall (existing)
Monitor	♦ What: Beach Width from water line to seawall toe at spring high tide ♦ When: At a to-be-determined frequency. Event-based monitoring (after tropical cyclone impact) as soon as area accessible from Onslow ♦ How: Physical on the ground surveys and aerial photography/satellite

	imagery where possible (noting limited accuracy)
Triggers	♦ Average Beach Width: (non- cyclonic) <10 m (assuming no significant storm event) ♦ Beach Recovery <20 % per year after tropical cyclone (based on historical 'natural' recovery time of ~5 years) ♦ Community concerns/complaints
Action	♦ Review pattern of erosion. ♦ If erosion is episodic (e.g. cyclonic) consider beach nourishment at Onslow ♦ If erosion is gradual, consider strategic placement of nourishment at Onslow and Sunset Beaches or Hooley Creek locations
Performance Review	♦ Generally will require at least 2-3 years to determine the effectiveness of any strategy to cope with seasonal effects
Trigger to Review Strategy	♦ No evidence of reversing the nearshore infrastructure-attributable erosion trend
Alternative Actions	♦ Modify beach nourishment programme ♦ Sand management

5.2 Environmental Performance Measures

Environmental management of coastal process impacts requires consideration of a number of environmental factors. These include mangrove habitats, coastal dune habitat, coastal recreational value, coastal protection (Onslow seawall) and geological, European and indigenous heritage sites. Performance measures have been identified for protecting these environmental factors. The following table outlines the management strategies proposed (Table 5.6).

Table 5.6: Structure of management strategies.

Management Area	Specific areas to be managed (e.g. Hooley Creek)
Performance Objective:	Applicable performance objectives against which environmental performance will be measured
Management:	Proposed management strategies including trigger levels, responses and contingency measures
Monitoring:	Applicable proposed monitoring programmes
Reporting:	Required reporting including frequency and recipient
Risk Assessment:	Residual risk ranking (i.e. end risk, taking into consideration management and monitoring measures)

5.2.1 Coastal Dune Habitat Management

Monitoring will be undertaken during the design, construction, and operation phases to identify changes to terrestrial coastal dune habitat as a result of changing coastal processes due to the presence of Project infrastructure. The following table outlines the management strategies proposed (Table 5.7).

5.2.2 Coastal Recreational Value Management

Monitoring will be undertaken during the design, construction, and operation phases to identify changes to recreational beach value as a result of changing coastal processes due to the presence of Project infrastructure. The following table outlines the management strategies proposed (Table 5.8).

5.2.3 Coastal Protection (Onslow Seawall) Management

Monitoring will be undertaken during the design, construction, and operation phases to identify changes to the Onslow seawall (as part of coastal protection) as a result of nearshore infrastructure-attributable changes to coastal processes. The following table outlines the management strategies proposed (Table 5.9).

5.2.4 Geological, European & Indigenous Heritage Management

Monitoring will be undertaken during the design, construction, and operation phases to identify changes to geological, European and indigenous heritage as a result of changing coastal processes due to the presence of Project infrastructure, as well as the excavation of onshore sites for use as borrow areas. The following table outlines the management strategies proposed (Table 5.10).

Table 5.7: Coastal Dune Habitat Management.

Management Area	Coastal Dune Habitat Management
Performance Objective	♦ "The Responsible Party will manage coastal processes so as to prevent the development of a nearshore infrastructure-attributable erosion trend in the position of the mean sea level shoreline and

	dune vegetation line between the Project site and Beadon Creek".
Management	♦ If required, a sand management system will be implemented to meet the performance objectives outlined above. ♦ Management response to be determined prior to construction, and implemented following the development of a nearshore infrastructure-attributable erosion trend in the beach monitoring programme.
Monitoring	♦ The proposed monitoring programme is outlined in Section 8 with the additional components: ▪ Site inspection of beach and entrance bar condition between Ashburton Delta and Beadon Creek. ▪ Hydrographic survey of nearshore area.
Reporting	♦ The following reporting is proposed: ▪ An annual Coastal Processes Management report. ▪ Mangrove habitat monitoring
Risk Assessment	♦ EIS/ERMP Chapter 9

Table 5.8: Coastal Recreational Beach Value Management.

Management Area	Coastal Recreational Value Management
Performance Objective	♦ "The Responsible Party will manage nearshore infrastructure-attributable changes to coastal processes so as to maintain the recreational value of beaches between the Project site and Beadon Creek".
Management	♦ A sand management system will be implemented to meet the performance objectives outlined above. ♦ Management response to be determined prior to construction, and implemented following any reduction in the recreational value of beaches identified in the monitoring programme or through direct

	community feedback.
Monitoring	♦ The proposed monitoring programme is outlined in Section 8 with the additional components: ▪ Site inspection of beach condition between Ashburton Delta and Beadon Creek. ▪ Community liaison to provide feedback on impacts on recreational values
Reporting	♦ The following reporting is proposed: ▪ An annual Coastal Process Management report.
Risk Assessment	♦ Not performed for social factors

Table 5.9: Coastal Protection (Onslow Seawall) Management

Management Area	**Coastal Protection (Onslow Seawall) Management**
Performance Objective	♦ "The Responsible Party will manage nearshore infrastructure-attributable changes to coastal processes and take other actions as necessary so as to maintain the integrity and performance of the Onslow seawall".
Management	♦ A sand management system will be implemented to meet the performance objectives outlined above. ♦ Mitigation measures may be required prior to Project construction/commencement. ♦ Management response to be determined and mitigation measures implemented by Responsible Parties, *prior* to Project

	commencement.
Monitoring	♦ The proposed monitoring programme is outlined in Section 8 with the additional components: ▪ Site inspection of beach and seawall condition between Beadon Point and Beadon Creek.
Reporting	♦ The following reporting is proposed: ▪ Results from field inspection of seawall condition ▪ An annual Coastal Processes Management report.
Risk Assessment	♦ EIS/ERMP Chapter 8

Table 5.10: Geological, European & Indigenous Heritage Management.

Management Area	**Geological, European & Indigenous Heritage Management**
Performance Objective	♦ "The Responsible Party will manage coastal processes and construction activities so as to maintain heritage sites and values between the Ashburton Delta and Beadon Creek, as far as practicable."
Management	♦ A sand management system will be implemented to meet the performance objectives outlined above. ♦ Mitigation measures will be put in place to manage potential disturbance to geological heritage sites during borrow area excavations. ♦ Management response to be determined prior to construction, and implemented following the development of a Project-attributable erosion trend or reduction in beach widths in the beach monitoring programme.

Monitoring	♦ The proposed monitoring programme is outlined in Section 8 with the additional component: ▪ Site inspection of important heritage locations to assess condition and potential threats.
Reporting	♦ The following reporting is proposed: ▪ An annual Coastal Processes Management report.
Risk Assessment	♦ Not performed for social factors ♦ EIS/ERMP Chapter 8

6.0 ROLES & RESPONSIBILITIES

6.1 Key Roles and Responsibilities

Key roles and responsibilities for Project personnel, both Chevron-employed and contractor companies, will be defined in subsequent versions of the Draft CPMP.

7.0 TRAINING & EDUCATION

Prior to the commencement of works, key personnel will be required to understand their environmental responsibilities in relation to the management of coastal processes and thus the protection of mangrove habitat, coastal dune habitat, coastal protection and other social aspects. Key site personnel, including contractors and visitors, will be required to undertake appropriate training that will convey the environmental responsibilities and management methods required. The level of training will be appropriate to the level of risk associated with the tasks to be undertaken. Training and education activities will typically include:

- a general environmental induction – provides an overview of the environmental requirements for the site
- area and activity-specific inductions – provide detailed information on environmental requirements for particular areas and activities. These inductions are targeted at the personnel carrying out the activity
- procedures and work instructions – provide personnel with information specific to the activity to be undertaken, including emergency response actions
- toolbox meetings – provide an opportunity to inform site personnel of changes to work processes, procedures and work instructions. They also enable discussion of incidents and outcomes to raise awareness of site personnel
- training and information sessions – provide personnel with skills and information to enable an activity to be undertaken in an appropriate manner.

Personnel with responsibilities in specific environmental practices will be adequately trained in effective implementation of work instructions and procedures. Required training will be included in future revised version of this Draft CPMP, following consultation with regulatory agencies, and prior to Public Review.

8.0 MONITORING, AUDITING & REPORTING REQUIREMENTS

8.1 Environmental Documentation Management

8.1.1 Chevron ABU OE Documentation

As part of the Chevron ABU, the Project is governed by the requirements of the ABU OEMS, within which a number of OE Processes exist. The Project will implement internal OE Processes (and supporting OE Procedures) that apply to the Projects activities. The OE Processes have been prepared by Chevron to address various issues that Chevron internally requires its employees, contractors, etc to comply with (or equivalent contractor process). These processes will also be applied to the requirements of this Draft CPMP where this is appropriate and reasonably practicable.

8.2 Monitoring Programmes

Monitoring programmes will be designed and implemented to assess mangrove habitat, coastal dune habitat, coastal protection, coastal recreational use and heritage. Where possible, monitoring programmes will utilise efficient and effective techniques that provide early warning of possible changes. The monitoring programmes will link the function of coastal processes to the potential site changes associated with the construction of and operations at the Project site and, in particular, focus on how those physical site changes may modify the key coastal processes in the area.

Monitoring programmes are designed to be adaptive and responsive to events, including erosion, cyclones and construction of nearshore infrastructure. For example, while monitoring programmes are generally proposed biannually and annually, event-based inspection would be proposed if beach profile data indicated nearshore infrastructure-attributable erosion trends developing in certain areas that pose a threat to any of the environmental factors. Similarly, monitoring would need to be adaptive to cyclonic events in recognition of the episodic nature of coastal change in the area.

The monitoring programmes include triggers for management response, which should be determined prior to the commencement of Project construction. However, mitigation measures for the Onslow seawall, for example, are proposed to be implemented prior to construction, due to the difficulty in responding to adverse impacts within a reasonable timeframe.

8.2.1 Coastal Geomorphology

A combination of beach profiles, hydrographic surveys and aerial photography and site inspection are proposed to identify potential changes to coastal processes associated with Project construction (Figure 8.1). Annual and event-based (i.e. post-cyclone) inspections of various environmental factors are proposed to define the potential impacts of any changes. This would include annual inspections of beach recreational value, tidal creek bar configuration, the condition of the Onslow seawall; and geological, indigenous and European heritage sites. Community liaison is proposed with regards to impacts on beach recreational value in recognition of the high value placed on the coast by the local community.

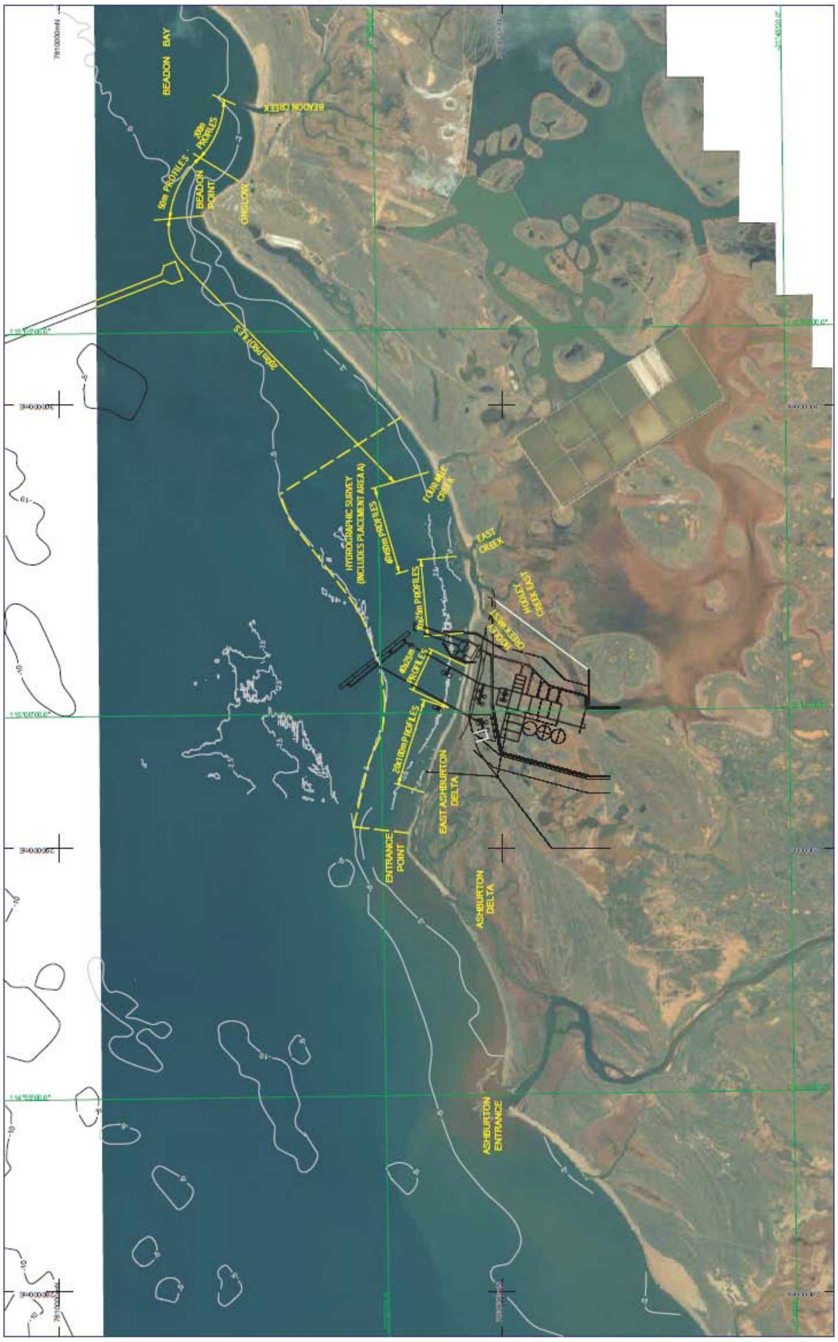

Figure 8.1: Proposed beach monitoring programme locations.

8.3 Inspection and Management Review

Inspections will be conducted by a representative of the Proponent against this Draft CPMP and the relevant HES plans during the works. Any corrective actions will be documented and their timely implementation tracked through programme team meetings. Any required remedial actions will be carried out as soon as practical. Items identified for urgent action, including amendments to procedures, will be dealt with immediately.

Chevron will undertake a review of environmental performance, including the results of the inspections following completion of the works.

8.4 Reporting Requirements

8.4.1 Coastal Processes Management Report

An annual Coastal Processes Management report is proposed, which consolidates the previous years monitoring programmes. The scope of this annual report would include monitoring results, assessment of sediment transport rates, entrance bar configuration, metocean conditions for the previous year, results of previous and future planned sand management activities.

The monitoring-triggered sand management system would be adaptive and flexible, to allow alternative measures to be implemented if monitoring shows that performance objectives are not being met.

9.0 CONSULTATION

9.1 Document Development

Chevron has prepared this Draft CPMP to provide an indication of how activities associated with the Project will be undertaken to reduce the potential impact to coastal processes. No formal consultation with the DEC, EPA, DEWHA, DPA or any other regulatory agency has occurred at this stage. It is intended that this Draft CPMP is included as an Appendix to the Project EIS/ERMP. It is expected that it will be reviewed by the appropriate regulatory agencies following submission of the EIS/ERMP. Comments and recommendations from this review may then be incorporated to produce the final document.

9.2 Ongoing Consultation

Management measures to be implemented for some elements of risk could be presented in detail as standard approaches that will be followed in accordance with the regulatory framework. However, management measures for other components of environmental risk are conceptual (e.g. implementation of a sand management system) with more detail likely to be required once Ministerial Conditions for the Project have been set.

This Draft CPMP will also be made publicly available during the EIS/ERMP public review period.

Should changes to the design or operation of the Project occur after completion of the finalised CPMP, the document will be reviewed and revised as appropriate. The review will include a reassessment of the environmental risks presented by the works and the corresponding management strategies being implemented. Any such changes will be communicated to the DEC, EPA, DEWHA, DPA and any other regulatory agencies as required.

10.0 ENVIRONMENTAL CONDITIONS

A set of Outcome Based Conditions (OBCs) have been developed for Coastal Processes (Table 10.1). These OBCs are also presented in Chapter 12 of the EIS/ERMP. In order to meet the OBCs, this Draft CPMP (Appendix T) has been developed which, in part, provides a high-level indication of how impacts to Coastal Processes will be managed. Prior to Project construction, a Final (detailed) CPMP will be developed that specifies the management and mitigation measures and actions which will be implemented to limit nearshore infrastructure-attributable impacts to Coastal Processes.

This process is designed to ensure that the OBCs are achieved, and are consistent with the EPAs Guidance Statement No. 4 - *Towards Outcome-based Conditions* (EPA 2009d). This approach is also consistent with the EPAs 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 Management Plan.

Table 10.1: Outcome Based Conditions – Coastal Processes.

1.	**Proposed Outcome-based Condition 1: Coastal Processes Protection**
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 X. This will be achieved by way of managing littoral transport to: ♦ Ensure that the placement of nearshore infrastructure does not result in an erosive shoreline trend under non-cyclonic conditions; ♦ Ensure that the placement of 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 X. 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 Table X. 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 Table X 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 Table X 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 Table X 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 Proponents 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. (*Notes for EIS/ERMP purposes – not to be included in actual condition):* ♦ *Standard Environment Performance Reporting will be covered under a standard condition* ♦ *The release of monitoring reports for public viewing will be covered under its own standard environmental condition.*
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.

11.0 GLOSSARY

Terminology	Description
Alluvial	Soils or sediments deposited, by a river or other running water body as it slows, in a river bed, delta, estuary or flood plain
Arcuate beach	A shore with an arc-shaped, concave plan form, often comprised of a sandy beach between two erosion resistant features which provide structural control (e.g. rocky headlands)
Arid, sub-tropical (sub-monsoonal)	the climatic region found adjacent to the tropics, generally distinguished by rainfall, and considered to be beyond the normal extent of monsoonal rain systems
Avulsion	Rapid abandonment of a river channel and the formation of a new river channel. Avulsion usually occurs during flood conditions where river or channel banks are breached, and the hydraulic resistance of the new channel is less than the previous channel. The 'new' channel may actually be a palaeochannel. This commonly produces delta switching when avulsion occurs in a deltaic landscape
Back-barrier flats	The flat area, often marshy and populated with low vegetation, on the bay or lagoon side of a barrier island
Bioregion	Large, geographically distinct areas of land, ocean or seafloor with common characteristics such as plant and animal communities, ecological features, and physical characteristics
Chenier	A discrete, elongated, vegetated marine beach ridge comprised of sand or shell which is stranded on a coastal mudflat or marsh, roughly parallel to a prograding shoreline. When cheniers are distributed across a wide plain, that feature is called a 'chenier plain'
Chenier spit	A chenier that is joined to the mainland at one end but not the other, thus forming a spit
Coalescing river deltas	Two or more river deltas fused or joined together to form one delta.
Coast	A strip of land of indefinite width that extends from the shoreline inland to the first major change in terrain features.
Coastal processes	Collective term covering the action of natural forces on the shoreline, and nearshore seabed
Cuspate foreland	The coastal convexity (in plan form) developed in the lee of a shoal or offshore feature by waves that are diffracted and/or refracted around both sides of the offshore feature. Elongated features may be referred to as cuspate spits. If the foreland links the feature to the mainland reaches, it is a tombolo
Delta	A landform comprised of branched or interleaved channels and alluvial deposits occurring at the mouth of a river due to high riverine sediment supply
Downdrift	The direction of predominant movement of littoral materials
Fluvial	Processes associated with rivers and streams and the deposits and landforms created by them
Foredune	The most seaward and immature dune of a coastal dune system
Lithified	A geological feature that has become cemented (turned into rock) through a combination of induration and compaction
Littoral drift / Littoral transport	The movement of beach material in the littoral zone by waves and currents (parallel movement = alongshore drift; perpendicular movement = cross-shore transport)

Terminology	Description
Metocean	The combination and interaction of meteorological and oceanographic factors (e.g. wind, waves, and currents)
Palaeochannel	Abandoned channels where the river previously flowed prior to the present flow path
Photogrammetry	The science of making maps and/or deriving the physical dimensions of objects from measurements on aerial photographs
Prevailing	The direction from which the wind most frequently blows
Residual mounds	The topography (e.g. small hills) remaining after inundation and erosion of the rest of the landscape (to a more planar shape) by high water levels
Sediment cell	A reach of coast, including the nearshore terrestrial and marine environments, within which movement of sediment is readily identifiable if not largely self-contained. Sediment cells are segments of the coast in which sediments being or derived from a common origin or source can be traced along transport paths to a sink where they are temporarily or permanently lost to the coast
Shoal	A detached mound of any material (except rock or coral), typically composed of sand, silt or small pebbles that has a relatively shallow depth. Similar continental or insular shelf features of greater depths are usually termed banks. Shoals may develop from a detached portion of a deltaic or tidal spit
Shoreface	The inner section of the continental shelf seafloor that is subject to wave action
Spit	A small point of land or a narrow shoal projecting into a body of water from the shore
Surge	The water level above normal expected tide levels for that point in time, usually due to a combination of pressure, wind and wave setup during a storm or cyclone
Transgression	The invasion of a large area of land by the sea in a relatively short geological time period
Updrift	The direction opposite to that of the predominant movement of littoral materials

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Appendix U1

Draft Construction Environmental Management Plan

Tables

Figures

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1.0 FRAMEWORK CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN

1.1 Introduction

1.1.1 Purpose

Chevron is committed to conducting all activities associated with the proposed Wheatstone Project (Project) in an environmentally responsible manner and intends to implement best practice environmental management as part of a program of continuous improvement. This will be achieved by addressing environmental issues systematically, consistent with internationally accepted standards and the Chevron Operational Excellence Management System.

The Wheatstone Environmental Management Program comprises a set of proposed Outcome-based conditions and Statutory Environmental Management Plans which will be submitted to the EPA/DEWHA for review/ approval. This framework Construction Environmental Management Plan (CEMP) is included in the set of Statutory EMPs.

The Environmental Management Program also involves the systematic development of Subsidiary plans which will detail the specific management measures and monitoring programs associated with each work package and contract required to complete the Project construction and commissioning activities.

The aim of the CEMP is to set out the basis by which environmental risks associated with the onshore construction and near-shore marine installation activities will be managed. This CEMP compliments the material presented in the main body of the Draft EIS/ERMP as it brings together activity-specific environmental management and protection measures currently under consideration. The CEMP has been included in the EIS/ERMP in draft form and will be finalised to meet the requirements of the relevant State and Commonwealth Ministerial Conditions.

This document has a specific lifespan in its current form. Its purpose is to provide stakeholders with the opportunity to better understand the management measures proposed for construction and commissioning of the Project.

1.1.2 Wheatstone Environmental Management Program

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. Figure 1.1 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 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).

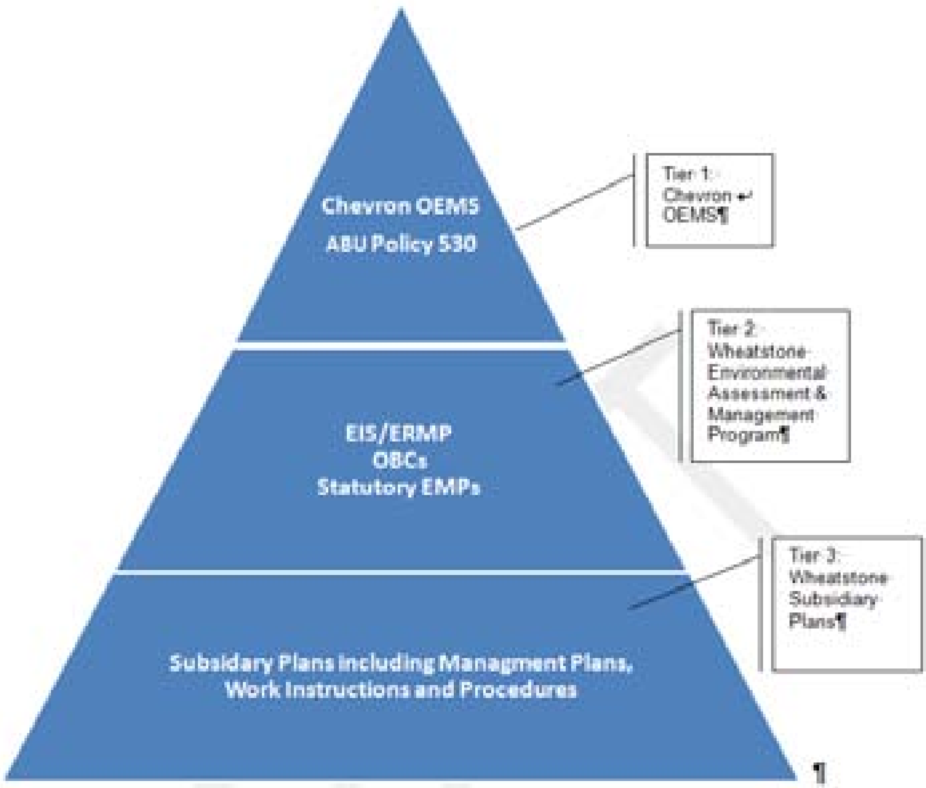

Figure 1.1: Wheatstone Environmental Management Program

The CEMP forms a part of Tier 2 of the Wheatstone Environmental Management Program and is complemented by a set of additional Statutory EMPs and Outcomes-based Conditions (OBCs).

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 where it is difficult to predict the environmental outcome.

OBCs are defined in these Guidelines as those conditions that are recommended in an EPA Report or set in a Ministerial 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.

Outcome-based conditions developed for the Project are listed in Table 1.1 below along with the relevant associated Statutory Management Plans

Table 1.1: Proposed Outcome-based Conditions

#	Proposed Outcome-based Condition	Proposed Statutory Plan
1	Coastal Processes Protection	*Coastal Processes Management Plan*
2	Mangrove and Estuarine Habitat Protection	*Construction Environmental Management Plan*
3	Benthic Primary Producer Habitat Protection	*Dredge Spoil and Disposal Management Plan*
4	Marine Fauna Protection	*Marine Fauna Management Plan & Dredge Spoil and Disposal Management Plan*
5	Terrestrial Flora and Vegetation Protection	*Construction Environmental Management Plan*
6	Terrestrial Fauna Protection	*Construction Environmental Management Plan*
7	Operational Marine Water and Sediment Quality Protection	*N/A*

Additional proposed Statutory EMPs are outlined in Table 1.2 below.

Table 1.2: Proposed Statutory Wheatstone 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 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
Operations	The purpose of the OEMP is to reduce the Project-	To Be

Plan	Purpose	Draft
Environmental Management Plan (OEMP)*	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.	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

1.1.3 Scope

This draft CEMP has been prepared as an appendix to the Wheatstone Project EIS/ERMP in order to outline the management and mitigation measures proposed for management of the environmental risks associated with the onshore and nearshore construction and installation activities. The management measures to be implemented for some elements of risk (such as accidental spills of hazardous chemicals or hydrocarbons) are presented in detail as standard approaches that will be followed in accordance with the regulatory framework. Additional EMPs have been developed for the project to manage the environmental aspects of other project related activities.

The scope of the EMP 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.

Activities beyond the scope of the CEMP and which will be managed by separate plans include:

- Dredging
- Coastal processes
- Offshore installation including drilling and pipelaying in Commonwealth managed waters.

1.1.4 Structure

The CEMP is structured as a set of frameworks which address the environmental issues and associated management strategies relating to the Project's construction and installation activities.

These frameworks highlight the key environmental objectives, performance criteria, management commitments, and guidelines which will be detailed in subsequent internal management plans.

The frameworks are presented in this format to facilitate review as part of the environmental impact assessment process. The measures detailed within each framework will be incorporated into subsidiary EMPs which will generally be structured by Project component.

Frameworks provided in the CEMP include:

1. Workforce conduct: including controlled work and recreational activities
2. Terrestrial vegetation and flora: including vegetation clearing, weed management and fire prevention
3. Terrestrial fauna: including fauna exclusion, habitat protection and quarantine management
4. Earthworks and erosion control: including grading, infill, bunding installation and potential onshore dredge material placement
5. Rock placement/dumping: associated with installation of rock walls and revetments for the MOF and armour protection for marine pipelaying
6. Piling and marine Infrastructure Installation: associated with the PLF
7. Drilling and blasting: including seismic vertical profiling
8. Microtunnelling/trenching: (including backhoe dredging) associated with installation of the feed gas trunkline
9. Pipelaying: associated with the installation of subsurface components of the LNG plant and support facilities as well as the domgas pipeline
10. Traffic and access management: including dust control and fire prevention
11. Shipping and vessel operations: including bulk marine transport, vessel traffic control, mooring and anchoring, and marine quarantine management
12. Lighting and light emissions
13. Dust and air emissions
14. Solid and liquid wastes: including construction waste, domestic waste, wastewater discharges, and drill cuttings disposal
15. Facility testing; commissioning and start-up including hydrotesting, purging etc
16. Spill contingency and response (onshore and nearshore)
17. Incident management and emergency response
18. Clean-up and rehabilitation (following temporary disturbance).

Unplanned events and emergencies are by nature not part of the anticipated Project program, however it is recognised that there is potential for incidents to occur during the course of a Project. Accordingly, separate to this CEMP, there will be a suite of documentation relating to contingency planning and emergency response.

1.1.5 Legislation, Approvals, Licenses and Permits

The applicable Commonwealth and State legislation pertinent to the activities described with this plan includes, but is not limited to, the following Acts and Regulations (and relevant amendments):

1.1.5.1 Western Australian

- Wildlife Conservation Act 1950
- Petroleum Act 1967
- Petroleum Pipelines Act 1969
- Petroleum (Submerged Lands) Act 1982
- Conservation and Land Management Act 1984
- Environmental Protection Act 1986
- Petroleum Act 1967 (WA) Schedule of Onshore Petroleum Exploration and Production Requirements 1991
- Fish Resources Management Act 1994
- P(SL) Acts Schedule Specific Requirements as to Offshore Petroleum Exploration and Production 1995 (regulates both State and Commonwealth activities)
- Acts Amendments (Marine Reserves) Bill 1997

1.1.5.2 Commonwealth

- Quarantine Act 1908
- Navigable Waters Regulations 1958
- Port and Harbour Regulations 1966
- Environment Protection (Sea Dumping) Act 1981
- Marine Act 1982
- Environment Protection (Sea Dumping) Regulations 1983
- Protection of the Sea (Prevention of Pollution from Ships) Act 1983
- Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)
- Australian Quarantine Regulations 2000
- Australian Ballast Water Management Requirements 2001

Note: *The Commonwealth Offshore Petroleum and Greenhouse Gas Storage Act 2006 has been omitted from this list as the scope of this CEMP does not extend to offshore installation activities in Commonwealth waters. Associated construction activities will be managed through a set of Environment Plans to be submitted and approved by the Western Australian Department of Mines and Petroleum under a Joint Authority with the Commonwealth Government of Australia.*

1.1.6 Approval, Review and Distribution

On completion of the environmental approvals process, this draft CEMP will be finalised in consultation with DEC and DEWHA. The final CEMP will address relevant requirements of State and Commonwealth Ministerial Conditions. Where considered necessary and appropriate, this plan will be updated to reflect the reassessment in consultation with the relevant State and Commonwealth agencies.

In the event that there is a significant change to the schedule or nature of the proposed construction works after this plan has been finalised, the plan will be reviewed. The review will include a reassessment of the environmental risks presented by the works and the corresponding management strategies being implemented.

1.2 Development Components and Construction Activities

The following sections briefly describe these components and associated construction activities. For a more detailed description refer to Chapter 2 in the EIS/ERMP.

1.2.1 Pipeline Shore-crossings

One pipeline will be installed for the Foundation Project with additional future pipelines to be installed during subsequent expansion phases. It is envisaged that these pipelines would be completed during each phase of the construction and would not be installed at the same time.

For the selected beach crossing location at the periphery of the mangroves, an open cut trench is feasible but not considered technically optimum.

The alternative approach being considered is micro-tunnelling which would entail creation of a tunnel beneath the dunes system and mangroves, exiting in approximately 2 m water depth. The micro-tunnel concept involves creation of an entrance shaft up to 10 m diameter close to the Liquefied Natural Gas (LNG) plant (inside the dune line) and subsequent creation of a 3 m tunnel using a combined drillhead/thrust system to install successive tunnel sections out to the exit point (a distance of approx 1200 m).

The construction requirements for the pipeline from the 2 m marine contour to approximately the 10 m contour (a distance of around 7 km) will be a dredged trench into which the pipeline will be laid. This trench will be created using a backhoe dredge and will vary in depth from 5 m to approximately 2 m. After pipelay is complete, the trench would be backfilled with rock or engineered backfill of a similar volume to achieve a relatively flush reinstated seabed.

In the event that mechanical trenching is not feasible for the stabilisation of the pipeline from 10 m to approximately 35 m water depth, dredging will be required with subsequent backfill using engineering material or rock.

Disposal of the excavated spoil from the micro-tunnel may be managed onshore, after cleaning of the drill cuttings.

It is anticipated that further trunkline systems will be installed adjacent to the Project trunkline at some later date, hence the parallel pipeline approach corridor and offshore routing has been selected to be able to accommodate such future pipelines. Shore-crossing concepts and allocated space envelopes/footprints have also been selected to enable similar expansion. Where open-cut trenching is employed, facilities may be pre-installed to minimise future environmental disturbance, particularly where reinstatement of shore line and mangroves is considered sensitive. Such pre-installed facilities may encompass conduits across the shore line to simplify pull-in of future lines or allocated space for future tunnels etc. For a micro-tunnelling concept, no pre-investment is required as future pipeline tunnel can be created when required without significant impact upon the mangrove system or shore line.

Potential construction activities include:

- Micro-tunnelling/trenching/backhoe dredging
- Transportation of rock/armour
- Rockplacement/dumping
- Blasting (unlikely)
- Vegetation clearing and earthworks
- Onshore dredge material placement and dewatering
- Drill cuttings disposal.

1.2.2 Nearshore Infrastructure

The Project will require two types of port facilities: a MOF and a PLF. The MOF will cater for the delivery of materials to the onshore construction sites by module carriers, heavy lift ships and roll-on, roll-off (RORO) vessels. Breakwaters will be provided on both the east and west side of the MOF entrance to create calm conditions inside the basin during normal conditions and a safe haven for the tugs during a cyclone.

The proposed PLF will provide berthing for LNG and condensate carriers. The PLF is likely to carry a roadway and a double piperack from the shore to the operations platform and the loading berth.

A navigation channel and a turning basin will also be required to enable the LNG and condensate carriers to safely access and depart the berths at the PLF. The channels and basin may need to be dredged periodically to maintain the required depth. Dredging and offshore dredge material placement will be managed under The Dredge and Spoil Disposal Management Plan (DSDMP).

The MOF will require a 3 km long solid fill breakwater with a dredged navigation berth-pocket. The breakwaters will probably be constructed from the shore using earthmoving equipment to place core material from a local quarry into the nearshore waters. The breakwater may be protected by heavy rock or concrete armour units. Wharves, pens and berths may be piled.

The MOF quay may be constructed by driving piles from onshore pile driving rigs and placing a concrete deck on top of the piles. It is anticipated that the MOF may take some 18 months to fully complete. It is expected to receive the first module delivery to site in month 15 and is likely to be in continuous use. In terms of plant construction, it is estimated that approximately 100 module barges could be required, based upon the proposed amount of modularisation for the Project.

Because of the shallow nearshore bathymetry (the -15.0 m contour is located approximately 23 km offshore), both the MOF and the PLF will require dredged access channels. The MOF will require a marine access channel approximately 1 km long, 120 m wide and 7 m deep, which provides access to the main navigation channel. The MOF will also require a breakwater.

The PLF and access trestle may be constructed by driving piles. This may be achieved by driving piles from a crane located on a temporary work platform alongside the trestle. Alternatively, the access trestle could be completed in part using floating plant.

The loading platform, mooring and berthing dolphins and Marine Operations Platform could be constructed using floating plant. The floating plant and equipment required for the construction of these elements may include:

- Flat deck barges
- Cranes mounted on barges
- Mobile crawler cranes (shore based construction and loading out materials)
- Pile driving hammers
- Tug boats and other support craft
- Air compressors, generators and welding equipment.

It is anticipated that berth 1 of the PLF will take about two years to complete. A further 18 months may be required to complete berths 2 and 3.

Typical construction traffic is expected to comprise up to two module transport vessels per week utilising a Roll-On/ Roll-Off (RORO) offloading method. Time in port is likely to be in the order of three days per vessel.

General cargo is expected to start arriving at the MOF from month 18 and will continue over the whole plant construction and operations period.

Potential construction activities include:

- Transportation and placement of rock/armour
- Piling and trestle installation
- Earthworks and general construction (e.g. concreting/hard topping)
- Vessel operations.

1.2.3 Domgas Pipeline

The proposed route of the domgas pipeline(s) to the Dampier-to-Bunbury Natural Gas Pipeline (DBNGP) runs from the domgas plant to the DBNGP easement over an approximate distance of 75 km. The pipeline corridor is expected to be approximately 30 m wide. Where possible, this corridor width may be reduced to reduce impacts. However, additional turn-around bays and lay down areas may be required to allow for stringing of the pipeline.

Construction activities are likely to include:

- Vegetation clearing
- Earthworks including trenching
- Access road construction and vehicle use.

1.2.4 Onshore Site Preparation

The site is located in an area of low lying land immediately behind the fore-dunes between the mouth of the Ashburton River and Hooley Creek. The LNG plant will be positioned behind these existing fore-dunes, and east of the mangroves associated with the Ashburton River. The existing fore-dunes will be maintained with any reinforcement necessary for the protection of the plant and associated offices and personnel quarters being constructed on the land side of the dunes.

Site preparation works will involve clearing the site of vegetation and establishing drainage catchments to reduce offsite silt migration. The site preparation works will include raising the current site level to protect the facility against flooding during cyclone and other severe weather events. Imported fill or onsite borrow pits will be needed to achieve the required levels. This may range from large armour stone to core material.

The construction of sediment ponds is expected to start simultaneously with site clearing and will be in place as soon as practicable during earthworks activities. Stormwater collection ditches and outfall structures will also be constructed as soon as practicable to ensure the conveyance of stormwater to the sediment ponds.

In the backshore area and longitudinal dune system area, filling will typically be achieved using a conventional earthwork process comprising the removal of vegetation and topsoil, proof rolling of the exposed surface and placement and compaction of fill in layers up to the finished levels.

In some areas, ground improvement and/or excavation and replacement may be required prior to the placement of fill. In particular, the low lying clay pans and supratidal flats have weak surface materials and are in close proximity to the groundwater which will hamper earthworks. Site preparation in these areas is likely to involve the removal of weak material and its replacement with structural fill.

A portion of dredged materials may be placed at the onshore site. Bunds may be constructed by earthmoving equipment and sand and fills, aggregates and rocks imported to the site from yet-to-be-defined quarry locations. The onshore disposal area may be subdivided into cells to provide stilling basins for settlement of sediments in tail water before it is discharged back to the environment.

The dredged material may be placed onshore in this specially constructed reception area potentially generating peak decant water discharge of up to $6m^3/s$ for the period of placement activity. This discharge will be pumped back to a near-shore marine outfall located to the west of the MOF location. After the onshore placement activity has been completed the pumping of discharge to the marine outfall will cease. From this time onwards any further decant water generated from the onsite placement will be allowed to seep to the natural site drainage system.

Potential construction activities include:

- Vegetation clearing
- Earthworks including grading and infill
- Construction of settlement pond bunding and stormwater diversion
- Onshore dredge material placement and dewatering
- Access road construction
- Vehicle and heavy traffic movement.

1.2.5 Onshore Facilities and Construction

The LNG and Domgas plants will be installed during the construction phase, In addition to the LNG trains the onshore site may also include power, water supply and wastewater treatment facilities, storage for process chemicals, fuel (diesel) and equipment spares, and lay down areas for the initial and future construction works. The onshore facilities will have several buildings to support the daily operation of the onshore process facilities and associated marine infrastructure.

Areas of the plant will be segregated to provide separate drainage systems for each category of surface run-off. Potentially contaminated stormwater will primarily come from stormwater in the process areas and will be routed to a series of process area catchment sumps. These sumps will hold a first-flush of stormwater. Non-contact surface runoff that is considered uncontaminated, will be routed to sediment pond(s) for removal of suspended solids. Emergency spillways will be provided to convey large floods safely past the sediment basins. The water from these ponds will be discharged via drainage-ways to Hooley Creek and the southwest catchment.

The accommodation village is likely to be developed in stages, beginning with accommodation for about 450 site workers at an initial pioneer village and expanding to accommodate about 5000 workers at peak.

The site will be serviced by a 20 km Shared Infrastructure Corridor, which includes an access road off Onslow Road servicing both the accommodation village and the plant site. Materials and equipment will initially be delivered via road. Upon completion of the MOF, materials will also be delivered via barge.

Potential construction activities include:

- Vegetation clearing and earthworks
- Installation of LNG process trains, LNG and condensate storage tanks
- Construction of domgas plant and onshore component of the trunkline
- Installation of permanent utilities and pipe work
- Stockpiling and onshore placement of dredge material
- Waste management including incineration of some solid wastes, discharges of aqueous wastes (eg settlement pond dewatering, sewage and stormwater discharges) and export of all other wastes to appropriate waste facilities
- Access road construction and vehicle activity
- Vessel movements and heavy lifting operations (including RORO)
- Concrete batching
- Power generation.

1.2.5.1 Water Usage and Wastewater Treatment

Freshwater supplies for the construction works are likely to be provided by a desalination reverse osmosis (RO) plant which converts seawater to drinking water.

Water source options for the Project are currently being evaluated. The preferred water source for construction is via an open seawater intake. The open seawater option for construction is the option assessed in this EIS/ERMP (see Chapter 8).

Hydrotest water from the first LNG tank may be used for testing the second tank and pipelines. It would then be returned back to hydrotest ponds prior to disposal.

Construction wastewater will include desalination plant discharges and domestic wastewater (greywater and sewage) associated with onsite construction personnel.

Potential construction activities include:

- Seawater intake, desalination and RO brine discharges
- Settlement pond and decant discharges and management of overflow run-off
- Facility testing and discharge of hydrotest water.

1.3 Environmental Risk Assessment

A series of environmental risk assessments have been completed to identify the most significant risks that will represent the focus of environmental management and monitoring.

These risk assessments, which have addressed each component of the Project, were undertaken in two phases:

- Phase 1 – An environmental risk assessment was conducted during the scoping phase of the Project to determine the environmental acceptability of the Project and identify key areas of risk
- Phase 2 - A detailed environmental risk assessment was conducted during the preparation of the EIS/ERMP and this Draft CEMP. This assessment assisted in detailing the environmental acceptability of the Project, identifying key areas of risk and developing potential monitoring and management strategies.

The risk assessment methodology used for the EIS/ERMP was developed in accordance with the principles and guidelines contained in the AS/NZ 4360:2004 – Risk Management and the EPA draft guidelines "Application of risk-based assessment in EIA" (EPA 2008).

The process evaluates the likelihood and consequence of environmental impacts occurring as a result of a factor's (receptor) exposure to one or more aspects (Project activities) to assess the environmental risk levels.

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

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

The risks have been assessed assuming the application of mitigation and management measures and therefore indicate the residual risk levels posed to each key environmental factor.

Table 1.5 summarises the environmental risks identified for the construction phase, which this EMP has been developed to address.

Table 1.3: Summary Risk Rankings for Project Construction and Commissioning – Marine

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Marine Water and Sediment Quality	Dredging	Construction dredging of the channel and berthing area. Increased turbidity and light attenuation exceeds agreed water quality targets.	Refer to Dredge and Spoil Disposal Management Plan (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.	4	1	HIGH	Large volumes of sediment to be dredged. Dredging campaign duration is 3-4 years. Impacts to water quality are predicted to be temporary.	**Reasonable** Modelling conducted	Not Applicable	8.2 Appendix S1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			Monitor: Monitor water quality to quantify temporal and spatial scale of impact associated with dredging in relation to baseline data.							
Marine Water and Sediment Quality	Dredging	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 capital 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	**MED**	Large volumes of sediment will be dredged and dredge material placed offshore. Dredging campaign duration is 3-4 years. Impacts to water quality are predicted to be temporary.	**Reasonable** Modelling conducted and confirms impact predictions	Not Applicable	8.2
Marine Water and Sediment Quality	Dredging	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. Mitigate: Discharge of decant water from the onshore	4	2	**MED**	Increased turbidity resulting from decant water release will be temporary. Receiving waters for decant water are seasonally turbid (Ashburton River flow and cyclones).	**Reasonable** Modelling conducted Available information is adequate.	Not Applicable	8.2

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			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: Monitor: Decant water discharge will be monitored for compliance with maximum turbidity limit of 250mg/l TSS.							
Marine Water and Sediment Quality	Nearshore Construction Activities	Construction of product loading facility (PLF) and rock placement for materials offloading facility (MOF) breakwater walls and trunkline trenching and stabilisation Turbidity and light attenuation	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 Construction Environmental Management Plan (CEMP) which will be finalized prior to commencement of construction activities. Mitigate: A DSDMP specific to trunkline trenching activities will be developed.	6	1	**LOW**	Localised and temporary impacts on water quality. Construction in a seasonally turbid marine environment (Ashburton River flow and cyclones).	**Reasonable** Survey data available and information is adequate.	Not Applicable	8.2 1
Marine Water and Sediment Quality	Nearshore Construction Activities	Nearshore trunkline trenching and stabilisation Turbidity and light attenuation	Refer to DSDMP for complete list of mitigation measures. 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	4	2	**MED**	Impacts to water quality have been modelled conservatively due to uncertainty in dredging methodology.	**Reasonable** Survey data available and information is adequate.	Not Applicable	8.2 Appendix S1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			content.							
Marine Water and Sediment Quality	Nearshore Construction Activities	Trunkline shore crossing by trenching Turbidity and light attenuation	Mitigate: Activity will be undertaken in accordance with the CEMP which will be finalized prior to commencement of construction activities. Mitigate: Use graded rock material with low fines content.	5	1	**MED**	Disturbance of the Ashburton East lagoon floor and adjacent seafloor will result in temporary elevated turbidity levels.	**Reasonable** Survey data available and information is adequate.	Not Applicable	8.2
Marine Water and Sediment Quality	Nearshore Construction Activities	Trunkline shore crossing by micro-tunnelling Turbidity and light attenuation	Design: micro-tunneling selected as best environmental action. Mitigate: Activity will be undertaken in accordance with the CEMP which will be finalized prior to commencement of construction activities.	6	2	**LOW**	Limited disturbance to the seafloor Temporary increase in turbidity near the seafloor entrance of the tunnel during construction.	**Reasonable** Survey data available and information is adequate.	Not Applicable	8.2
Marine Water and Sediment Quality	Vessel Movements	Accumulation of anti-fouling paints in marine sediments.	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.	4	3	**LOW**	Vessels will comply with the requirements of AQIS.	**High** Available information is adequate.	Not Applicable	8.2
Marine Water and Sediment Quality	Discharges from Onshore Construction	Construction discharges 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 finalized prior to commencement of construction activities. Design: Nearshore discharge locations have been selected to reduce risks to sensitive water quality receptors Mitigate: Adherence to the threshold limits of the ANZECC/ARMCANZ guidelines.	5	2	**LOW**	Discharges from onshore construction will be managed to comply with relevant guidelines (ANZECC/ARMCANZ). The use of a diffuser to increase rapid dilution. Construction discharges will be temporary	**Reasonable to Low** Available information is adequate to inadequate	Not Applicable	8.2

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			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.							
Marine Water and Sediment Quality	Discharges from Offshore Construction	Exceedance of Commonwealth Regulations for TPH concentration outside the mixing zone	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). Mitigate: Controlled release of hydrotest water to limit potential for toxicity impacts.	4	3	**LOW**	Discharges from offshore construction will comply will relevant Conventions and Regulations (Compliance with Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009), MARPOL). Construction discharges will be temporary	**High** Long term monitoring results available (from similar facilities)	Not Applicable	8.2
Benthic Primary Producer Habitat (BPPH)	Dredging	Dredging Direct: Loss of sub-tidal BPPH through removal within foot print.	Design: Nearshore infrastructure location based on presence or absence of BPPH and MPAs.	6	1	**LOW**	There is no BPPH in and immediately adjacent to the dredge footprint.	**Reasonable** Excellent survey data, modelling conducted	Not Applicable	8.3

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Benthic Primary Producer Habitat (BPPH)	Dredging	Dredging 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	Large volumes of sediment to be dredged Dredging campaign duration is 3-4 years. There is no BPPH in and immediately adjacent to the dredge footprint.	**Reasonable** Excellent survey data, modelling conducted	Not Applicable	8.3 Appendix S1
Benthic Primary Producer Habitat (BPPH)	Dredging	Dredge material placement offshore Direct: Loss of sub-tidal BPPH due to placement of dredge material directly on sea	Design: Selection of dredge material placement sites to reduce risks to BPPH.	6	1	LOW	There is no BPPH in and immediately adjacent to the placement sites. Corals closest to placement sites monitored to confirm no adverse impacts from placement	**Reasonable** Excellent survey data, modelling conducted	Not Applicable	8.3

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
		bed.					activities.			
Benthic Primary Producer Habitat (BPPH)	Dredging	Dredge material placement offshore Indirect: Impact on BPPH due to increased turbidity, sedimentation and light attenuation.	Refer to DSDMP for complete list of mitigation measures. Design: Diffusers will be utilised during offshore dredge material placement via the CSD.	4	2	**MED**	There is no BPPH in and immediately adjacent to the placement sites. Corals closest to site monitored to confirm no adverse impacts from placement activities.	**Reasonable** Excellent survey data, modelling conducted	Not Applicable	8.3 Appendix S1
Benthic Primary Producer Habitat (BPPH)	Dredging	Dredge material placement onshore Indirect: Impact on mangroves due to ground water seepage and exceedance of acceptable levels due to increased turbidity and light attenuation from to decant water discharge.	Refer to DSDMP for complete list of mitigation measures. Refer to Chapter 12 for Draft OBCs for BPPH and mangroves Design: Placement site location selected to reduce risks to BPPH. Design/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 quality into the near-shore water will not exceed 250mg/L TSS Design: The onshore dredge material will be contained in a bunded area to reduce the risk	3	3	**MED**	Ground water characteristics at mangrove locations not predicted to alter. Monitoring of mangroves to confirm no adverse impacts. Large buffer area between the onshore placement site and mangroves. Sump to the south of the onshore placement area and thus well away from the mangroves to the west of the placement area	**Reasonable** Excellent survey data, modelling conducted	Not Applicable	8.3 Table 12.4 and 12.5 Appendix S1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			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 the decant water discharge will be undertaken. 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							

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			Risk Assessment and Management relating to ground water monitoring.							
Benthic Primary Producer Habitat (BPPH)	Vessel 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**	Vessels will comply with the requirements of AQIS.	**High** Expert investigation studies	Not Applicable	8.3
Benthic Primary Producer Habitat (BPPH)	Vessel Movements	Discharge of ballast water	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**	Vessels will comply with the requirements of AQIS.	**High** Expert investigation studies	Not Applicable	8.3
Benthic Primary Producer Habitat (BPPH)	Onshore Construction Activities	Direct loss of intertidal BPPH in excess of EPA Guidelines	Design: Nearshore infrastructure location selected to limit disturbance to BPPH as far as 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.	3	2	**HIGH**	Intertidal BPPH in site footprint will be permanently removed. Exceedence of EPA GS No. 3 loss guidelines.	**High** Excellent survey data	Not Applicable	8.3 Appendix S1 Appendix T1 1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			Confirm mangrove habitat losses by survey and redefine clearing boundaries. Investigate options for rehabilitation of mangrove habitat. Identify the cause of excessive clearing, review work procedures and amend as necessary to prevent further exceedance 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.							
Benthic Primary Producer Habitat (BPPH)	Offshore Construction Activities	Direct disturbance to the seabed.	Design: Nearshore infrastructure location selected to limit disturbance to BPPH as far as practicable.	6	1	**LOW**	Offshore infrastructure location does not support BPPH. Trunkline route location does not overlie significant areas of BPPH (a small area of seagrass will be temporarily impacted). Offshore and nearshore infrastructure location contains limited BPPH.	**Reasonable** Excellent survey data	Not Applicable	8.3

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Benthic Primary Producer Habitat (BPPH)	Near-shore 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 exceedance of acceptable levels.	Design: MOF and PLF location selected to reduce loss of BPPH. Mitigate: Use graded rock material with low fines content. Mitigate: MOF and PLF mitigation covered under the CEMP.	6	1	LOW	Nearshore infrastructure location contains limited BPPH.	**Reasonable** Survey data available Available information is adequate	Not Applicable	8.3
Benthic Primary Producer Habitat (BPPH)	Near-shore Construction Activities	Trunkline trenching and trunkline stabilisation Indirect disturbance to the seabed from increased turbidity, sedimentation and light attenuation leading to loss of BPPH in exceedance of acceptable levels.	Design: Trunkline route location selected to reduce risks to BPPH. Mitigate: Use engineered rock material with low fines content.	4	2	HIGH	Impacts to BPPH have been modelled conservatively due to uncertainty. BPPH will be temporary impacted due to trunkline construction. Ashburton mangrove habitat is of high conservation status	**Reasonable** Survey data available Available information is adequate	Not Applicable	8.3
Benthic Primary Producer Habitat (BPPH)	Near-shore Construction Activities	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 groin structures to	4	1	HIGH	The first trenching activity is predicted have small impacts on juvenile mangroves and has a risk ranking of 'Medium'.	**Reasonable** Survey data available Available information is	Not Applicable	8.3

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			reduce the risk of potential sediment smothering impacts on mangroves. Mitigate: Re-instate to former topography. Mitigate: Use engineered rock material with reduced fines content. Mitigate: A DSDMP specific to trunkline trenching activities will be developed.				Trenching will result in disturbance of potential mangrove habitat. Trenching will temporarily block water movement to some areas of the Ashburton East Lagoon. Repeated trenching is predicted to damage older and more established mangroves, therefore the risk ranking is 'High' Ashburton mangrove habitat is of high conservation status Micro-tunnelling is the preferred option (see below)	adequate		
Benthic Primary Producer Habitat (BPPH)	Near-shore Construction Activities	Trunkline shore crossing by micro-tunnelling No impact predicted	No management controls or mitigation measures required	6	2	**LOW**	Micro-tunnelling is not anticipated to cause impacts to BPPH, including mangrove habitat. The entry and exit points of the micro-tunnel have a low BPPH abundance.	**Reasonable** Survey data available Available information is adequate	Not Applicable	8.3
Benthic Primary Producer Habitat (BPPH)	Discharge and Waste from Offshore Construction	Turbidity and sediment changes. Toxicity to biota. Potential contamination with TPH and MEG.	Design: PNEC to be determined for PW discharge. Mitigate: Compliance with Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009. Mitigate: Treatment in compliance with the International	6	2	**LOW**	Offshore infrastructure locations contain limited BPPH.	**High** Excellent survey data	Not Applicable	8.3

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
		Increased turbidity, smothering, reduced dissolved oxygen (DO). Bioaccumulation of chemicals and trace metals in species / food chain. Exceedance of Commonwealth Regulations on TPH.	Convention for the Prevention of Pollution from Ships (MARPOL 73/78, Annex IV) (ref) Mitigate: Treatment of PW to achieve Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 requirements. Mitigate: Controlled release of hydrotest water to reduce potential for toxicity impacts. Monitor: Monitor PW concentrations prior to discharge.							
Benthic Primary Producer Habitat (BPPH)	Discharges from Onshore Construction	Increased metals and other contaminants. Increased turbidity, salinity, nutrients and algal blooms leading to loss or damage to BPPH in exceedance of acceptable levels.	Design: Nearsrhoe outfall location selected to reduce risks to BPPH. Mitigate: Adherence to the threshold limits of the ANZECC/ARMCANZ guidelines. Monitor: Monitoring to confirm applicable water quality targets at mixing zone boundary.	6	1	**LOW**	Offshore infrastructure locations contain limited BPPH.	**Reasonable** Modelling conducted	Not Applicable	8.3
Marine Fauna	Dredging	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 for Draft OBC for Marine Fauna Protection Mitigate: Prior to commencement of dredging and dredge material management activities selected crew will receive training, which will	4	3	**LOW**	Marine mammals and turtles occur in low densities in near shore waters where dredging will occur. Low entrainment rate during dredging campaigns.	**Reasonable** Short-term monitoring data available	No significant impact	8.4 Table 12.6 Appendix S1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			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 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. Mitigate: Management of cetacean interactions will be in accordance with the requirements for cetacean interactions specified under Part 8 of the EPBC Regulations 2000 (Cth), the Australian National Guidelines for Whale and Dolphin Watching. Mitigate: Release of healthy entrained turtles back to the marine environment and contact the Department of Environment and Conservation (DEC) if an injured turtle is collected after				Adoption of mitigation measures such as marine fauna observers and exclusion zones.			

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			being entrained. Mitigate: In the event of turtle mortality incidents as a result of entrainment during dredging, revision of existing management controls will be undertaken to investigate additional controls which may be put in place to reduce the potential for such incidents to occur. Monitor: Humpback Whale 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.							
Marine Fauna	Dredging	Loss of or disturbance to critical habitat associated with protected marine fauna Potential to directly impact marine fauna Disturbance and avoidance of area by protected marine fauna Heightened community concern	Refer to DSDMP for complete list of mitigation measures. Refer to Chapter 12 for Draft OBC for BPPH Refer to Section 8.3 for a list of 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 Humpback Whales, Dugongs and turtles. Mitigate: Favourable weather, tide and current conditions will	5	4	**VERY LOW**	Marine mammals and turtles occur in low densities in near shore waters. No foraging habitats (e.g. seagrass beds) for turtles and dugongs will be permanently damaged as a result of dredging. Critical habitat for marine mammals and turtles does not occur in the nearshore infrastructure location. Construction is a temporary activity.	**Reasonable** Short-term monitoring data available Modelling conducted	No significant impact	8.4 Table 12.5 Appendix S1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
		Impacts on local tourism operators	be used as far as reasonably practicable to limit effects when dredging or disposing in close proximity to sensitive areas.							
Marine Fauna	Dredging	Loss of or disturbance to designated nearshore nursery habitat for prawns	As above.	4	2	**MED**	Disturbance to prawn nursery habitat, such as seagrass beds, is predicted to be short term; recovery is predicted to occur after cessation of dredging. Other important nursery habitat, such as lagoons and creeks, will not be directly impacted. Construction is a temporary activity.	**Reasonable** Short-term monitoring data available Modelling conducted	No significant impact	8.4
Marine Fauna	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 Humpback whales, 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).	5	2	**LOW**	The proposed channel, MOF and placement sites do not traverse or support critical habitat for marine mammals and turtles. Marine mammals and turtle occur in low densities in areas proposed for the PLF and trunkline.	**Reasonable** Short-term monitoring data available	No significant impact	8.4
Marine Fauna	Construction Activities (marine): Installation of	Loss of, or disturbance to, habitat critical to marine fauna from	Design: Selection of navigation channel, MOF and placement sites to reduce risks to habitat critical (nesting, feeding and	5	4	**VERY LOW**	The location of the offshore infrastructure does not support critical habitat for marine mammals or turtles.	**Reasonable** Short-term monitoring	No significant impact	8.4

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
	all offshore infrastructure	seabed disturbance during offshore construction	calving areas) for marine fauna such as Humpback whales, dugongs and turtles. Mitigate: Implementing an approved Drilling Environmental Management Plan (DEMP) in accordance with the OPGGS Act (Cth) and the Petroleum (Submerged Lands) (Management of Environment) Regulations 1999 (as amended 2005).					data available		
Marine Fauna	Vessel Movements	Injury or fatalities to 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 for Draft OBC for Marine Fauna Protection 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. Humpback Whales, Dugong, turtles, dolphins). All sightings of Humpback Whales and Dugong that result in management actions being	4	3	**LOW**	Vessel speeds will be regulated. The location of the proposed navigation channel does not support high densities of marine fauna (based on aerial and boat based surveys). Turtle densities are highest over offshore reefs. Presence of large numbers of Humpback Whales is seasonal. The majority of Humpback Whales remain in deepwater beyond the nearshore construction location. Use of mitigation measures such as marine fauna observers and exclusion zones.	**Reasonable** Short-term monitoring available	No significant impact	8.4 Table 12.6 Appendix S1 Appendix O6

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			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 300m observation zone and ceasing dredging activities if whales or dugongs enter a 100m exclusion zone. A trained crew member will maintain a lookout, during daylight hours, for Humpback Whales and Dugongs while any dredge is on route to and from the dredge area to dredge material placement grounds. 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.							
Marine Fauna	Vessel Movements	Loss of biodiversity Introduction of disease to fisheries	Design: Some re-alignment of LEP boundaries. Mitigate: Introduced marine pest (IMP) risk assessments for all construction vessels entering the	5	3	**LOW**	Will reduce the risk for introducing marine pests	**Reasonable** Available information is adequate	No significant impact	8.4

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
		Introduction of marine pest species	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 regulations (Australian Ballast Water Movement V4 2008).							
Marine Fauna	Increased Recreational Pressure (Fishing, Boating and Island Access)	Overfishing of fish stock, resulting in stock decline, reduction in abundance and population health, altered trophic level, potential trophic cascade	Refer to the MFMP Mitigate: To reduce the potential for overfishing the following action may be implemented: Inform Project staff/contractors of Fisheries regulations and best practice fishing guidance The Proponent will work with the WA Department of Fisheries 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	2	3	**MED**	An increase in the level of recreational fishing activity. A code of conduct will be developed to reduce the impact of fishers on local fish stocks. Difficult to predict the potential fishing pressure associated with large numbers of people.	**Low** Uncertainties surrounding management, local fish stock size and population health	None known	8.4 Appendix O6

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			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							
Marine Fauna	Increased Recreational Pressure (Fishing, Boating and Island Access)	Injury/mortality and/or disturbance to dugongs and turtles due to vessel collision	Refer to MFMP Refer to Chapter 12 for Draft OBC for Marine Fauna Protection 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 workforce accommodation village or to travel on the access road from Onslow Road Behaviour standards to be	2	3	**MED**	An increase in the level of recreational boating activity. A code of conduct will be developed to reduce the impact of boaters on marine fauna. Difficult to predict the level of potential recreational vessel activity associated with large numbers of people.	**Low** Uncertainties surrounding management Short-term monitoring data available but with gaps	Dugongs Turtles	8.4 Table 12.6 Appendix O6

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			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							
Marine Fauna	Increased Recreational Pressure (Fishing, Boating and Island Access)	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 for Draft OBC for Marine Fauna Protection 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 (as presented in the EIS) 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	2	3	**MED**	Increase in the level of recreational use of the islands. A code of conduct will be developed to reduce the impact of recreationists on island fauna. Difficult to predict the level of potential recreational vessel activity associated with large numbers of people.	**Low** Uncertainties surrounding management There is some information on island habitats and species of nesting birds and turtles available.	Turtles Seabirds	8.4 Table 12.6 Appendix O6

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			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 appropriate action taken							
Marine Fauna	Increased Recreational Pressure (Fishing, Boating and Island Access)	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 for Draft OBC for Marine Fauna Protection Mitigate: To reduce impacts to marine fauna from entanglement/ingestion of marine debris the following	5	3	LOW	A code of conduct will be developed to reduce the impact of recreationists on the marine environment. Difficult to predict the level of potential recreational vessel activity associated with large numbers of	**Reasonable** Available information is adequate	No significant impact	8.4 Table 12.6 Appendix O6

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			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 appropriate action taken				people			
Marine Fauna	Noise and Vibration	Altered distribution of fauna due to avoidance of area during noisy construction activities (piling,	Refer to MFMP Refer to Chapter 12 for Draft OBC for Marine Fauna Protection Design: Nearshore infrastructure location selected to reduce risks to critical habitat.	4	3	**LOW**	Marine mammals and turtles occur in low densities in the proposed PLF (piling) area. No turtle nesting on beaches adjacent to piling activity.	**Reasonable** Short-term monitoring data available	No significant impact	8.4 Table 12.6 Appendix O6

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
		dredging, drilling) Behavioural effects to protected marine fauna	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 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).				Piling is a short term construction activity. The adoption of mitigation measures such as fauna observers and observation zones.			
Marine Fauna	Noise and Vibration	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 for Draft OBC for Marine Fauna Protection Mitigate: Management measures will be implemented during maintenance dredging works as follows: Prior to commencement of 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. Humpback Whales, Dugong, turtles, dolphins).	6	2	**LOW**	Marine mammals and turtles occur in low densities in the proposed dredging area. No turtle nesting on beaches adjacent to dredging area. The adoption of mitigation measures such as fauna observers and observation zones.	**Reasonable** Short-term monitoring available	No significant impact	8.4 Table 12.6 Appendix O6

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			All sightings of Humpback Whales and Dugong that result in management actions being implemented will be recorded. Humpback Whale and Dugong observations and response procedures including application of 300 m observation zone and 100 m exclusion zone will be implemented during dredging and dredge material placement works as outlined above in Section 2.1. In the event that a Humpback Whale 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 Whale 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 Humpback Whale or Dugong have been observed within this zone for 10 minutes. A lookout will be maintained, during daylight hours, for Humpback Whales and Dugongs while any dredge is on route to and from the dredge area to dredge material placement grounds. If sighted, direction/speed will be adjusted to reduce the likelihood of							

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			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.							
Marine Fauna	Noise and Vibration	Behavioural Changes, Injury or Mortality to Marine Fauna Associated with Blasting	If blasting is required, a Blasting Environmental Management Plan (BEMP) will be developed. Example mitigations may include: Use of marine fauna observers to confirm no mammals and turtles within the vicinity of designated fauna exclusion zones. Activities may be undertaken outside Humpback Whale migration period	5	4	**VERY LOW**	Blasting is unlikely to be required. If required, short term in duration. Many potential mitigation measures to reduce impacts to marine fauna.	**Low** Available information is inadequate		8.4
Marine Fauna	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 for Draft OBC for Marine Fauna Protection 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. Monitoring: The Proponent will	4	3	**LOW**	Closest nesting beach (Ashburton Delta) is > 4 km from plant site. Closest island rookery > 8 km from plant site. Modelling predicts low levels of illumination on nesting beaches. Ashburton Delta nesting beach screened by high dunes.	**Reasonable** Modelling conducted	No significant impact	8.4 Table 12.6 Appendix S1 Appendix O6

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			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. Monitoring: 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.				Monitoring will be used to test prediction that flaring will not negatively influence hatchlings.			
Marine Fauna	Light Emissions from Onshore Infrastructure	Interference with marine turtle nesting behavior	As above	4	3	**LOW**	As above.	**Reasonable** Modelling conducted	No significant impact	Chapter 8.4
Marine Fauna	Light Emissions from Onshore Infrastructure	Attraction of seabirds creating potential for increased predation of hatchlings	Design: Onshore infrastructure location selected to reduce risks to critical habitat.	4	3	**LOW**	No turtle nesting on beaches near the Plant site. Closest nesting beach (Ashburton Delta) is > 4 km from plant site.	**Reasonable** Modelling conducted	No significant impact	8.4
Marine Fauna	Additive Effects	As listed above	See above for all environmental aspects/activities.	4	2	**MED**	The risk ranking of the additive effects of all Project aspects is determined by the highest risk ranking of any individual aspect.	**Reasonable**	No significant impact	8.4

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Coastal Processes	Construction of Nearshore Infrastructure	Interruption of the non-cyclonic littoral sediment paths Entrance Regime of Hooley Creek	Refer to CPMP for complete list of mitigation measures. for complete list of mitigation measures. Refer to Chapter 12 for the OBC relating to Coastal Processes Protection. 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. 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. 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 destabilization. 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	4	2	**MED**	Without sand supply from the west, the existing spit would erode over approximately 5-10 years	**Reasonable** Available information is adequate	Not Applicable	8.5 Table 12.3 Appendix T1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			existing beach) Report: The Proponent to prepare an annual coastal processes monitoring report. This report shall be made available to relevant agencies.							
Coastal Processes	Construction of Nearshore Infrastructure	Interruption of the non-cyclonic littoral sediment paths 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. Monitor: Adaptive monitoring program to monitor changes to beach profile and width. 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. Report: The Proponent to prepare an annual coastal processes monitoring report. This report shall be made available to relevant agencies.	5	3	**LOW**	Structural control at Beadon Point limits the potential for erosion as a direct result of reduced sand supply	**Reasonable** Available information is adequate	Not Applicable	8.5 Appendix T1
Coastal Processes	Construction of Nearshore	Interruption of the non-cyclonic littoral sediment	Refer to CPMP for complete list of mitigation measures.	4	3	**LOW**	The structurally controlled nature of this beach determines that a loss of		Not Applicable	8.5

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
	Infrastructure	paths Erosion of Onslow Town Beach	See Disruption of non-cyclonic littoral sediment path: Erosion of Sunset Beach above.				supply would not cause erosion			Appendix T1
Coastal Processes	Construction of Nearshore Infrastructure	Interruption of the non-cyclonic littoral sediment paths Destabilisation of Ashburton East chenier	Refer to CPMP for complete list of mitigation measures. Refer to Chapter 12 for the OBC relating to Coastal Processes Protection. 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 destabilization. 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	3	4	**LOW**	MOF breakwaters are likely to have negligible effect on ongoing sediment transport to the west of the MOF		Not Applicable	8.5 Table 12.3 Appendix T1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			prepare an annual coastal processes monitoring report. This report shall be made available to relevant agencies.							
Coastal Processes	Construction of Nearshore Infrastructure	Interruption of the cyclonic littoral sediment paths Entrance Regime of Hooley Creek	Refer to CPMP for complete list of mitigation measures. Refer to Chapter 12 for the OBC relating to Coastal Processes Protection. See Disruption of non-cyclonic littoral sediment path: Entrance Regime of Hooley Creek above.	4	2	**MED**	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	**Reasonable** Available information is adequate	Not Applicable	8.5 Table 12.3 Appendix T1
Coastal Processes	Construction of Nearshore Infrastructure	Interruption of the cyclonic littoral sediment paths Erosion of Sunset Beach	Refer to CPMP for complete list of mitigation measures. See Disruption of non-cyclonic littoral sediment path: Erosion of Sunset Beach above.	5	2	**LOW**	In the event of a cyclone impacts to Sunset Beach will only be slightly increased The existing beach is sufficiently wide to withstand severe cyclone impact, and to recover	**Reasonable** Available information is adequate	Not Applicable	8.5 Appendix T1
Coastal Processes	Construction of Nearshore Infrastructure	Interruption of the cyclonic littoral sediment paths Erosion of Onslow Town Beach	Refer to CPMP for complete list of mitigation measures. See 1.1 Disruption of non-cyclonic littoral sediment path: Erosion of Onslow Town Beach above.	4	2	**MED**	Interruption of the non-cyclonic littoral transport path will slow beach recovery following an erosion event	**Reasonable** Available information is adequate	Not Applicable	8.5 Appendix T1
Coastal Processes	Construction of Nearshore Infrastructure	Interruption of the cyclonic littoral sediment paths Destabilisation of Ashburton East	Refer to CPMP for complete list of mitigation measures. Refer to Chapter 12 for the OBC relating to Coastal Processes Protection.	3	3	**MED**	Due to MOF breakwaters, downdrift erosion may focus on the chenier under cyclonic pressure.	**Reasonable** Available information is	Not Applicable	8.5 Table 12.3 Appendix T1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
		chenier	Refer to "Disruption of non-cyclonic littoral sediment path: Destabilisation of Ashburton East chenier".					adequate		
Coastal Processes	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 for the OBC relating to Coastal Processes Protection. 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: Control 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	**LOW**	The sequence of events that will reduce hydraulic resistance of the breakout pathway are unlikely to occur	**Reasonable** Available information is adequate	Not Applicable	8.5 Table 12.3 Appendix T1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Coastal Processes	Construction of Onshore Infrastructure	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	**LOW**	Reactivtiation has low environmental consequences	**Reasonable** Available information is adequate	Not Applicable	8.5 Table 12.3 Appendix T1
Coastal Processes	Loss of geological heritage features	Excavation of some onshore features for use as borrow pits	Refer to CPMP. Field surveys to be undertaken to confirm the geological heritage value of the Project area and identify sites requiring protection. Mitigate: During borrow pit excavation measures will be implemented to reduce the potential impacts, and to protect these features as reasonably practicable.	4	4	**LOW**	Geoheritage sites exist in the project area and are worthy of protection; however there are effective management measures to mitigate disturbance of these features	**Low** No survey data	Not Applicable	8.5 Appendix T1
Coastal Processes	**Additive Effects**	As listed above	See above for all environmental aspects/activities.	5	**1**	**MED**	The risk ranking of the additive effects of all Project aspects is determined by the highest risk ranking of any individual aspect.	**Low** No modelling conducted on additive effects	Not Applicable	8.5

Table 1.4: Summary Risk Rankings for Project Construction and Commissioning – Terrestrial

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Soils & Landforms	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) Increased sedimentation	Management of PASS material utilising best 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 Manage potential dust generation and sedimentation from erosion through the implementation of erosion controls and measures, as outlined in the CEMP.	5	2	LOW	Project area has been refined to limit impacts to Hooley Creek and Ashburton River Delta. The Project area generally has a low risk of encountering PASS material. Health issues assessed in social impacts section. The residual risk ranking has been obtained due to the excavation of the borrow sites being likely to lead to the minor erosion or loss of local landforms.	**Reasonable** Survey data available from one expert – complies with EPA Guidance. Available information is adequate.	Not Applicable	9.2.5.1 Appendix U1
Soils & Landforms	Leaks & 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	3	4	LOW	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. The residual risk ranking has been obtained by assessing the impacts of a major onshore spill or leak. It is anticipated that, with the adoption of management controls and mitigation measures, this event would be “Unlikely”, but could perceivably be of “Major” consequence	**High** Several expert investigations/ studies. Excellent survey data	Not Applicable	9.2.5.3

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Ground-water	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 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 18-24 months will be pumped via pipeline to a marine outfall Installation of a drainage ditch to collect and divert seepage Groundwater monitoring	4	2	**MED**	The placement of material into the sites will promote trapping of fines in the settled material and reduce the amounts of fines in suspension. Drainage of decant water over the placement area will be to the south away from the mangrove systems therefore managing the potential impact from rising ground water levels. The residual risk ranking has been obtained as it is likely that the onshore placement of dredged material will lead to a local and major change in sub-catchment groundwater recharge patterns over a local area over the long term	**Reasonable** Survey data available from one expert – complies with EPA guidance. Short term monitoring results available. Available information is adequate.	Not Applicable	9.3.5.1
Ground-water	Presence of Infrastructure -Presence of Plant Pad, Access Road, Infrastructure	Groundwater mounding Change in groundwater flow directions Change in groundwater	Monitoring bores	4	4	**LOW**	The residual risk ranking has been obtained as it is unlikely that the presence of the infrastructure will lead to local and major change in sub-catchment groundwater recharge	**Reasonable** Survey data available from one expert – complies with EPA guidance.	Not Applicable	9.3.5.2

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
	Corridor and Accommodation Village area	quality					patterns over a local area over the long term.	Short term monitoring results available. Available information is adequate.		
Surface Water	Earthworks- Clearing and Disturbance of Surface Soils	Increased runoff and erosion Increased mobility of sediments Increased sediment loads and sediment concentrations	The Project will be designed to incorporate practical runoff 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 runoff from the Plant Pad to storm water sedimentation ponds.	5	2	**LOW**	The local terrestrial and tidal marine habitats are turbid; accordingly it may be assumed that these habitats are resilient to potential impacts from sediment in stream flow and tidal reaches of the local watercourse. The residual risk ranking was obtained as it is likely that minor changes to local water resources, may result in local short-term and small reduction in water quality with no exceedence of baseline water quality levels.	**Reasonable** Short term monitoring results available. Available information is adequate.	Not Applicable	9.4.5.1
Surface Water	Dredge Material Placement Area	Disposal of decanted seawater to the near-shore marine environment Seepage from the dredge material placement area Changes to surface water	The placement area has been selected to reduce the footprint used. Dredged material will be contained in a bunded area 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	4	2	**MED**	Impacts to marine environment from nearshore decant water disposal discussed and assessed in Chapter 8. Impacts to surface water may not be measurable. The dredge material is inert, thus the seawater would not accumulate	**Reasonable** Short term monitoring results available. Available information is	Not Applicable	9.4.5.2

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk C	Residual Risk L	Residual Risk R	Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
		quality	of the placement area. 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 Installation of a drainage ditch to collect and divert seepage Surface water monitoring				dissolved salts except by evaporation processes. The assumed short transit times in the placement area would limit accumulation of salts in the decanted seawater. The residual risk ranking was obtained as it is likely that local and major change in sub-catchment surface water hydrology and flow regimes over a local area over the long term would occur.	adequate.		
Surface Water	Potential Oxidation of Acid Sulphate Soils	Oxidation resulting in generation of acid and/or mobilisation of metals	Management of PASS material utilising best management practice methods, as outlined in the CEMP.	5	3	**LOW**	The Residual risk to surface water from potential acid sulphate soils was obtained as it is possible that minor changes to local water resources, resulting in a local short-term and small reduction in water quality, with no exceedence of baseline water quality, could occur.	**High** Excellent survey data	Not Applicable	9.4.5.3 Appendix U1
Flora & Vegetation	Vegetation Clearing- Site Preparation and Site Access	Loss of flora and vegetation Loss of habitat critical to flora and vegetation Erosion Spread of introduced flora	Implement vegetation clearing process Limit clearing to designated areas and clearly mark these areas. Utilise previously cleared areas where practical. Implement vehicle hygiene procedures appropriate for the	4	2	**MED**	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. No DRF located within Project area.	**High** Several expert investigations/ studies Excellent survey data.	Not Applicable	9.5.5.1 Appendix U1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
		Over-clearing Increase surface water runoff and velocity leading to increased sedimentation on vegetation outside of cleared area	site. Develop and implement an employee environmental education program/induction. Develop flora and vegetation management as part of the CEMP. Rehabilitate disturbed areas where practicable. Weed management procedures				The Project area has a medium risk of impacting flora and vegetation due to the presence of flora and vegetation with conservation significance within the project footprint. The residual risk ranking has been obtained as clearing of vegetation is likely to lead to a local long-term reduction in the abundance of a Commonwealth or WA Listed Flora species			
Flora & Vegetation	Earthworks- Site Preparation and Trenching	Introduction and/or spread of introduced flora Changes to natural drainage patterns and ground water 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**	This aspect assumes that all vegetation within the Project area has been removed (risk to vegetation from clearing assessed above) The Project has a low residual risk of impacting flora and vegetation it is likely that earthworks could lead to an increase in the abundance of an existing non-native flora species within the Project area.	**High** Several Expert investigations/ studies Excellent survey data	Not Applicable	9.5.5.2

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Flora & Vegetation	Vehicular activity- Site Access, Construction Vehicles on Site and Haulage Vehicles	Direct impact as a result of off-road driving Introduction or spread of introduced flora species Increased erosion Increased dust emissions Causing fires	Manage potential dust generation through implementation of measures to be outlined in the CEMP and OEMP. Clearly mark authorised access tracks and roads Construct access routes in a manner that reduces potential for erosion	6	3	**VERY LOW**	The residual risk ranking has been obtained as vehicle activity could possibly result in a local short-term reduction in the abundance of a species or vegetation community.	**High** Several Expert investigations/ studies Excellent survey data	Not Applicable	9.5.5.3 Appendix U1
Flora & Vegetation	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	Fire fighting and fire awareness training for project personnel. Establish a continuous firebreak around the perimeter of the LNG plant through vegetation clearance.	5	4	**VERY LOW**	Potential impacts from fire to flora and vegetation outside of the Project area is not believed to be significant as fires adjacent to the Project will be limited or rapidly extinguished. The residual risk ranking has been obtained as it is unlikely that a fire would result in a local short-term reduction in the abundance of a species or vegetation community.	**High** Several Expert investigations/ studies Excellent survey data	Not Applicable	9.5.5.4
Flora & Vegetation	Alteration of Surface Water Drainage - Site Preparation, Earthworks and Presence of infrastructure	Detriment to vegetation due to changes in surface drainage patterns Alterations to ground water infiltration Increased erosion leading to	Retain natural drainage where practicable Facilities designed to limit impacts to surface water systems. Culverts are incorporated into the hydrodynamic flow model for drainage crossings traversed by the road and infrastructure corridor.	5	3	**LOW**	Diversion of natural surface water drainage lines will be required to develop the Project area. Management measures for this impact have resulted in the residual environmental risk for this potential impact being assessed as being low.	**High** Several Expert investigations/ studies Excellent survey data	Not Applicable	9.5.5.6

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
		downstream impacts on remnant vegetation	Monitor down-stream vegetation							
Flora & Vegetation	Dust Suppression-Application of saline water or other suppressants for dust control	Detriment to vegetation due to overspray or run-off of saline water used for dust suppression	Fringing vegetation monitoring A management plan will be developed as part of the CEMP and OEMP 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.	5	3	**LOW**	The residual risk ranking has been obtained as it is possible that dust suppression could result in a local loss of a species or vegetation community outside of the project area.	**High** Several Expert investigations/ studies Excellent survey data	Not Applicable	9.5.5.7 Appendix U1
Flora & Vegetation	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 Seepage	Monitoring bores Monitoring and management program (as a part of the CEMP and the OEMP) Containment and controlled release strategies including sediment ponds Discharge via a control point (e.g. weir box) The placement area has been selected to reduce the footprint used. Dredged material will be	5	3	**LOW**	It is assumed that the flora and vegetation outside of the project area could be subject to an indirect risk should the dredge material placement area cause impacts through sea-water seepage. The residual risk ranking has been obtained as the dredge material placement area may possibly cause a local long-term reduction in the abundance of a species or vegetation	**High** Several Expert investigations/ studies Excellent survey data	Not Applicable	9.5.5.9 Appendix U1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			contained in a bunded area 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. Discharge of decant water during the first 18-24 months will be pumped via pipeline to a marine outfall Installation of a drainage ditch to collect and divert seepage				community			
Terrestrial Fauna	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	Monitoring and management program (as a part of the CEMP and the OEMP) Implement vegetation clearing process Rehabilitate disturbed areas where practicable. Inspect cleared areas immediately for presence of injured animals Develop and implement an employee environmental education program/induction	5	3	**LOW**	No impacts to the status of any threatened fauna are expected. Habitats present are well represented within the local and regional area. The residual risk ranking has been obtained as it is possible that a local short-term reduction in the abundance of a Commonwealth or WA Listed Fauna species could occur.	**High** Several Expert investigations / studies Excellent survey data Long term monitoring results available	Not Applicable	9.6.5.1 Appendix U1
Terrestrial Fauna	Earthworks – Site Preparation and Construction	Direct impact through modification or destruction of habitat Entrapment in trenches and bunds	Monitoring and management program (as a part of the CEMP and the OEMP) Conduct inspection of all open trenches and remove any trapped fauna. Provide escape routes from trenches, or fencing trenches off	5	3	**LOW**	No impacts to the status of any threatened fauna are expected. Habitats present are well represented within the local and regional area. The residual risk ranking has been obtained as it is	**High** Several Expert investigations / studies Excellent survey data	Not Applicable	9.6.5.2 Appendix U1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk C	Residual Risk L	Residual Risk R	Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
		Direct impact with machinery	Develop and implement an employee environmental education program/induction.				possible that a local short-term reduction in the abundance of a terrestrial fauna species could occur.	Long term monitoring results available		
Terrestrial Fauna	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 firefighting equipment on site, training of site personnel Establish a continuous 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**	The residual risk ranking has been obtained as it is unlikely that fire will occur, but would lead to a local short-term reduction in the abundance of a Commonwealth or WA Listed terrestrial Fauna species	**High** Several Expert investigations / studies Excellent survey data Long term monitoring results available	Not Significant	9.6.5.3
Terrestrial Fauna	Vehicle 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	Vehicles will be required to keep to authorised access tracks and roads and these will be clearly marked to facilitate this Reduced vehicle speeds, enforcement of speed limits Develop and implement an employee environmental education program/induction	5	2	**LOW**	The residual risk ranking has been obtained as it is possible that vehicle impacts may occur, and that this may lead to a local short-term reduction in the abundance of a Commonwealth or WA Listed terrestrial Fauna species.	**High** Several Expert investigations / studies Excellent survey data Long term monitoring results available	Not Applicable	9.6.5.4

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Terrestrial Fauna	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**	Noise emissions within the Project area has been ranked as having a low risk of impacting terrestrial fauna. The residual risk ranking has been obtained as there is a possibility that a local short-term reduction in the abundance of a Commonwealth or WA Listed Fauna species could occur.	**High** Several Expert investigations / studies Excellent survey data Long term monitoring results available	Not Applicable	9.6.5.6 Appendix U1
Terrestrial Fauna	Light Emissions - Plant and General Operations, Accommodation Village	Changes to behaviour of local terrestrial fauna populations (terrestrial) 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	Light intensity will be limited to that necessary for the safe operation of the plant	5	2	**LOW**	It is assumed that lighting and light spill will be reduced wherever practicable and safe to do so in order to limit impacts to terrestrial fauna from light emissions, The residual risk ranking has been obtained as it is likely that a local short-term reduction in the abundance of a Commonwealth or WA Listed Fauna species could occur.	**High** Several Expert investigations / studies Excellent survey data Long term monitoring results available	Not Applicable	9.6.5.8

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Terrestrial Fauna	Waste Handling & Storage – Plant and General Operations, 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	Solid waste receptacles will have covers where practicable. 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 reduce accumulation Management measures will be used to limit fauna access to stormwater ponds.	5	4	**VERY LOW**	The residual risk ranking has been obtained as the management measures described for waste handling and storage are unlikely to lead to a local short-term increase in the abundance of an introduced animal.	**High** Several Expert investigations / studies Excellent survey data Long term monitoring results available	Not Applicable	9.6.5.9
Terrestrial Fauna	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 undisturbed downstream areas Impacts on terrestrial fauna and fauna habitat due to changes in vegetation community composition and the drying out or inundation of areas Fauna and in particular birds may enter, become	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**	Infrastructure will be designed to retain natural drainage features where practicable. The residual risk ranking has been obtained as it is possible that the physical presence of infrastructure could lead to a local long-term increase in the abundance of an introduced animal and cause a local long-term reduction of a Commonwealth or WA Listed Fauna species.	**High** Several Expert investigations / studies Excellent survey data Long term monitoring results available	Not Applicable	9.6.5.10

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
		entrapped and drown within sedimentation and other water collection ponds								
Stygofauna	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	Retain vegetation wherever practicable Implement vegetation clearing process Limit clearing to designated areas and clearly mark these areas. Utilise previously cleared areas where practical. Develop and implement an employee environmental education program/induction. Rehabilitate disturbed areas where practicable.	6	3	**VERY LOW**	Only two species of stygofauna have been located within the Project area, and both species are likely to be widespread throughout the Pilbara. The residual risk ranking has been obtained as it is possible that a short-term impact to subterranean fauna habitat could occur. If an impact does occur, a full recovery is expected.	**High** Excellent Survey Data	Not Applicable	9.7.5.1
Stygofauna	Earthworks – Site Preparation	Loss of habitat due to compaction	Retain vegetation wherever practicable Implement vegetation clearing process Limit clearing to designated areas and clearly mark these areas. Utilise previously cleared areas where practical. Develop and implement an employee environmental education program/induction. Rehabilitate disturbed areas where practicable.	6	3	**VERY LOW**	Only two species of stygofauna have been located within the Project area, and both species are likely to be widespread throughout the Pilbara. The residual risk ranking has been obtained as it is possible that a short-term impact to subterranean fauna habitat could occur. If an impact does occur, a full recovery is expected.	**High** Excellent Survey Data	Not Applicable	9.7.5.1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Stygofauna	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	Groundwater monitoring Monitoring and management program (as a part of the CEMP and the OEMP) The placement area has been selected to reduce the footprint used.	6	3	**VERY LOW**	It is assumed that the landforms, stratigraphy and the small amount of habitat space available between ground surface and the water table are not conducive to troglobitic fauna. The residual risk ranking has been obtained as it is possible that a short-term impact to subterranean fauna habitat could occur. If an impact does occur, a full recovery is expected.	**High** Excellent Survey Data	Not Applicable	9.7.5.2 Appendix U1
Stygofauna	Surface Water Drainage	Changes to surface water flows resulting in impacts to undisturbed downstream areas	Retain natural drainage where practicable Facilities designed to limit impacts to surface water systems. Culverts are incorporated into the hydrodynamic flow model for drainage crossings traversed by the road and infrastructure corridor.	6	3	**VERY LOW**	The residual risk ranking has been obtained as it is possible that a short-term impact to subterranean fauna habitat could occur. If an impact does occur, a full recovery is expected.	**High** Excellent Survey Data	Not Applicable	9.7.5.4
Stygofauna	Physical Presence of Infrastructure , (Surface Water Drainage)- Construction of Road/Cause way, Location of	Changes to surface water flows resulting in impacts to undisturbed downstream areas	Retain natural drainage where practicable Facilities designed to limit impacts to surface water systems. Culverts are incorporated into the hydrodynamic flow model for drainage crossings traversed by the road and infrastructure corridor.	6	3	**VERY LOW**	It is assumed that impacts from the physical presence of infrastructure will not significantly affect the diversity, geographic distribution and conservation status of stygofauna at and surrounding the Project. The residual risk ranking has been obtained as it is	**High** Excellent Survey Data	Not Applicable	9.7.5.4

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
	Plant Pad						possible that a short-term impact to subterranean fauna habitat could occur. If an impact does occur, a full recovery is expected.			

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Air Quality	Dust generation – vegetation clearing	Dust deposition leading to vegetation loss.	Dust control measures will be undertaken during site clearance. A management plan will be developed as part of the CEMP with the key objective to manage the generation of dust. Speed limits will be used in the construction area to reduce dust generated by vehicle movements. Early sealing of the site access roads will be investigated to assist in reducing dust generation caused by vehicle traffic. 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. Ground clearance leading to the exposure of bare surfaces will be reduced, where practicable. Stockpiles management	5	2	**LOW**	The site preparations involve site clearing and the import of soil infill material. The nature of the material is not yet known, however is likely to require dust management during handling. The residual risk ranking has been obtained as it is likely that a short-term impact to ground-level concentrations at identified sensitive receptors represent a small increase over the baseline conditions.	**Low** Site clearance and construction activities have been undertaken at many locations across the Pilbara Construction activities involving batching plants have been undertaken at many locations across the Pilbara Large volumes of potentially dust generating material are transport around the Pilbara.	Not Applicable	9.8.5.1 Appendix U1

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Air Quality	Other atmospheric emissions	These emissions may contribute to overall emission leading to human health and environmental impacts.	All equipment will be well maintained and comply with Australian Standards and Regulations. Clearing activities will be reduced, where practicable.	6	5	**LOW**	Other atmospheric emissions during the construction phase are likely to be associated with marine vessel engines, additional airline flights to and from Onslow and from vehicles and equipment required to support construction. The residual risk ranking has been obtained as there is only a remote chance that there will be measurable air quality impacts associated with other atmospheric emissions generated during construction.	**Low** Site clearance and construction activities have been undertaken at many locations across the Pilbara	Not Applicable	9.8.5.1

Table 1.5: Summary Risk Rankings for Project Construction and Commissioning - Social

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Recreational Fishing	Fishing by Project workforce	Reduced catch due to fishing by Project workforce in local waters and offshore 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 25km radius of Onslow. For safety reasons, recreational activities such as fishing will not be permitted within the nearshore exclusion zones (for	3	3	**MED**	Target fish species are well represented in the local and regional area, however the low productivity of oceanic waters in the Pilbara means it is possible (although unlikely) that fish populations could be overfished. Therefore, Chevron has proposed a number of management measures to reduce the impact of fishing by the Project workforce in local waters and nearshore islands	**Reasonable** Available information is adequate Extent of access restrictions currently uncertain	Not Applicable	10.4

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
			example, MOF and PLF).							
Commercial Fishing & Pearling	Construction Activities	Reduced catch due to restricted access (exclusion zones)	Chevron will create a commercial fishing industry liaison role to liaise between Chevron and commercial fishers. 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**	Target fish species are well represented in the local and regional area and fishing activities can relocate to other sections of the fisheries Exclusion zones will only affect a small proportion of fishing areas	**Reasonable** Available information is adequate Importance/presence of nurseries, related changes to productivity of fisheries and full footprint of development is uncertain	Not Applicable	10.4
Commercial Fishing & Pearling	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 25km radius of Onslow.	4	3	**LOW**	Target fish species are well represented in the local and regional area, however the low productivity of oceanic waters in the Pilbara means it is possible (although unlikely) that fish populations could be overfished. Therefore, Chevron has proposed a number of management measures to reduce the impact of fishing by the Project workforce in local waters and nearshore islands	**Reasonable** Available information is adequate Extent of access restrictions currently uncertain	Not Applicable	10.4

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Recreation	Dredging	Reduced marine recreational activity due to exclusion zones or reduced visibility as a result of Increased silt in creeks, waterways and sea 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	1	**MED**	Social investment funding will be available for community projects	**Reasonable** Modelling conducted. Extent of exclusion zones currently uncertain	Not Applicable	10.5
Recreation	Housing of Construction Workforce	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**	All workers associated with the Project will be housed at the accommodation village. There may be some short-term impacts while the accommodation village is being constructed.	**Reasonable** Available information is adequate	Not Applicable	10.5

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Recreation	Housing of Residents who Relocate due to Economic Opportunitie s	Reduced access to temporary tourism accommodation due to population growth 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 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	**MED**	All workers associated with the Project will be housed at the accommodation village. There may be some short-term impacts while the accommodation village is being constructed.	**Low** No modelling conducted and available information is inadequate	Not Applicable	10.5
Noise	Construction Activities	Diminished quality of life due to acoustic emissions that are audible from key receptor points and diminish quality of life / sense of serenity 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	**LOW**	Industry standard traffic controls will be in place Noise levels during construction will comply with Environmental Protection (Noise) Regulations 1997	**Reasonable** Survey data available from one expert – complies with EPA guidance Uncertainties exist around pile driving program of works	Not Applicable	10.6

Factor	Aspect	Potential Impacts	Mitigations/Management	Residual Risk			Comments/ Assumptions	Confidence Level and Justification	MNES	EIS/ ERMP
				C	L	R				
Air Emissions	Construction Activities	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**	Air emissions will generally consist of dust from vehicle movements and ground clearance and emissions from construction equipment. Air quality will comply with the EPA Guidance for the Assessment of Environmental Factors – prevention of air quality impacts from land development sites – No.18, 2000. Industry standard traffic management controls will be in place.	**Reasonable** Survey data available from one expert – complies with EPA guidance Uncertainties around number, volume and type of road traffic and heavy vehicles not yet known	Not Applicable	10.6

1.4 Environmental Management Objectives

To guide the development of environmental management for the Project, a series of environmental objectives will be developed to align with the respective objectives set by the EPA (EPA, 2009c). Each management framework references the relevant EPA objectives which will guide the development of Project specific objectives used in subsidiary management plans.

Table 1.6: EPA Environmental Objectives (EPA, 2009c)

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

Factor		Environmental Objective
	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.
Social Surrounds	Risk	To ensure that risk from the proposal is as low as reasonably achievable and complies with acceptable standards and EPA criteria.
Social Surrounds	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.
Social Surrounds	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

1.5 Environmental Management Frameworks

The following section provides a set of EMP frameworks which outline the key activities, environmental issues, and strategies that Chevron and its contractors will employ to mitigate and manage potential Project Attributable impacts.

Table 1.7: Workforce Conduct: Environment

Environmental Management Framework for Workforce Conduct
Associated Activities
♦ General workforce conduct ♦ Fire prevention ♦ Quarantine management ♦ Workforce recreation
Environmental Issues
♦ Overfishing, reduced commercial and recreational fishery catches due to fishing by the Project workforce in local waters and offshore islands ♦ Potential impacts to Dugongs and turtles due to vessel collision. Disturbance to marine fauna behaviours and migratory patterns due to vessel movements ♦ Disturbance to nesting marine turtles and sea birds including nests and burrows. Interference with adults or hatchling turtles

Environmental Management Framework for Workforce Conduct
♦ Creation of marine debris from recreational activities (e.g. garbage, plastics, fishing line) ♦ Fire prevention and control ♦ Introduction and spread of weeds and non-native species ♦ Hydrocarbon and chemical spills ♦ Interference with Indigenous and/or European heritage sites
Environmental Objective
♦ Environmental Objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ Only contractor authorised personnel shall be allowed on the work site. ♦ Construction personnel shall confine their activities and equipment to approved and designated work site areas ♦ Vehicle speeds at the work site shall be restricted on site to reduce potential impacts to fauna and dust generation ♦ Inductions will include details on waste management requirements for all waste streams. Personnel shall be required to manage general rubbish in accordance with Project guidelines ♦ To reduce the risk of fires due to smoking, designated work areas shall have designated smoking areas/facilities including appropriate waste receptacles for receiving cigarette butts. Matches shall be banned ♦ Job Hazard Analysis (JHAs) shall be prepared with appropriately trained personnel and equipment to undertake identified task(s) ♦ “Tailgate meetings” shall be regularly scheduled with work crews, where current or specific environmental, health, social and safety issues shall be discussed ♦ Project personnel shall not bring firearms or pets onto the site ♦ Wildlife (including marine fauna) shall not be fed, or harassed, and shall not be deliberately injured or killed ♦ Recreational facilities shall be provided within the accommodation village to limit requirement for recreational activity beyond the accommodation village ♦ 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

Environmental Management Framework for Workforce Conduct
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 ♦ 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.
EIS/ERMP Reference
♦ Table 8.34: Summary of Management Controls and Residual Risk Analysis for BPPH ♦ Table 8.46: Summary of Management Controls and Residual Risks for Marine Fauna ♦ Table 9.18: Summary of Management Controls and Residual Risk for Flora and Vegetation ♦ Table 9.21: Summary of Management Controls and Residual Risk for Terrestrial Fauna ♦ Table 9.24: Summary of Management Options and Residual Risk for Stygofauna ♦ Table 10.8: Summary of Management Controls and Residual Risk for Recreational Fishing ♦ Table 10.13: Summary of Management Controls and Residual Risk for Recreation Use
Key Guidelines
♦ N/A

Table 1.8: Terrestrial Vegetation and Flora

Environmental Management Framework for Terrestrial Vegetation and Flora
Associated Activities
♦ Vegetation clearing ♦ Earthworks and erosion control ♦ Dust and air emissions ♦ Waste management ♦ Vehicle movements and materials transport
Environmental Issues
♦ Native Flora protection ♦ Vegetation community fragmentation and alteration ♦ Weed introduction and dispersion ♦ Fire control
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ Physical footprint of the operations is reduced as far as practicable ♦ Buffer zones are established between the Project area and the mature mangrove habitat in the Ashburton Delta ♦ Unauthorised clearing shall not be permitted ♦ Experienced and trained Site Environmental Officers will be employed to inspect construction areas prior to any site clearing ♦ Sensitive vegetation communities and habitats in proximity to working areas shall be clearly marked and access to these areas will be prohibited, unless otherwise approved ♦ No burning of vegetation during site clearing shall occur unless otherwise approved ♦ Quarantine requirements shall be included in pre-qualification and contracts for relevant suppliers and contractors ♦ Relevant personnel shall be inducted regarding quarantine management requirements

Environmental Management Framework for Terrestrial Vegetation and Flora
♦ Vehicle hygiene procedures appropriate to site will be developed and implemented ♦ Weed management procedures including monitoring and eradication, appropriate to site, will be developed and implemented ♦ Vegetation monitoring for changes to the condition of flora and vegetation communities including physical condition, species diversity, population density of threatened species
EIS/ERMP Reference
♦ Table 9.18: Summary of Management Controls and Residual Risk for Flora and Vegetation
Key Guidelines
♦ *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia No.51 (Final) (WA)* ♦ *Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline – Guidance for the Assessment of Environmental Factors (in accordance with the EP Act 1986) No.1 (Final) (WA)* ♦ *Terrestrial Biological Surveys as an Element of Biodiversity Protection – EPA Position Statement No.3 (WA)*

Table 1.9: Terrestrial Fauna

Environmental Management Framework for Terrestrial Fauna
Associated Activities
♦ Workforce conduct and recreation ♦ Vegetation clearing ♦ Earthworks and erosion control ♦ Dust and air emissions ♦ Vehicle movements and materials transport ♦ Waste management
Environmental Issues
♦ Native fauna protection ♦ Habitat fragmentation/alteration ♦ Fauna disturbance/behavioural impact ♦ Quarantine control for non-native fauna
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ Physical footprint of the operations is reduced as far as practicable ♦ Unauthorised clearing and burning of vegetation shall not be permitted ♦ All planned land disturbance shall be clearly designated, with areas to be cleared surveyed and pegged in the field in accordance with design plans and in advance of any clearing activities ♦ Areas of high biodiversity, supporting threatened fauna or important fauna habitat value will be avoided during construction as far as practicable ♦ All work-site personnel shall be inducted regarding the proper response to wildlife encounters (including unexpected encounters) ♦ Vehicle collisions with wildlife on the worksite or access routes shall be reported to the Site Environmental Officer who shall maintain a record of all reportable wildlife incidents and non-compliance ♦ The appropriate care and handling of injured animals will be identified in a plan prepared in consultation with the Department of Environment and Conservation

Environmental Management Framework for Terrestrial Fauna
(DEC) ♦ Routine pre-fill/ pre-work trench and project waterbodies inspections will be conducted to identify trapped fauna and enable the implementation of fauna assistance and escape methods ♦ Quarantine requirements shall be included in pre-qualification and contracts for relevant suppliers and contractors ♦ Relevant personnel shall be inducted regarding quarantine management requirements ♦ Vehicle hygiene procedures appropriate to site will be developed and implemented
EIS/ERMP Reference
♦ Table 9.13: Summary of Management Options and Residual Risk for Surface Water ♦ Table 9.18: Summary of Management Controls and Residual Risk for Flora and Vegetation ♦ Table 9.21: Summary of Management Controls and Residual Risk for Terrestrial Fauna ♦ Table 9.24: Summary of Management Options and Residual Risk for Stygofauna
Key Guidelines
♦ *Consideration of Subterranean Fauna in Groundwater and Caves During Environmental Impact Assessment in Western Australia – Guidance for the Assessment of Environmental Factors (in accordance with the EP Act 1986) No.54 (Final) (WA)* ♦ *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia No.56 (Final) (WA)* ♦ *Terrestrial Biological Surveys as an Element of Biodiversity Protection – EPA Position Statement No.3 (WA)*

Table 1.10:Earthworks and Erosion Control

Environmental Management Framework for Earthworks and Erosion Control
Associated Activities
♦ Construction earthworks including infrastructure corridor development ♦ Dredge and microtunnelling material placement ♦ Bunding and drainage system installations ♦ Trenching
Environmental Issues
♦ Potential Acid Sulfate Soils ♦ Erosion of topsoils and impacts to surface water quality ♦ Dust management ♦ Impacts to terrestrial fauna
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (refer Section 1.1.7) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ Physical footprint of the operations is reduced as far as practicable ♦ Cleared vegetation, topsoil or subsurface material shall not be stored in drainage channels ♦ All planned land disturbance shall be clearly designated, with areas to be cleared surveyed and pegged in the field in accordance with design plans and in advance of any clearing activities ♦ The area of exposed soils shall be limited to that required for safe construction and operation ♦ Drainage channel crossings shall be designed and constructed in a manner that minimises sediment release (e.g. installation of erosion berms, silt fences and retention/settling basins), does not prevent water flow and is capable of accommodating locally significant rainfall events ♦ Hardstand runoff shall be contained within a settling/holding basin and should be discharged to natural drainage if it meets agreed water quality standards ♦ Storm/cyclone events could potentially breach retention/settling basins. Basins should be engineered and constructed to allow for storm events without erosion or

Environmental Management Framework for Earthworks and Erosion Control
damage ♦ Erosion and drainage control devices shall be installed where required and maintained on drainage lines to control surface run-off and minimise soil loss from the working areas ♦ Disturbed soils will be managed in accordance with the Western Australian Department of Environment and Conservation "Treatment and management of soils and water in acid sulfate soil landscapes"
EIS/ERMP Reference
♦ Table 9.5: Summary of Management Controls and Residual Risk for Soils and Landforms ♦ Table 9.9: Summary of Management Options and Residual Risk for Groundwater ♦ Table 9.13: Summary of Management Options and Residual Risk for Surface Water ♦ Table 9.24: Summary of Management Options and Residual Risk for Stygofauna ♦ Table 9.30: Summary of Management Options and Residual Risk for Air Quality
Key Guidelines
♦ *Treatment and Management of Soils and Water in Acid Sulfate Soil Landscapes – DEC Guidelines (Draft) (WA)* ♦ *National Strategy for the Management of Coastal Acid Sulphate Soils – Australian and New Zealand Environment Conservation Council & Agricultural and Resource Management Council of Australia and New Zealand (2000) (Cth)* ♦ *National Strategy for the Management of Coastal Acid Sulphate Soils – Australian and New Zealand Environment Conservation Council & Agricultural and Resource Management Council of Australia and New Zealand (2000) (Cth)* ♦ *Planning Bulletin No. 64 Western Australian Planning Commission (2003)* ♦ *Department of Environment and Conservation (2003) Preparation of Acid Sulfate Soil Management Plan (ASSMP)* ♦ *Ahern. C.R., McElnea. A.E., Sullivan. L.A., (2004) Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1-June 2004* ♦ *Department of Environment and Conservation (2009a) Acid Sulfate Soils Guideline Series-Treatment and Management of Acid Sulfate Soils* ♦ *Department of Environment and Conservation (2009b) Acid Sulfate Soils Guideline Series-Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes* ♦ *Department of Environment and Conservation (2003) Contaminated Sites Guideline Series-Assessment of Soil, Sediment and Water (Draft)*

Table 1.11: Piling and Marine Infrastructure Installation

Environmental Management Framework for Piling and Marine Infrastructure Installation
Associated Activities
♦ Pile driving ♦ Topside installations ♦ Vessel movements
Environmental Issues
♦ Behavioural changes, injury or mortality to protected and other marine fauna ♦ Disruption of acoustic hunting behaviour and communications between cetaceans ♦ Explosion impact risk to marine and terrestrial fauna ♦ Seabed disturbance from barge and vessel anchoring ♦ Disturbance to residents associated with noise and light
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ All marine and navigational infrastructure will be located, verified and marked prior to construction activities. Survey and identification procedures (i.e. system of buoys, flagging, navigational lighting, signage, etc.) will be used. Work specifications will clearly define equipment limitations and procedures for working in the vicinity or crossing these facilities ♦ A “Notice to Mariners” shall be prepared and posted to identify the location, timing, and any new navigational aids or details related to the construction and installation of the jetty and berthing dock ♦ Sensitive marine fauna activities (e.g. nesting, migration) shall be considered when planning drilling, piling and installation operations ♦ Plant site selected to avoid sensitive habitat ♦ A marine mammal observation program shall be developed prior to the commencement of activities
EIS/ERMP Reference

Environmental Management Framework for Piling and Marine Infrastructure Installation
♦ Table 8.46: Summary of Management Controls and Residual Risks for Marine Fauna ♦ Table 10.16: Summary of Management Controls and Residual Risk for Public Amenity (Noise)
Key Guidelines
♦ *Environmental Protection (Noise) Regulations 1997* ♦ *EPA Guidance Statement No. 8: Environmental Noise (Draft) (2007)* ♦ *Australian Standard AS 2436-1981: Guide to Noise Control on Construction, Maintenance and Demolition Sites 1981*

Table 1.12: Blasting and Vertical Seismic Profiling (if required)

Environmental Management Framework for Blasting and Vertical Seismic Profiling
Associated Activities
♦ Drilling (for purposes relating to blasting) ♦ Blasting ♦ Vertical seismic profiling
Environmental Issues
♦ Behavioural changes, injury or mortality to protected and other marine fauna ♦ Disruption of acoustic hunting behaviour and communications between cetaceans ♦ Explosion impact risk to marine and terrestrial fauna ♦ Seabed disturbance from barge and vessel anchoring ♦ Disturbance/risk to residents associated with blasting
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ A "Notice to Mariners" shall be prepared and posted to identify the location, timing, and any new navigational aids or details related to drilling and blasting operations ♦ If blasting is required, a Blasting Environmental Management Plan will be developed. Mitigations could potentially include: o Use of marine fauna observers to ensure no mammals and turtles within the vicinity of designated fauna exclusion zones o Activities may be undertaken outside Humpback whale migration period. ♦ Vertical seismic profiling will be managed in accordance with the PSLA - Schedule Specific Requirements as to Offshore Petroleum Exploration and Production 1995
EIS/ERMP Reference
♦ Table 8.46: Summary of Management Controls and Residual Risks for Marine Fauna ♦ Table 9.21: Summary of Management Controls and Residual Risk for Terrestrial Fauna

Environmental Management Framework for Blasting and Vertical Seismic Profiling
♦ Table 9.24: Summary of Management Options and Residual Risk for Stygofauna ♦ Table 10.16: Summary of Management Controls and Residual Risk for Public Amenity (Noise)
Key Guidelines
♦ *Environmental Protection (Noise) Regulations 1997* ♦ *EPA Guidance Statement No. 8: Environmental Noise (Draft) (2007)* ♦ *Australian Standard AS 2436-1981: Guide to Noise Control on Construction, Maintenance and Demolition Sites 1981* ♦ *Guidelines on minimising acoustic disturbance to marine fauna. Department of Industry and Resources, Government of Western Australia (Now Department of Mines and Petroleum) 1995*

Table 1.13: Rock Placement and Dumping

Environmental Management Framework for Rock Placement and Dumping
Associated Activities
♦ Materials Offloading Facility breakwater construction ♦ Pipeline armouring and trench backfill
Environmental Issues
♦ Loss or disturbance to habitat critical to protected and other marine fauna ♦ Disturbance to marine fauna behaviours and migratory patterns ♦ Degradation of nearshore marine water and sediment quality
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ A suitably scaled map of the rock dumping/placement site (the relevant sector from an AusMap), including a clear grid reference, showing bathymetric contours, the boundaries of the site and distance from land shall be prepared ♦ Graded rock material will be used with minimal fines content ♦ Selection of MOF and pipeline routes will be designed to avoid sensitive and critical marine habitat ♦ The method(s) to be used in positioning the dumping vessel shall be identified ♦ Details of the sea-bed topography, sediment characteristics, and biological characteristics (including life-cycle and timing sensitivities of cetaceans, turtles, dugongs, etc), and history of the area shall be described ♦ The disposal techniques (i.e. side-cast, chute or flexible fall-pipe) and procedures shall be identified along with the size distribution and type of rock to be dumped ♦ The anticipated schedule, vessel(s) and other relevant information shall be identified
EIS/ERMP Reference
♦ Table 8.46: Summary of Management Controls and Residual Risks for Marine Fauna ♦ Table 10.10: Summary of Management Controls and Residual Risk for Commercial Fishing and Pearling

Environmental Management Framework for Rock Placement and Dumping
♦ Table 10.13: Summary of Management Controls and Residual Risk for Recreation Use
Key Guidelines
♦ *N/A*

Table 1.14: Microtunnelling and Trenching

Environmental Management Framework for Microtunnelling and Trenching
Associated Activities
♦ Microtunnelling (preferred method) ♦ Marine pipeline trenching (option only) ♦ Backhoe dredging
Environmental Issues
♦ Direct disturbance to the seabed ♦ Increased turbidity, sedimentation and light attenuation leading to loss of habitat ♦ Degradation of nearshore marine water and sediment quality ♦ Degradation of soil quality through the disturbance of PASS (acidity and heavy metals) ♦ Soil erosion due to ground disturbance (wind and water)
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ Microtunnelling is nominated as the preferred option because it will have less impact on the coastal environment compared with trenching ♦ The clearing or the onshore footprint shall be minimised as far as practicable ♦ Drill-cuttings to be managed in accordance with Petroleum Guidelines – Drilling Fluids Management
EIS/ERMP Reference
♦ Table 8.34: Summary of Management Controls and Residual Risk Analysis for BPPH ♦ Table 9.18: Summary of Management Controls and Residual Risk for Flora and Vegetation ♦ Table 9.21:Summary of Management Controls and Residual Risk for Terrestrial Fauna

Environmental Management Framework for Microtunnelling and Trenching
Key Guidelines
♦ *Petroleum Guidelines - Drilling Fluids Management* ♦ *National Strategy for the Management of Coastal Acid Sulphate Soils – Australian and New Zealand Environment Conservation Council & Agricultural and Resource Management Council of Australia and New Zealand (2000) (Cth)* ♦ *National Water Quality Management Strategy*

Table 1.15: Pipelaying

Environmental Management Framework for Pipelaying
Associated Activities
♦ Nearshore trunkline pipelaying ♦ Pipelay barge operations and anchoring ♦ Onshore pipelaying for LNG plant and support facilities ♦ Domgas pipelaying
Environmental Issues
♦ Seabed disturbance ♦ Impacts to terrestrial fauna through entrapment in pipeline trenches ♦ Marine sediment and water quality impacts ♦ Soil and groundwater quality impacts ♦ Marine heritage disturbance ♦ European and Aboriginal heritage disturbance ♦ Community disturbances including recreation and amenity ♦ Disturbance to commercial fishing activities
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
Marine Pipelines ♦ A “Notice to Mariners” shall be prepared and posted to provide advance notification of the installation vessel’s planned location to the local fishing industry, the public and other affected parties ♦ Pipeline route to avoid sensitive or critical habitats ♦ Pipeline installation method and stabilisation technique will include environmental aspects. Stabilisation technique will be mainly driven by metocean conditions at site ♦ All marine pipelines will be located, verified and marked prior to construction activities. Survey and identification procedures (i.e. system of buoys, flagging, navigational lighting, signage, etc.) will be used. Work specifications will clearly

Environmental Management Framework for Pipelaying
define equipment limitations and procedures for working in the vicinity or crossing these facilities ♦ Sensitive marine fauna activities (e.g. nesting, migration) shall be considered when planning pipelaying activities *Onshore Pipelaying* ♦ All pipeline and other underground and above-ground facilities including gas, water, sewer, and communication systems will be located, verified and marked prior to construction activities ♦ Routine pre-fill/ pre-work trench inspections will be conducted to identify trapped fauna and enable the implementation of fauna assistance and escape methods *Pipeline hydrotesting is addressed in Table 1.21: Facility Testing*.
EIS/ERMP Reference
♦ Table 9.5: Summary of Management Controls and Residual Risk for Soils and Landforms ♦ Table 9.9: Summary of Management Options and Residual Risk for Groundwater ♦ Table 9.13: Summary of Management Options and Residual Risk for Surface Water ♦ Table 9.18: Summary of Management Controls and Residual Risk for Flora and Vegetation ♦ Table 9.21: Summary of Management Controls and Residual Risk for Terrestrial Fauna ♦ Table 9.24: Summary of Management Options and Residual Risk for Stygofauna
Key Guidelines
♦ *The Australian Pipeline Industry Association Ltd: Code of Environmental Practice Onshore Pipelines (2009)*

Table 1.16: Solid and Liquid Wastes

Environmental Management Framework for Solid and Liquid Wastes
Associated Activities
♦ Operation of accommodation facilities and offices ♦ Operation of waste management and treatment facilities ♦ Solid waste removal including earth works (construction phase only) ♦ Segregation, storage and disposal of construction, domestic, and industrial wastes ♦ Liquid waste management, including sanitary wastewater and desalination brine discharges ♦ Hazardous waste management, for example, insoluble salts, used oils and greases ♦ Settlement pond dewatering
Environmental Issues
♦ Soil, surface water and groundwater condition ♦ Marine water and seabed/sediment quality ♦ Air quality including particulate matter and odours ♦ Public health and amenity ♦ Quarantine management for weeds and non-native terrestrial fauna
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ All waste streams will be managed in accordance with regulatory requirements and industry standards ♦ Excavated soil will be either stored within the site boundary to enable reuse, reused locally where possible or disposed at a “clean fill” area at a licensed landfill facility ♦ All hazardous waste materials will be segregated, documented and, tracked, segregated from other waste streams and stored in suitable containers ♦ Contingency planning to manage waste water in cases where unexpected volumes and/or quality of waste water are produced

Environmental Management Framework for Solid and Liquid Wastes
♦ Wastes shall be managed in accordance with the principles of: eliminate, reduce, reuse, recycle/recover, treat and dispose of wastes in an environmentally responsible manner ♦ MSDS information on hazardous materials shall be reviewed to identify opportunities to substitute them with a less hazardous or non hazardous replacement ♦ Waste management shall be included in the Job Hazard Analysis process ♦ To minimise packaging wastes, supply materials shall be purchased in bulk wherever practicable ♦ Specific waste management procedures shall be developed for each waste stream (solid, liquid and hazardous) ♦ The handling of non-destructive test media shall be in accordance with industry and regulatory requirements
EIS/ERMP Reference
♦ Table 8.18: Summary of Management Controls and Residual Risk for Marine Water and Sediment Quality ♦ Table 8.46: Summary of Management Controls and Residual Risks for Marine Fauna ♦ Table 9.9: Summary of Management Options and Residual Risk for Groundwater ♦ Table 9.13: Summary of Management Options and Residual Risk for Surface Water ♦ Table 9.18: Summary of Management Controls and Residual Risk for Flora and Vegetation ♦ Table 9.21: Summary of Management Controls and Residual Risk for Terrestrial Fauna ♦ Table 9.24: Summary of Management Options and Residual Risk for Stygofauna ♦ Table 10.10: Summary of Management Controls and Residual Risk for Commercial Fishing and Pearling ♦ Table 10.13: Summary of Management Controls and Residual Risk for Recreation Use
Key Guidelines
♦ *Best Practice Guidelines for the Provision of Waste Reception Facilities at Ports, Marinas and Boat Harbours Australia and New Zealand (Cth)* ♦ *National Occupational Health and Safety Commission (NOHSC). Approved Criteria for Classifying Hazardous Substances (NOHSC:1008 [2002]) (Cth)* ♦ *Assessment of Odour Impacts from New Proposals – Guidance for the Assessment of Environmental Factors (in accordance with the EP Act 1986) No.47 (Final) (WA)* ♦ *Separation Distances Between Industrial and Sensitive Land Uses – Guidance for the Assessment of Environmental Factors (in accordance with the EP Act 1986) No.3 (Final) (WA)* ♦ *DEC Review of Waste Classification and Waste Definitions 1996 (as amended) 2005*

Environmental Management Framework for Solid and Liquid Wastes
(WA) ♦ *Australian and New Zealand Environment Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) (Cth)* ♦ *National Water Initiative 2004 (Cth)* ♦ *Department of Environment and Conservation, State Water Quality Management Strategy No.6, Implementation Framework for Western Australia for the Australia and New Zealand Guidelines for Fresh and Marine Water Quality Monitoring and Reporting (Guidelines Nos 4 and 7: National Water Quality Management Strategy) (WA)*

Table 1.17: Transport, Traffic and Site Access

Environmental Management Framework for Transport, Traffic and Site Access
Associated Activities
♦ Personnel transportation ♦ Materials transportation ♦ Road installation and maintenance
Environmental Issues
♦ Vehicle-fauna interactions resulting injury/casualties ♦ Introduction or spread of non-indigenous species ♦ Habitat fragmentation/alteration ♦ Erosion control ♦ Dust and air emissions ♦ Hydrocarbon spills/leaks ♦ Fire control ♦ Public health and amenity
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ A Traffic Management Plan will be developed and implemented ♦ Vehicle speeds shall be restricted to minimise potential wildlife collisions and dust generation ♦ Vehicles shall remain on designated access roads and within the defined Project construction area and associated work/staging sites unless otherwise authorised. This shall be supported by workforce education, signs, boundary markers and fences ♦ Vehicle parking shall be restricted to designated areas unless otherwise authorised ♦ Existing roads, and other previously disturbed areas, shall be used in preference to creating new access where practicable ♦ Where new access tracks are required, important ecological features, listed vegetation species and cultural heritage sites shall be avoided

Environmental Management Framework for Transport, Traffic and Site Access
♦ Road drainage will not result in surface erosion or impacts to surface, ground or marine waters ♦ Surface drainage patterns intercepted by access not required for the Project's operation or maintenance shall be rehabilitated as soon as practicable ♦ Drainage channel crossings shall be designed and constructed in a manner that minimises sediment release (e.g., erosion berms, silt fences and sediment basins), does not prevent water flows and is capable of accommodating locally significant rainfall events ♦ Potential sources of ignition shall be identified through the Job Hazard Analysis process. ♦ Vehicle activity in high risk areas such as long grass will be managed to reduce the risk of fire ignition
EIS/ERMP Reference
♦ Table 9.5: Summary of Management Controls and Residual Risk for Soils and Landforms ♦ Table 9.13: Summary of Management Options and Residual Risk for Surface Water ♦ Table 9.18: Summary of Management Controls and Residual Risk for Flora and Vegetation. ♦ Table 9.21: Summary of Management Controls and Residual Risk for Terrestrial Fauna ♦ Table 9.30: Summary of Management Options and Residual Risk for Air Quality
Key Guidelines
♦ *Land evaluation Standards for Land Resource Mapping Third Edition December 2005* ♦ *EPA Position Statement No. 2 - Environmental Protection of Native Vegetation in Western Australia – Clearing of Native Vegetation with Particular Reference to the Agricultural Area* ♦ *EPA Draft State Environmental (Ambient Air) Policy* ♦ *EPA Guidance Statement No. 33: Environmental Guidance for Planning and Development* ♦ *Shire of Ashburton Town Planning Scheme No 7* ♦ *EPA Guidance Statement No. 14: Road and Rail Transportation Noise (Preliminary Draft - Version 3)*

Table 1.18: Shipping and Vessel Operations

Environmental Management Framework for Shipping and Vessel Operations
Associated Activities
♦ Dredge vessel movements while transiting and transporting dredge material to disposal sites ♦ Barges laying pipeline ♦ Vessels towing platform and drilling rigs ♦ Standby tugs ♦ Vessel refuelling, support, accommodation vessels and crew transfer vessels and barges ♦ Support and environmental monitoring vessel movements ♦ Anchoring and mooring installation
Environmental Issues
♦ Direct (vessel strike) and indirect (light, noise etc.) disturbance to marine fauna behaviour (migration, foraging, breeding) ♦ Marine fauna injury/casualty ♦ Introduction of marine pests and pathogens ♦ Direct disturbance to the seabed through anchoring/mooring installation ♦ Disturbance/loss of marine BPPH ♦ Leaks, spills and discharges and a reduction in marine water and sediment quality ♦ Bioaccumulation of chemicals and trace metals in species/food chain
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ All relevant vessel navigation crews shall be qualified under the Flag State and International regulations and shall be duly certified to perform their duties ♦ Prior to the start of any operations, operations and communications will be developed to be used within the Project area. Specified communication channels will be established and available for all marine traffic

Environmental Management Framework for Shipping and Vessel Operations
♦ Management measures to reduce direct (vessel strike) and indirect (behavioural disturbance) impacts to marine mammals and turtles will be contained within specific management plans for marine activities ♦ Humpback Whale and Dugong observations and response procedures including application of 300 m observation zone and 100 m exclusion zone will be implemented during dredging and dredge material placement works ♦ In the event that a Humpback Whale or Dugong is sighted within the 300 m observation zone, the dredge will relocate a minimum distance of 300 m away from the individual ♦ In the event that a Humpback Whale 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 Humpback Whale or Dugong have been observed within this zone for ten minutes ♦ A lookout will be maintained, during daylight hours, for Humpback Whales and Dugongs while any dredge is on route to and from the dredge area to dredge material placement grounds. If sighted, direction/speed will be adjusted to avoid impact (within the safety constraints of the vessel) ♦ Incidents of vessel-fauna strike will be reported in accordance with Section 14(2)(ba) of the Wildlife Conservation Act 1950, to the DEC within 48 hours of the proponent becoming aware of such deaths ♦ Introduced marine pest (IMP) risk assessments will be completed for all construction vessels entering the Project area. Vessels assessed as high or uncertain risk will be inspected prior to mobilisation. If IMP are found, vessels will be cleaned prior to mobilisation ♦ If vessels on site are found to have IMP, surveys will be conducted to determine if further action is required. All vessels will comply with AQIS ballast water discharge regulations ♦ Legislative requirements, such as MARPOL requirements, for discharge criteria, garbage, harmful substances and sewage management shall be met ♦ An Oil Spill Contingency Plan (OSCP) will be developed and implemented for the Project to manage and mitigate potential impacts from leaks and spills
EIS/ERMP Reference
♦ Table 8.18: Summary of Management Controls and Residual Risk for Marine Water and Sediment Quality ♦ Table 8.34: Summary of Management Controls and Residual Risk Analysis for BPPH ♦ Table 8.46: Summary of Management Controls and Residual Risks for Marine Fauna ♦ Table 9.18: Summary of Management Controls and Residual Risk for Flora and Vegetation ♦ Table 9.21: Summary of Management Controls and Residual Risk for Terrestrial Fauna

Environmental Management Framework for Shipping and Vessel Operations
Key Guidelines
♦ *National Water Quality Management Strategy* ♦ *International Convention for the Control and Management of Ships' Ballast water and Sediments (IMO 2004)* ♦ *International Convention on the Control of Harmful Anti-fouling Systems on Ships* ♦ *International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)* ♦ *EPA Environmental Assessment Guideline 3 (EAG 3): Protection of BPPH in Western Australia's Marine Environment*

Table 1.19: Lighting and Light Emissions

Environmental Management Framework for Lighting and Light Emissions
Associated Activities
♦ Construction of onshore plant and facilities ♦ Installation of marine facilities (jetty and MOF) ♦ Flaring (during commissioning only) ♦ Stationary vessels and mobile vessels ♦ Vehicle movements ♦ Boundary, security and safety lighting
Environmental Issues
♦ Marine fauna disturbance and/or behavioural changes, injury or mortality ♦ Terrestrial fauna disturbance and/or behavioural changes, injury or mortality ♦ Disturbance to migratory shorebird species ♦ Diminished quality of life for Onslow township residents ♦ Stress-related impacts on community well-being
Environmental Objective
♦ Environmental Objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ Lighting will meet all applicable regulations and safety design standards ♦ Unless otherwise prohibited by safety considerations, lighting at construction locations shall only be lit when personnel are present or equipment is operating ♦ 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 ♦ The Proponent will monitor Project-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 ♦ Monitoring will be conducted during commissioning, to coincide with planned flaring events to assess the effects of this activity on turtle hatchling behaviour, particularly

Environmental Management Framework for Lighting and Light Emissions
in relation to their orientation to the beach and sea-finding success
EIS/ERMP Reference
♦ Table 8.46: Summary of Management Controls and Residual Risks for Marine Fauna ♦ Table 9.21: Summary of Management Controls and Residual Risk for Terrestrial Fauna ♦ Table 10.10: Summary of Management Controls and Residual Risk for Commercial Fishing and Pearling ♦ Table 10.13: Summary of Management Controls and Residual Risk for Recreation Use
Key Guidelines
♦ *Australian Maritime Safety Authority Marine Order, Part 32* ♦ *EPA Guidance Statement No 33: Environmental Guidance for Planning and Development* ♦ *Australian Standard AS4282:1997 Control of the Obtrusive Effects of Outdoor Lighting* ♦ *State Industrial Buffer Statement of Planning Policy 4.1* ♦ *EPA Guidance Statement No. 3: Separation Distances between Industrial and Sensitive Land Uses 2005* ♦ *EPA Guidance Statement No. 56 - Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* ♦ *EPA Position Statement No. 3 - Terrestrial Biological Surveys as an Element of Biodiversity Protection* ♦ *EPBC Act (Cth) Policy Statement 1.1 Significant Impact Guidelines*

Table 1.20: Dust and Air Emissions

Environmental Management Framework for Dust and Air Emissions
Associated Activities
♦ Construction earthworks and excavation ♦ Construction of general infrastructure ♦ Burning and incineration ♦ Vehicle use (wheel generated dust, exhaust emissions) ♦ Waste management and treatment facilities ♦ Stockpiling
Environmental Issues
♦ Marine water quality ♦ Surface water quality ♦ Wind erosion of cleared/exposed areas ♦ Air quality ♦ Human health and amenity ♦ Terrestrial fauna and flora health
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ Standard Operating Procedures to minimise air emissions including dust generation/discharge potential, CO_2 and associated emissions ♦ A Traffic Management Plan will be developed and implemented to ensure stringent controls on vehicle speeds and restricting travel to designated roads/tracks during construction activities ♦ Unpaved surfaces shall be stabilised to reduce dust generation. Dust suppression measures, such as use of water carts and sprinklers on exposed soils and roadways, shall be implemented. Where required, dust suppression shall be managed to ensure that measures do not result in erosion or significant runoff ♦ Rehabilitation of vegetation will be undertaken in temporarily disturbed areas to

Environmental Management Framework for Dust and Air Emissions
minimise dust generation ♦ Construction vehicles and equipment shall be regularly maintained to ensure efficient operation and appropriate emissions standards ♦ Industry standards shall be adopted for refuelling, transfer and storage of fuels and chemicals (e.g. level indication, overflow protection, containment, bunding, appropriate drainage systems and hardstand areas) to reduce fugitive emissions and prevent spills ♦ Any hydrocarbon or volatile chemical spill shall be cleaned up as soon as possible ♦ Alternatives to ozone depleting substances shall be selected wherever practicable. Contractors shall be required to advise of the use of ozone depleting substances and develop management plans to avoid release ♦ Waste incineration will be managed in accordance with *NSW Protection Of The Environment Operations (Clean Air) Regulation 2002*
EIS/ERMP Reference
♦ Table 8.18: Summary of Management Controls and Residual Risk for Marine Water and Sediment Quality ♦ Table 8.34: Summary of Management Controls and Residual Risk Analysis for BPPH ♦ Table 8.46: Summary of Management Controls and Residual Risks for Marine Fauna ♦ Table 8.48: Summary of management controls and residual risk analysis for Coastal Processes ♦ Table 9.13: Summary of Management Options and Residual Risk for Surface Water ♦ Table 9.18: Summary of Management Controls and Residual Risk for Flora and Vegetation ♦ Table 9.21: Summary of Management Controls and Residual Risk for Terrestrial Fauna ♦ Table 9.24: Summary of Management Options and Residual Risk for Stygofauna ♦ Table 10.10: Summary of Management Controls and Residual Risk for Commercial Fishing and Pearling ♦ Table 10.13: Summary of Management Controls and Residual Risk for Recreation Use
Key Guidelines
♦ *National Environment Protection Measure (NEPM) for Ambient Air Quality. The standards defined in this measure are concentrations set to ensure that public health, amenity and the environment are protected. The NEPM has established standards for particulates as PM10, and advisory reporting standards for PM2.5; and* ♦ *EPA Guidance Statement No.18 (Prevention of Air Quality Impacts from Land Development Sites 2000) also provides guidance on the control of dust and smoke from land development sites.*

Environmental Management Framework for Dust and Air Emissions
♦ *NSW Protection Of The Environment Operations (Clean Air) Regulation 2002*

Table 1.21: Facility Testing

Environmental Management Framework for Facility Testing
Associated Activities
♦ Pipeline and tank hydrotesting
Environmental Issues
♦ Water quality degradation ♦ Soil, surface water and groundwater quality degradation
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (refer Section 1.1.7) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ Prior to testing, the contractor shall prepare a hydrostatic testing plan which as a minimum shall include: o the location and detailed description of the water source o the volume of water required o the anticipated quality of the source water (including chemistry and total suspended solids) o the equipment and infrastructure required for the testing o the location and detailed description of the receiving environment into which the effluent shall be discharged o a description and the concentration of any biocides, oxygen scavengers, rust inhibitors or other materials to be added to the test water o methods proposed to prevent biophysical impacts at the point of water discharge. ♦ Where feasible, test water shall be reused for a series of test sections ♦ Water quality monitoring shall include the results of sampling prior to use, and again prior to discharge

Environmental Management Framework for Facility Testing
♦ Used test water shall meet ANZECC/ARMCANZ (2002) water quality standards at the point of discharge, after dilution and shall be discharged into areas and at times during high tidal exchange where practicable ♦ Where practicable piping, vessels and fabrication plant sections shall be pre-tested prior to mobilisation to site ♦ The handling of non-destructive test media shall be in accordance with industry and regulatory requirements
EIS/ERMP Reference
♦ Table 8.18: Summary of Management Controls and Residual Risk for Marine Water and Sediment Quality ♦ Table 8.46: Summary of Management Controls and Residual Risks for Marine Fauna ♦ Table 9.9: Summary of Management Options and Residual Risk for Groundwater ♦ Table 9.13: Summary of Management Options and Residual Risk for Surface Water
Key Guidelines
♦ *Australian and New Zealand Environment Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) (Cth)*

Table 1.22: Spill Contingency and Response

Environmental Management Framework for Spill Contingency and Response
Associated Activities
♦ Construction and Installation activities ♦ Operation and loss of integrity of facilities, pipelines, sumps, wells, tanks, ponds, treatment plants ♦ Failure of containment facilities/bunding
Environmental Issues
♦ Soil quality/condition including salinity effects ♦ Surface water and groundwater quality degradation including nutrient loading ♦ Vegetation loss and decrease in vegetation health ♦ Marine water and sediment quality ♦ Fauna injury/casualty ♦ Decrease in BPPH habitat health ♦ Odour and air quality impacts to occupational health and public amenity values ♦ Impacts to public recreational activities including fishing and pearling
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ Spill Contingency Plans(SCP) shall be developed for potential spill scenarios. Offshore hydrocarbon spill response shall be approved by the relevant regulatory agency ♦ Site inductions prior to construction activities will include correct materials handling procedures, spill management and spill response procedures. Training will include the correct use of the spill response equipment to be maintained onsite ♦ Adequate emergency response capabilities will be maintained appropriate to the nature and level of construction and installation activities ♦ Optimised design, construction and maintenance of infrastructure and integrity management and testing program ♦ All port authority and pollution prevention regulations shall be adhered to when

Environmental Management Framework for Spill Contingency and Response
delivering product from supply vessel to drilling rig, lay barge, dredgers and support vessels ♦ All hazardous materials will be contained in accordance with all relevant codes and standards and with intent to prevent harm to the environment. All required bunding and containment measures will be put in place ♦ Fuel and chemical storage, handling and distribution systems, and areas where vehicles, plant and machinery are stored shall be regularly inspected to identify, repair and respond to leaks ♦ Fuel storage tanks, handling areas, drainage and bunding systems shall be inspected and maintained with particular emphasis on condition and performance of foundations and supports, serviceability of fittings, vents, valves and lines and condition of welds, surface corrosion and paintwork ♦ Regular maintenance of dredges, drilling rigs, barges, supply vessels, plant and equipment shall be conducted to reduce the chance for equipment failure, spills and leaks. Maintenance logs shall be kept for all major vessels, plant and equipment ♦ Vehicles and equipment will be appropriately maintained ♦ Safe fuel transfer procedures shall be adopted. Refuelling of marine vessels shall only be conducted under suitable sea-state and visibility conditions ♦ The avoidance of spills through the implementation of best practice to the initial design integrity built into process and utility equipment, materials handling and operating and maintenance procedures ♦ Provision of numerous primary and secondary barriers (sub sea safety valves, Production Master Valve, Swab Valve, Tree Cup, Production Shutdown Valve, Production Wing Valve etc.)
EIS/ERMP Reference
♦ Table 8.18: Summary of Management Controls and Residual Risk for Marine Water and Sediment Quality ♦ Table 8.34: Summary of Management Controls and Residual Risk Analysis for BPPH ♦ Table 8.46: Summary of Management Controls and Residual Risks for Marine Fauna ♦ Table 8.48: Summary of Management Controls and Residual Risk Analysis for Coastal Processes ♦ Table 9.9: Summary of Management Options and Residual Risk for Groundwater ♦ Table 9.13: Summary of Management Options and Residual Risk for Surface Water ♦ Table 9.18: Summary of Management Controls and Residual Risk for Flora and Vegetation ♦ Table 9.21: Summary of Management Controls and Residual Risk for Terrestrial Fauna ♦ Table 9.24: Summary of Management Options and Residual Risk for Stygofauna ♦ Table 10.10: Summary of Management Controls and Residual Risk for Commercial

Environmental Management Framework for Spill Contingency and Response
Fishing and Pearling ♦ Table 10.13: Summary of Management Controls and Residual Risk for Recreation Use
Key Guidelines
♦ *Working Together to Reduce Impacts from Shipping Operations: ANZECC Strategy to Protect the Marine Environment (Cth)* ♦ *EPA Environmental Assessment Guideline 3 (EAG 3): Protection of BPPH in Western Australia's Marine Environment* ♦ *Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment – Guidance for the Assessment of Environmental Factors (in accordance with the EP Act 1986) (WA)* ♦ *Consideration of Subterranean Fauna in Groundwater and Caves During Environmental Impact Assessment in Western Australia – Guidance for the Assessment of Environmental Factors (in accordance with the EP Act 1986) No.54*

Table 1.23: Incident Management and Emergency Response

Environmental Management Framework for Incident Management and Emergency Response
Associated Activities
♦ Upset conditions arising from unanticipated weather events (e.g. cyclones, fire, floods) ♦ Significant equipment failure during installation and construction ♦ Major traffic accident/vessel collisions ♦ Oil or hazardous chemical spills ♦ Rescue operations
Environmental Issues
♦ Human injury and/or death resulting from collision, explosion and fire etc. ♦ Soil, surface water and ground water quality degradation from hydrocarbon and chemical spills ♦ Fauna/flora disturbance, injury or casualty associated with fire ♦ Degradation of air quality resulting from dust and smoke generation ♦ Destruction of property including unplanned impacts to heritage sites ♦ Degradation of public health and amenity
Environmental Objective
♦ Environmental objectives will be established to align with EPA environmental objectives (Refer Section 1.1.4) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
<u>General</u> ♦ Construction and installation activities undertaken as planned and in accordance with established procedures and protocols ♦ Emergency Response Plans in place for all major activities including facility testing and commissioning ♦ Adequate emergency response capabilities will be maintained appropriate to the nature and level of activities on site ♦ Emergency response teams will be established, and will be adequately trained and capable

Environmental Management Framework for Incident Management and Emergency Response
♦ Communication systems will be put in place to enable effective escalation of an incident response Leaks and Spills Response ♦ *See* Table 1.22 Fire Prevention and Control ♦ A list of available equipment and manpower to be employed on the Project including an organisation chart identifying personnel, contact numbers and responsibilities on the job site, shall be prepared ♦ Continuous firebreaks will be established around operating plant and equipment , where practicable, to reduce the risk of ignition and potential spread of fires ♦ Fire control measures to be taken by each crew (i.e. welding, fuel transportation and handling, equipment servicing, etc.) and for the work proposed, shall be clearly documented and communicated ♦ All earthmoving equipment shall be fitted with spark arrestors or similar devices ♦ Appropriate fire fighting equipment shall be stored at all suitable work sites in accordance with relevant regulations. Fire fighting equipment shall be regularly inspected and well maintained ♦ Flammable material shall be cleared from around potential fire ignition sources ♦ In the event that a fire is ignited the following shall be undertaken: o On-site personnel shall immediately report the fire to the Project component Site Manager o Chevron and contractor personnel shall carry out initial fire suppression and take all reasonable steps to extinguish a fire that spreads beyond an area authorised or intended for burning o Chevron and contractor personnel shall mobilise heavy equipment, man power, and water trucks as necessary for fire suppression o All fires observed shall be reported immediately to the Project's operations control and CALM European Cultural Heritage Discovery ♦ All areas likely to be disturbed shall be assessed for European cultural heritage by a qualified archaeologist prior to commencement of ground disturbing activities ♦ All personnel and contractors on site shall be advised that it is an offence under legislation to interfere with a site or collect artefacts ♦ Site clearing works shall be monitored by suitably qualified personnel to ensure only designated areas are disturbed ♦ Monitoring activities shall seek to identify potential for new discovered cultural heritage material uncovered during site clearing ♦ All reasonable efforts to protect the site or artefacts shall be made. For example, buffer zones shall be established or temporary barriers (i.e. stakes and appropriate flagging) shall be erected

Environmental Management Framework for Incident Management and Emergency Response
♦ No material shall be further disturbed or removed without appropriate authorisation Aboriginal Cultural Heritage and Artefact Discovery *In addition to the above measure the following management actions will be applied where Aboriginal Cultural Heritage Artefacts are discovered* ♦ All areas likely to be disturbed shall be assessed for Aboriginal cultural heritage with appropriate assessment from Thalanyji community representatives ♦ Where a discovery is made, at the same time as other individuals and agencies are contacted, a designated Thalanyji representative shall be notified of the discovery, as well as the steps which have been taken to protect the site ♦ Arrangements will be made to enable the nominated Thalanyji people to attend the site, if not already present ♦ The Thalanyji people shall be consulted regarding the management of the material once Aboriginal origin has been determined ♦ No further work at the locations shall be undertaken until all parties have been consulted and agreement has been reached ♦ A detailed recording of the site(s) shall be undertaken Weather and Climate Events ♦ During high-risk season(s), a reserve of suitable material and equipment shall be located on-site to mitigate potential erosion and sedimentation due to heavy rainfall events ♦ Drainage channel crossings shall be designed and constructed in a manner that minimises sediment release (e.g. erosion berms, silt fences and retention/settling basins), does not prevent or unnecessarily restrict water flows and is capable of accommodating locally significant rainfall events ♦ Installed retention/settling basins shall be cleaned and maintained regularly ♦ Construction site drainage shall be regularly reviewed for the potential to temporarily diverting storm water away from area and materials susceptible to erosion
EIS/ERMP Reference
♦ Table 8.46: Summary of Management Controls and Residual Risks for Marine Fauna ♦ Table 8.48: Summary of management controls and residual risk analysis for Coastal Processes ♦ Table 9.5: Summary of Management Controls and Residual Risk for Soils and Landforms ♦ Table 9.10: Summary of Management Options and Residual Risk for Groundwater ♦ Table 9.18: Summary of Management Controls and Residual Risk for Flora and Vegetation ♦ Table 9.21: Summary of Management Controls and Residual Risk for Terrestrial Fauna

Environmental Management Framework for Incident Management and Emergency Response
Key Guidelines
♦ *Emergency Management Act 2005* ♦ *Safety Case documentation*

Table 1.24: Clean-up and Rehabilitation

Environmental Management Framework for Clean-up and Rehabilitation
Associated Activities
♦ Access corridor and pipeline installation ♦ Construction of temporary laydown areas ♦ Disposal of construction wastes ♦ Placement of dredge material (dredge/microtunnelling/ earthworks)
Environmental Issues
♦ Soil, surface water and groundwater quality degradation associated with hydrocarbon or chemical spills ♦ Wind and surface water erosion at temporarily cleared areas ♦ Habitat fragmentation and edge-effects on remnant vegetation stands ♦ Introduction or spread of non-indigenous species
Environmental Objective
♦ Environmental Objectives will be established to align with EPA environmental objectives (refer Section 1.1.7) and to be consistent with Project with relevant regulatory, local and Project requirements
Performance Indicators
♦ Performance indicators will be developed to be consistent with relevant regulatory, local and Project requirements
Management Strategies
♦ Rehabilitation strategies will aim to ensure disturbed land is returned to a condition which is equivalent to the areas baseline status where practicable. Disturbed areas shall be rehabilitated where no longer required for operations ♦ Sensitive vegetation communities and habitats in proximity to working areas shall be clearly marked and access to these areas will be prohibited, unless otherwise approved ♦ On sites to be cleared or graded, vegetation shall be removed, mulched and either stored for later rehabilitation or directly placed on disturbed areas to reduce erosion and to encourage native seed propagation ♦ Soil and surface stability shall be maintained; cut and fill excavation will be shaped to maintain slope stability and temporary erosion control berms, drains and sediment barriers shall be installed as necessary and maintained until final construction clean-up is completed ♦ Rehabilitation strategies will be implemented which introduce works and land use practices appropriate for areas of disturbed ASS and which mitigate acid drainage

Environmental Management Framework for Clean-up and Rehabilitation
♦ Native plant species shall be used to maintain biodiversity, reduce opportunity for weed establishment, and maintain wildlife habitat. Rehabilitation measures shall actively promote the regeneration of native groundcover and shrubs ♦ Weed management procedures will including monitoring and eradication, appropriate to site, will be developed and implemented for rehabilitated areas
EIS/ERMP Reference
♦ Table 8.18: Summary of Management Controls and Residual Risk for Marine Water and Sediment Quality ♦ Table 9.5: Summary of Management Controls and Residual Risk for Soils and Landforms ♦ Table 9.13: Summary of Management Options and Residual Risk for Surface Water ♦ Table 9.18: Summary of Management Controls and Residual Risk for Flora and Vegetation ♦ Table 9.21: Summary of Management Controls and Residual Risk for Terrestrial Fauna ♦ Table 10.13: Summary of Management Controls and Residual Risk for Recreation Use
Key Guidelines
♦ *EPA Guidance Statement No. 6 – Rehabilitation of Terrestrial Ecosystems* ♦ *Land evaluation Standards for Land Resource Mapping Third Edition December 2005* ♦ *National Water Quality Management Strategy*

1.6 Environmental Monitoring

Environmental monitoring will form an integral part of the Project construction. Detailed monitoring programs will be developed in consultation with regulators, subject matter experts and appropriate stakeholders to address activities that have the potential to adversely impact the environment.

The monitoring programs will be used to assess the effectiveness, and guide further development, of the management of environmental and associated social impacts. The aim of the monitoring programs will be to:

- enable early identification of potential environmental issues
- determine actual versus predicted change to factors resulting from Project activities
- evaluate the effectiveness of management strategies
- provide data for the assessment of adherence to EMPs and licence conditions
- guide necessary amendments to management strategies if required.

Monitoring programs will be developed and conducted by appropriately qualified personnel to provide valid, quantifiable data that can be used to assess Project impacts. These programs will be reviewed periodically and modified as required to ensure they remain effective.

The construction activities will be managed through a compliance monitoring program, consisting of data collection regarding the following aspects and activities:

- Terrestrial flora and fauna
- Surface and groundwater quality
- Acid Sulfate Soils
- Marine flora and fauna
- Marine sediment and water quality
- Quarantine
- Noise and vibration
- Dust and air quality
- Light emissions
- Wastes and discharges
- Spill response and remediation.

1.7 Environmental Management Implementation

1.7.1 Roles and Responsibilities

Key roles and responsibilities in implementing the CEMP are detailed in Table 1.25. The implementation of the CEMP will be managed in accordance with The Chevron OE Contractor HES Management Process (Chevron Australia 2008).

Table 1.25: Responsibilities for the Management of Onshore Construction and Nearshore Installation Program

Chevron Australia	♦ Proponent and overall responsibility for Project ♦ Undertakes some monitoring of construction activities ♦ Receives all monitoring data and reports to regulatory agencies as required ♦ Undertakes a compliance auditing role of the implementation of the approved CEMP
Construction Contractors	♦ Owner of finalised CEMP and associated Subsidiary plans ♦ Prepares and implements relevant Subsidiary plans in accordance with approved CEMP ♦ Implements the construction and installation works ♦ Undertakes environmental monitoring ♦ Undertakes compliance auditing of sub-contractors ♦ Reports to Chevron ABU

1.7.2 Induction and Training

All personnel (including contractors and subcontractors) are required to attend environmental inductions and training that are relevant to their roles on the Project. Training and induction programs will facilitate the understanding that personnel have of their environmental responsibilities, and increase the awareness of the management and protection measures required to reduce potential impacts on the environment.

1.7.3 Reporting

An annual Construction Environmental Management report is proposed, which consolidates the previous year's monitoring programmes. The scope of this annual report would include monitoring results, summary information relating to reportable incidents and status update on the construction program schedule.

1.7.4 Auditing

A detailed Project environmental audit program will be developed in consultation with the relevant State and Commonwealth agencies. Internal environmental audits will be conducted by company personnel as well as third party auditors engaged by Chevron. These audits will be conducted to assess compliance with regulatory requirements, licence conditions, EMPs and Chevron Australia standards.

1.7.5 Management Review

Where monitoring and/or audits indicate that performance does not conform to environmental management requirements, or further improvement in performance standards is necessary, corrective action will be required. Investigation and corrective action procedures will be established to:

- determine the cause of non-conformance
- identify and implement corrective action
- initiate preventative actions
- apply controls to ensure that preventative actions are effective
- record any changes in written procedure resulting from the corrective action.

Corrective actions may include management responsibilities for addressing, tracking and close-out of incident investigations, audits, inspections and monitoring programs.

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Appendix V1

Archaeological and Historical Survey Report

Figures

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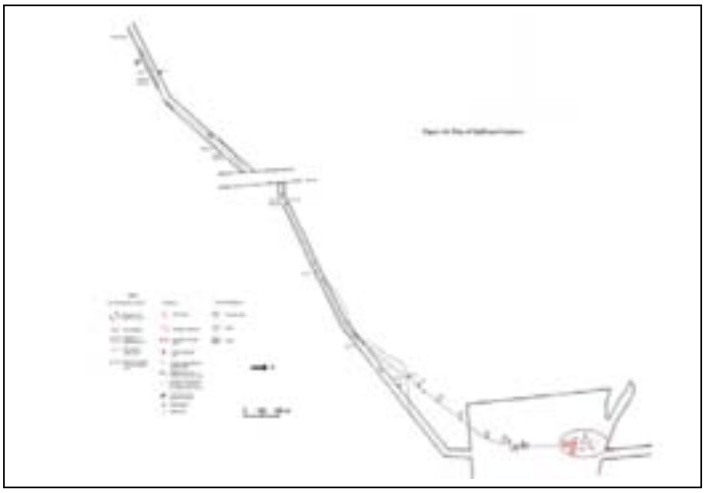
WHEATSTONE PROJECT EUROPEAN HERITAGE IMPACT PROJECT

ARCHAEOLOGICAL AND HISTORICAL SURVEY REPORT



PREPARED BY

Gaye Nayton Heritage Archaeologist
In association with
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FOR

Chevron Australia Pty Ltd

December 2009

♦♦♦♦❖♦♦♦♦

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EXECUTIVE SUMMARY

This report follows on from a desktop survey and aerial analysis carried out by the consultant in 2008. The pertinent findings of the desktop survey has been summarised within this report. Both reports are part of a larger Project to identify possible impacts of the Wheatstone Project on European heritage.

Listings

The Old Onslow Townsite, is a registered European heritage site under the *Heritage of Western Australia Act 1990*, and is located near to the chosen location for the Wheatstone Project. Part of the registered curtilage, being the area of a former, tramway, telegraph line, sea jetty and port area is contained within the area of interest to Chevron Australia. Any impact on these sites must gain Heritage Council of Western Australia (HCWA) development approval before development can go ahead. The HCWA conservation area extends to the seabed associated with the 1901 Jetty.

The sea jetty and port sites, plus any possible shipwrecks within the off shore area are maritime sites and potentially protected under the *West Australian Maritime Archaeology Act 1973* or the *Commonwealth Historic Shipwrecks Act 1976*. However, the port and associated jetty date from 1901 and are therefore not protected under the *Maritime Archaeology Act 1973*. Therefore the provisions of this act do not currently apply to on-shore assets and seabed material relating to the jetty. However, it should be noted that this Act is under review and that a likely outcome of the review is a rolling protection cut off date for maritime archaeological sites of 75 years bringing the legislation in line with the *Commonwealth Historic Shipwrecks Act 1976*. If this becomes law then the maritime archaeological sites within the development area will be declarable under the *West Australian Maritime Archaeology Act.*

Historic research suggests there is a faint possibility of historic shipwrecks protected under the *Commonwealth Historic Shipwrecks Act 1976* being located within the area of interest to Chevron Australia. However, a marine survey carried out by them has not yielded results which suggest the presence of shipwrecks or substantial timber jetty piles within the surveyed area. It is therefore unlikely that such evidence will be found during construction phases. However, if shipwreck material is encountered then the Director of the Western Australian Maritime Museum has to be notified under the provisions of the two maritime acts.

Summary of previous research

The desktop survey found that previous research had identified six sites surveyed in 1991, an explosive magazine and a store by the sea jetty added but not located or surveyed in 1998 during research for a conservation plan.

The conservation plan identifies all the sites within the Ashburton North Strategic Industrial Area (SIA) as being part of a complex of exceptional significance with pertinent recommendations being:

- Retention and statutory protection
- Conservation and precinct management

- Interpretation
- Protection for vandalism

Of the eight sites noted in 1991 and 1998:

Site 1: Jetty no longer exists, metal detector evidence suggests up to three bolts or lower sections of jetty piles still exist under the sand.
Site 2: Telegraph poles – 8 standing poles and one fallen pole were located and the line route established.
Site 3: Small section of tramway no longer exists
Site 4: Small timber bridge no longer exists
Site 5: Small artefact midden may still exist but the tram wheel has been relocated
Site 6: Large timber bridge (1909) is still extant but located outside of Ashburton North SIA
Store: The likely site of the Clark's store by the jetty was identified
Magazine: It was identified that this site is likely to lie outside of Ashburton North SIA.

Current research results

A combination of survey techniques revealed a series of sites of low archaeological potential associated with pastoralism, remnants of the 1901 telegraph line and tramway and archaeological sites of considerable archaeological potential within the 1901 -1925 port area lying within Ashburton North SIA. They were variously assessed as being of considerable, some or little heritage value. The main area of the Old Onslow Townsite to the east of the industrial area still retains its exceptional significance status as an abandoned early frontier town dating from 1883 which contains a wealth of undisturbed archaeological sites.

Level of Significance

Exceptional
Main area of Old Onslow Townsite including 1879-1901 landing place and cemetery, all sites are located outside of Ashburton North SIA.

Considerable
1901-1925 Port Area: Area 7 (sites 1, 2, 6, 7, 8 & 9)
1901 Telegraph Poles & Anchor Points: Areas 4, 6 & 7
1901 Tramway Causeway: Areas 1, 1A, 2A & 3
1909 Large Timber Bridge, 1991 site 6: Located outside of Ashburton North SIA.

If located
Any artefact spread associated with 1901 jetty
Any historic shipwreck located within study area

Some
Telegraph Pole Anchor Point: Area 3

Little
Pastoral sites: Area 1 (sites 2, 3, 4), Areas 4, 6 & 9

Isolated finds: Areas 1, 1A, 2A, 2, 3, 6 and 7 (sites 3 & 4)

1901-1925 Port Area – Considerable Significance: Six areas with archaeological materials were located within the port area with most material associated with the store, tram stop and well. Cut out features, isolated artefacts and one artefact spread associated with a sand pad foundation were the only evidence found associated with the 1901 jetty, land backed wharf and warehouses. The jetty remanet photographed in 1991 is no longer extant and no evidence was found of the earlier unsuccessful 1897 jetty.

1901 Telegraph Poles & Anchor Points – Considerable Significance: Eight standing telegraph poles, one fallen pole and associated anchor points were located and mapped. All the evidence was located in the northern half of the study area. The line was found to run parallel to the tramway on its western side.

1901 Tramway – Considerable Significance: The actual route of the tramway between the 1909 timber bridge and the jetty site was mapped. It was found to largely run parallel to a 4WD track with some areas of route overlap. Areas of overlap were on areas of firmer ground where the tramway was constructed directly onto the sandy clay surface. This construction technique has resulted in very little evidence of the tramway surviving where it follows the same route as the current dirt track. However, areas 1A, 2A and Area 6 contain some sparse scattered artefacts on and beside the 4WD track.

Where the tramway route is located off the current dirt track it mainly runs across softer ground and is consequently raised on an earthen causeway. There is much more evidence of the tramway surviving on sections of causeway with the most obvious evidence being metal objects such as railway spike and iron straps.

There appears to be no evidence left of timber sleepers and tram rails except where the odd tram rail survives in a secondary use as a fence post. It should be noted that the tramway route does not follow the HCWA reserve corridor at the northern end of the corridor.

1909 Large Timber Bridge – Considerable Significance: The central section of this bridge is still standing however, both end sections have been considerably damaged since 1991. It is situated in a tidal flat to the east of the Ashburton North SIA.

Seabed materials – Considerable Significance: Historic and survey evidence suggest that there is little likelihood of historic shipwrecks being located within the study area. There is a stronger possibility of a seabed spread of artefactual material associated with the use of the 1901-1925 sea jetty.

Pastoral sites– Little Significance: This new research has identified a series of crop marks within four areas along the tramway. The majority of crop marks were rectangular and where they could be identified on site were marked by squared bare areas of vegetation or vegetation growing in straight lines and right angles. They were associated with little surface or sub surface artefactual material and therefore have a low archaeological potential.

Impact of proposed Project plans on European heritage sites

The Project plans supplied for the purpose of this report (Figs. 45 and 46) show that there is proposed construction impact on part, or all, of the heritage registered curtilage which falls within Ashburton North SIA. The proposed construction will either destroy or bury archaeological sites within the area. These sites have been previously assessed as being of exceptional significance with conservation policies aimed at conservation of their heritage values which are incompatible with such a level of impact.

However, these previous assessments of significance and conservation plan policies were based on old and inadequate knowledge. Recent inspections for this report determined that key features recorded in 1991 are no longer extant and defined the exact extent of surviving material within the delineated industrial area. Sites associated with the 1901 jetty, tramway and telegraph line have been reassessed as being of considerable significance with pastoral sites within the area being of little significance.

Impacts to European heritage will occur as a result of Wheatstone Project activities and are unavoidable under the present Project design. The impact will not be to the Old Onslow town site heritage area itself, but to the archaeological heritage of the 1901 to 1925 sea jetty and port, and associated tramway and telegraph line.

Chevron Australia proposes to manage all impacts on European heritage through a Wheatstone European Heritage Mitigation Strategies document (EHMS) the provisions of which will be prepared in consultation with HCWA the Shire of Ashburton and the Western Australian Maritime Museum.

The EHMS should be divided into two sections, one dealing with mitigation of direct development impacts on the heritage of the Old Onslow Township registered place including the seabed component of the maritime heritage. The second section should deal with offset measures to ensure that the loss of *in situ* heritage is balanced with measures designed to enhance the heritage of the Old Onslow Township registered place and help promote heritage tourism within the shire.

WHEATSTONE PROJECT: EUROPEAN HERITAGE IMPACT PROJECT ARCHAEOLOGICAL AND HISTORICAL SURVEY

INTRODUCTION

This archaeological survey is the second stage of a larger project to identify possible impacts of the Wheatstone Project on European heritage. The Old Onslow Townsite, which is a registered European heritage site, is located near to a possible location for the Wheatstone Project. Part of the registered curtilage is contained within the area of interest to Chevron Australia.

The archaeological survey report combines the first stage desktop and aerial photographic analysis information with archaeological site survey information and metal detector site survey information to draw together all the strands of research so far to determine the location of archaeological features and deposits within the study area and assess their level of significance.

The report will also undertake a preliminary assessment of development plans, as currently proposed, to determine likely impacts for forward planning purposes.

An onsite archaeological inspection to locate visible archaeological features and archaeological deposits was undertaken on the 18 and 19th of December 2008. Archaeological deposits are sediments that contain the remains of structures, other man made features, artefacts or ecofacts.

The survey was assisted by aerial photographic analysis undertaken using imagery from Google Earth. While Google Earth imagery is not ideal for the task it proved to have a better resolution than imagery currently able to be supplied by Chevron Australia. However the size of pixels in the Google imagery meant that features look more regular and manmade then they might have with better resolution. The aerial photographic analysis therefore picked up a number of features which proved not to be manmade when examined in the field.

Initial analysis of crop marks visible in the Google Earth images indicated eight areas of interest along the tramway and at the jetty site (Fig. 1). Possible building sites and activity areas indicated by crop marks within these areas of interest were marked on A4 sized printouts for use in the physical site survey. All possible sites suggested by the aerial photographic analysis were inspected during the physical survey.

Chevron Australia has also undertaken a marine survey and a geophysical survey of the area. Analysis of the marine survey results was provided by Anthony Bougher on 3 February 2009. Land based geophysical methods undertaken by Chevron Australia proved to be too coarse for archaeological purposes therefore a metal detector survey was undertaken on the 22 July 2009 across all identified places of interest. This information was then added to that from aerial analysis, site survey and the marine survey to provide four strands of evidence to identify the location of archaeological sites and deposits associated with the Old Onslow tramway and jetty area.

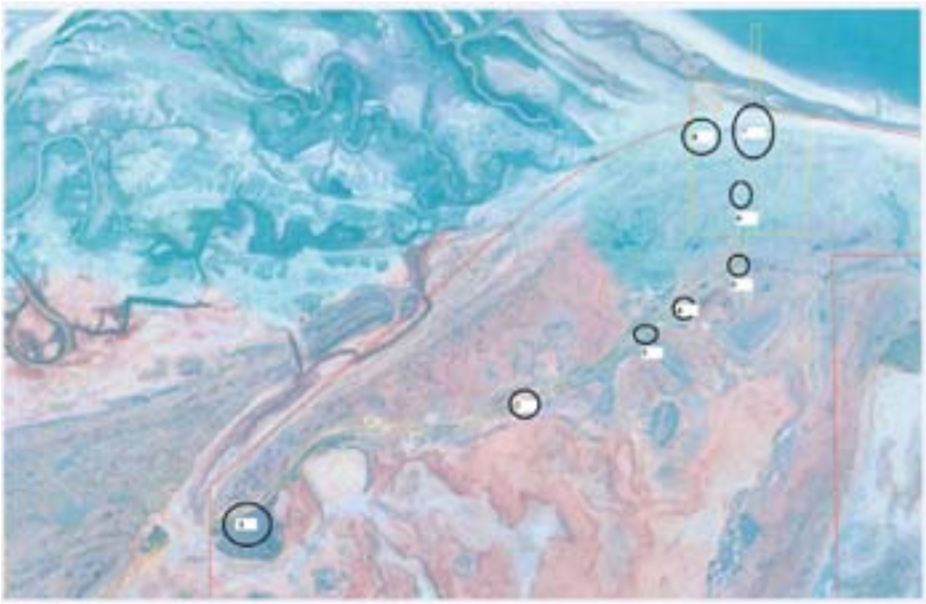

Figure 1: Location plan for areas of interest found during aerial photographic analysis

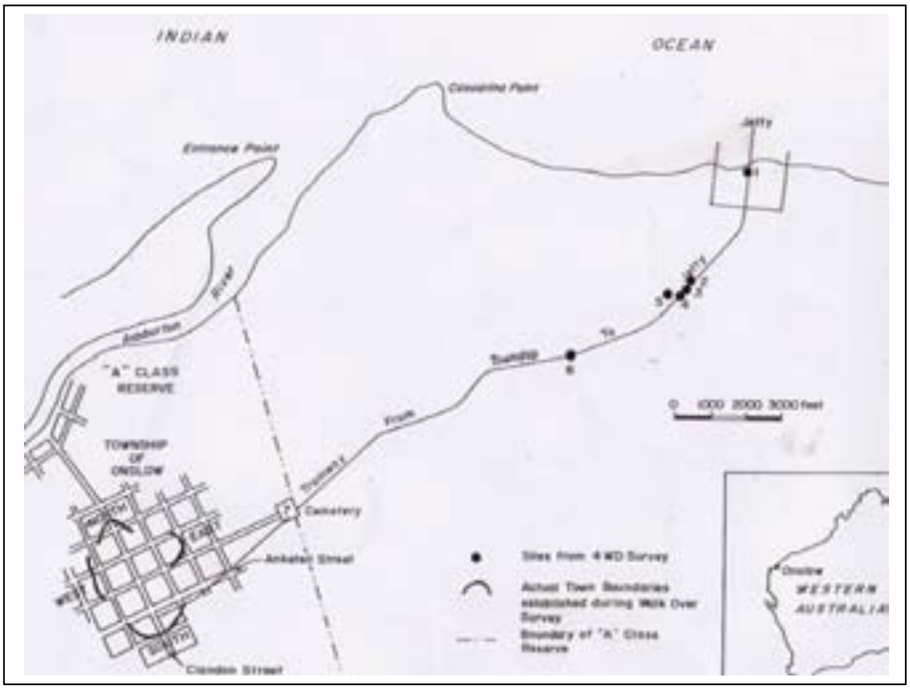

Figure 2: Site Location plan (Nayton 1991, page 45) showing sites outside of Old Onslow

Wheatstone Project: European Heritage Impact Project Archaeological and Historical Survey

Gaye Nayton, Heritage Archaeologist

Review of Heritage Documents

Under the *Heritage of Western Australia Act 1990* HCWA is charged with registering and protecting the heritage values of significant European heritage sites within Western Australia.

The Old Onslow Townsite is registered as place 3444 on the Western Australian Register of Heritage Places under the *Heritage of Western Australia Act 1990*. The registered area consists of a town site area, the line of a former tramway, telegraph line and a 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 which was compiled under the direction of the *Heritage of Western Australia Act 1990.*

The tramway, telegraph line and jetty sites fall within areas of interest to Chevron Australia, however the 'A' class reserve which contains both the Old Onslow Townsite and Old Onslow Cemetery falls outside of the Ashburton North SIA.

There are two previous reports on European heritage sites within the areas of interest to Chevron Australia. These reports are:

Nayton G. 1991 An archaeological survey of Cossack and Old Onslow. Report for the Heritage Council of Western Australia

Jean, Bosworth, Goulder and Hayes 1998 Old Onslow Townsite, Pilbara, Western Australia: A Conservation Plan. Report for the Shire of Ashburton and Heritage Council of Western Australian in conjunction with the Australian Heritage Commission

Both reports were reviewed for the desktop survey, of pertinence to this study is that the earlier archaeological study identified six sites within the area of Ashburton North SIA (Fig. 2) 2 to 5 of which cluster in areas 3, 4 and 5 within Figure 1 showing areas of possible archaeological interest identified during aerial photographic analysis.

The six sites were:

Site 1: Jetty
Site 2: Telegraph poles
Site 3: Small section of tramway with wooden sleepers and iron bolts still in place.
Site 4: Small Timber Bridge
Site 5: Small artefact midden
Site 6: Large Timber Bridge

The conservation plan for the Old Onslow Townsite (Jean, Bosworth, Goulder and Hayes 1998) identified the archaeological area of Ashburton North as zone 8. Eight sites were noted which consisted of the six sites identified in the earlier report (Nayton 1991) and a store by the sea jetty and a magazine, thought to lie outside of the area of Ashburton North SIA. Neither of these two extra sites were located or surveyed for the conservation plan report.

Conservation polices developed for all the identified sites were the same being:

- Retention and statutory protection
- Conservation and precinct management
- Interpretation
- Registration at state and national levels
- Protection for vandalism

However the conservation plan further assesses all the sites in zone 8, along with all the sites in the Old Onslow Townsite, as being part of a complex of exceptional significance. This assessment also extends to each site individually.

It was noticeable that while the conservation plan contains some historical photographs it does not contain any historical plans showing the route and location of features along the tramway or at the sea jetty. Therefore the on-line archives of the Battye Library and State Archives were searched for documents that might pertain to these features during the compilation of the desktop report. Several plans from the state archives were visually inspected; however no plans showing the tramway route or details or the jetty and other structures at the jetty location were located.

Short contextual history of Old Onslow

In 1863 the first European settlement of the Northwest occurred. This settlement was centred on the Harding River. Early colonization of the attempts at Camden Harbor, Roebuck Bay and the De Grey River during 1863/1864 and the Ashburton River in 1866 were not successful and the settlement frontier contracted back to the Fortescue, Maitland, Harding and Sherlock rivers.

The northwest settlement frontier was based on pastoralism with sheep grown for their wool the dominant crop. There were several unsuccessful attempts to establish a second viable staple and eventually pearl shell was gathered and exported setting off a 'pearling rush' in 1867/1868. This transformed the settlement frontier from a marginal area with a very small population to a successful settlement area. With this success the settlement frontier consolidated then expanded into new areas with the successful colonisation of the Ashburton River in 1879 being the first move out of the original area. By 1883 there were one hundred and six pastoral leases within the Ashburton area with many of the settlers also being listed as early pearling masters.

Goods were imported and exported out of the Ashburton region through the Ashburton River but there were no facilities at the landing place until a goods shed was built by pastoralists which was passed on to Clarke and McKenzie, the first residents in Old Onslow, in 1883. By 1884 they had constructed a house and had a license to sell liquor. In 1885 the Northwest telegraph line reached the area and town lots were laid out and a telegraph station and timber wharf at the river landing built.

Between 1885 and 1897 the size of coastal trading vessels gradually increased causing them problems travelling down the Ashburton River to access the river landing. This led to attempts to construct a sea jetty and connecting tram line in 1897 but the first jetty was destroyed before completion. A sea jetty was later successfully built nearer the river mouth and it was opened in 1901. The tramway to the jetty was built by prisoner chain gangs which consisted of mainly Aboriginal prisoners. The sea jetty was not very functionally successful with silting being a major problem so a new jetty was built at Beadon Creek. Then, over the period 1923 to 1927, buildings from old Onslow were relocated to Beadon Creek. This site became the current town of Onslow.

History of tramway and jetties

The chronology below sets the tramway and sea jetty within the major chronological events associated with the town.

1863: First European settlement of the Northwest
1879: First successful colonisation of the Ashburton River by colonial pastoralists
1883: Clark and McKenzie establish a store and liquor outlet by river landing
1885: Northwest telegraph line reached site and town lots laid out
1897: Commencement of new sea jetty which was destroyed before it was finished
1901: Opening of new sea jetty designed by C Y O'Connor and tramway built by convict chain gangs
1923-1927: Buildings moved to Beadon Creek and new sea jetty built
Source: Jean, Bosworth, Goulder and Hayes 1998

The tramway and sea jetty located within Chevron's area of interest therefore functioned as the town's port for the last 22 years of the life of the Old Onslow Townsite. The tramway is approximately 4 km long and was built in 1897 and 1899-1901 to connect Old Onslow Townsite to the sea jetties built at the same time.

It ran alongside and occasionally over areas of tidal flats with physical on-site evidence suggesting it required at least two timber bridges to be built to carry sections of tramway over tidal flats or gullies. Physical on site evidence indicates that in other low lying areas the tramway bed was built up to form a causeway proud of the ground surface. The 2 foot gauge track was for horse drawn trams (Fig.3) and was constructed of timber sleepers and narrow iron rails. In 1909 eight chains (approximately 161 metres) of the tramway causeway was destroyed by a cyclone prompting replacement of that section of track with a large timber bridge. This bridge is thought to be the larger of the two bridges still extant in 1991 (Fig. 4).

Two sea jetties were built but only one was used as the earlier of the two was destroyed by a cyclone before it was opened. The second jetty built 1899-1901 can be seen in an historic photograph (Fig. 5) as consisting of a raised timber land backed wharf set into a dune area on which was located a warehouse or shed. The timber jetty extended out from the wharf at a point just north of the warehouse/shed. Further details cannot be seen in the historic photograph. A remnant of the jetty was located on the beach in 1991 (Fig. 6). It was constructed of large jarrah timbers 50 cm thick and 3 metres high.

There is also historical evidence of a large store in the jetty area connected to the town via a telegraph line (Fig. 7). The historical photograph clearly shows the store lying alongside the telegraph line within an area of flat land. It is not clear from the

Figure 3 Historic photograph of horse drawn tram in 1901

Source: Jean, Bosworth, Goulder and Hayes 1998, Page 73

Figure 4 1991 photograph of large timber bridge over tidal flats

Source: Nayton 1991, Page 83

Figure 5 Historic photograph of sea jetty showing timber platform in dune system

Source: Jean, Bosworth, Goulder and Hayes 1998, Page 71

Figure 6 Two views of jetty remnant; one showing location to dune system

Source: Nayton 1991 survey; unpublished photographs

Figure 7 Historic photograph of store and telegraph line

Source: Jean, Bosworth, Goulder and Hayes 1998, Page 72

Figure 8 Photographs of telegraph line in 1991

Source: Nayton 1991, page 80 and unpublished survey photograph

photograph if the telegraph line extended beyond the store. Evidence of the telegraph line was found in the jetty area in 1991 (Fig.8).

The 1998 conservation plan also cites the location of a magazine within zone 8 but as this was noted on a town plan this feature would be located in the portion of zone 8 near the town which is outside of Ashburton North SIA.

ANALYSIS OF AERIAL PHOTOGRAPHIC INFORMATION

Aerial photographic information was initially supplied to the consultant by Chevron Australia; however, it was at too large a scale for use in aerial photographic analysis of archaeological sites. Therefore images from Google Earth were utilized to provide information for the geophysical and archaeological surveys.

On aerial photographs sites can be located through the visible presence of ruined structures or through the presence of crop marks. Crop marks are places where the vegetation grows differently because the soil conditions in that place are different to those outside the crop mark. The presence of crop marks with geometric shapes such as rectangles, squares and circles are particularly suggestive of human activity. However the size of pixels within the Google Earth imagery meant a general squaring of details which made the aerial analysis less reliable than if undertaken with a photograph with higher resolution.

Prior to field work the whole tramway and jetty area within the Ashburton North SIA was scrutinised and eight areas of possible historic activity located. Each area was quickly studied to provide field maps and initial analysis for the desktop survey. Possible archaeological sites marked in white for easy identification both in report format and in the field. Print outs of each area with sites marked were taken into the field to assist the archaeological survey.

ARCHAEOLOGICAL SURVEY AND METAL DETECTOR SURVEY

An onsite archaeological inspection to locate visible archaeological features and archaeological deposits was undertaken on the 18^{th} and 19^{th} of December 2008. The survey was assisted by aerial photographic analysis undertaken using imagery from Google Earth. The analysis indicated eight areas of crop marks indicating foundations or activity areas, with six areas noted along the tramway and two areas within the jetty port area. All eight areas were inspected during the physical survey.

There was a difference in site conditions between the day the aerial was taken, which was in June winter conditions, and the day the survey was undertaken in December summer conditions. In the aerial the sites are visible as green forms within a sea of vegetation. On the ground they were visible largely as squared bare areas with some evidence of Spinifex growing in straight lines and right angles.

The survey also searched for the six sites located in 1991 to assess their current condition and attempted to locate the store site highlighted in the 1998 conservation plan (Jean, Bosworth, Goulder and Hayes 1998).


Figure 9 1991 and 2008 photographs of 1909 timber bridge

Looking west

Figure 10 Close up view 2008

Orientation of bridge

Figure 11 View from 4WD track

Bridge

Orientation of bridge

Evidence of tram tracks on raised causeway

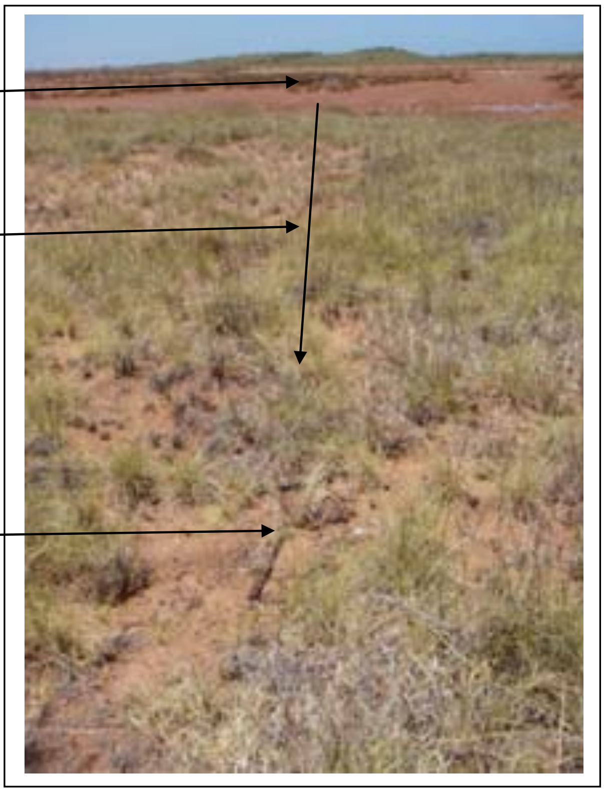

Figure 12 View of bridge from section of raised tramway causeway south of 4WD track

As few possible sites had visible evidence of artefacts in July 2009 the onsite survey was completed with a metal detector survey. All sites noted in December 2008 were tested to see if they contained buried cultural material in the form of metal, the most common material on historical period sites. GPS readings were taken of sites with positive results. Results of both surveys are detailed below in sequence starting at the southern boundary of Ashburton North SIA and moving north and eastwards to the 1901 jetty area.

1991 Site 6: 1909 large timber bridge

This timber structure is still extant and forms the largest visible remanet of the tramway. It lies just outside of the boundaries of Ashburton North SIA within an extensive area of tidal flats subject to frequent flooding. The 1991 view of the bridge (Fig 9) and the 2008 close up view of the structure (Fig. 10) are both taken from the Old Onslow Townsite side of the tidal flats looking east towards the Ashburton North SIA. Comparison between these 1991 and 2008 photographs (Figs. 9 & 10) indicates that there is no decking and few cross timbers still extant in 2008 and much of the flanking lines of uprights are now missing. The evidence for the cross supports extending out from the flanking line of uprights at the Old Onslow end of the bridge is also now missing. It appears that both ends of the bridge have been washed away with only a central portion situated within the tidal flat still extant. The bridge is not oriented towards the current 4WD track running between Old Onslow Townsite and the jetty area as shown in Figure 11. It is orientated to a section of raised causeway for the tramway located to the south of the 4WD track (Fig. 12) in Area 1.

2008 Area 1: Possible camp sites near 1909 bridge

Area 1 is an area of slightly higher ground to the east of the 1909 bridge and the large area of tidal flats. Aerial photographic analysis indicated that this might be an area of human activity, possibly being the location of a construction camp for the bridge or a camping spot for stockmen taking sheep to and from the jetty. Not all the features noted during the aerial photographic analysis could be located during the 2008 survey, others were not visibly convincing. However four sites were located (Fig 13 and Fig. 20).

Site 1-Tramway section

GPS 290022, 7598762 +- 3 m

Site 1 was a section of raised causeway with iron fish plates and railway spikes scattered along its length (Fig. 12 & 13) that was located south of the 4WD track. The causeway was orientated to the 1909 bridge and joined the 4WD track at a point halfway across the peninsula of higher ground which forms Area 1. The feature was 197 metres long and was located between 13 and 19 metres south of the 4WD track. This section of tramway was not located in either 1991 or 1998.

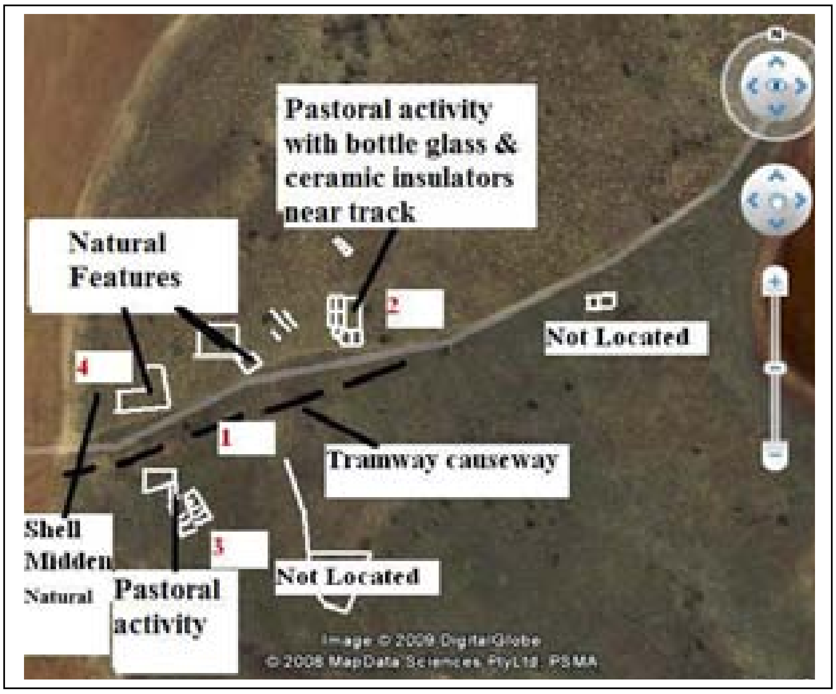

Figure 13 Area 1 physical survey results

Site 2- Pastoral activity: possibly temporary stock pen or tent location

Site 2 was a set of rectangular crop marks located between 0-26 metres to the north of the 4WD track that are currently noticeable on the ground as a large squared area of bare ground with a very sparse scatter of 19th century glass associated with it. The most visual of the set of crop marks within the aerial photograph is a feature approximately 10 metres long by 7 metres wide divided internally into four sections or rooms. The size and internal divisions of this crop mark are strongly suggestive of a building foundation. Other fainter crop marks around the main set could be from an adjacent yard and activity areas. This area was tested with the metal detector and produced few signals. This does not suggest a building site or even a temporary stock structure built of post and fencing materials. The feature could be the result of other temporary structures such as tents or bush timber and twine based stock folds but if so the evidence does not indicate frequent use.

On the section of track adjacent to the feature a broken ceramic insulator from the telegraph line was found. The feature is close to where the tramway and 4WD track converge and is likely to denote where a section of the telegraph line converges with the current 4WD track.

Site 3 – Pastoral activity: probably stock pens

GPS 290022, 7598762 + - 3 m

Site 3 is a set of crop marks located between 21 and 57 metres south of the 4 WD track. The top of the features is approximately 12 metres south of the tramway (Site 1). The site is a complex of crop marks all of which are not on the same alignment. There are two, possibly one large, rectangular crop marks aligned to the northwest with internal divisions suggestive of one or two building foundations close together measuring 13 by 5 and 14 by 4 metres. Adjacent to the north is a third rectangular area orientated to the north east which could be a yard feature with another at a different orientation further north. On the ground at least part of this complex was visible as squared bare areas but no artefact were visible in association. The metal detector survey indicated that this was a site associated with a sparse scatter of metals however the signals were not dense and did not suggest a permanent structure or long term or frequent occupation. Given this signature the features are unlikely to be the result of a construction camp; they are more likely to be the result of pastoral activities such as stock pens.

To the southeast of this site was a large crop mark suggestive of a corral which could not be located during the survey.

Site 4- Crop mark and possible shell midden

The area of site 4 was inspected for traces of two sets of crop marks suggestive of building foundations. Bare areas were located but their shape was not convincing as evidence of foundations the area also did not return any signals during the metal detector survey. This crop mark is not considered to be from historic activity.

A shell midden was identified north of the 4WD track above the tidal flats. Some older glass was located near to the 4WD track but no historic artefacts were definitely associated with the midden. There were also no visible indigenous artefacts such as stone tools therefore it is likely that this midden is the result of natural processes.

2008 Area 1 A: Tramway and isolated fines or features

The physical survey identified a series of isolated fines and features between Area 1 and 2 within this area the tramway could also be identified. The finds and features were vaguely grouped with one set being closer to Area 1 and the other closer to Area 2. The two groups were numbered 1A (Fig.20) and 2A (Fig. 19). The tramway run north of the of the 4WD track for most of Area 1A but crossed the track to run to the south just after a point where a tram rail and straps were found *in situ* to the west and at a point where metal was found on the 4WD track to the east. In Area 2A the tramway rans to the south of the 4WD track. Isolated finds were not revisited during the metal detector survey.

The location of features within Area 1 and Area 1A are shown in Figure 15. In order from Area 1 northeast along the 4WD track the finds in Area 1 consisted of:

Cut landform: Where the tramway track to the south of the 4WD track rejoined the 4WD route both features went through a sand dune via a cutting (Fig. 14). The section of tramway associated with the 4WD track was not raised and there is little evidence left of the tramway between this point and the section south of the 4WD track in Area 1.

Tramway rail and iron straps *in situ*: These finds (Fig. 15) were located immediately to the north of the 4WD track at a point where the tramway crossed the track to run to the north of the track.

Metal scattered on 4WD track: These metal fragments were found on the 4WD track where the tramway crossed the track from north to south. Tramway continues south of 4WD drive track Area 2A.

Bottle glass: Base fragment from a pre 1930 bottle.

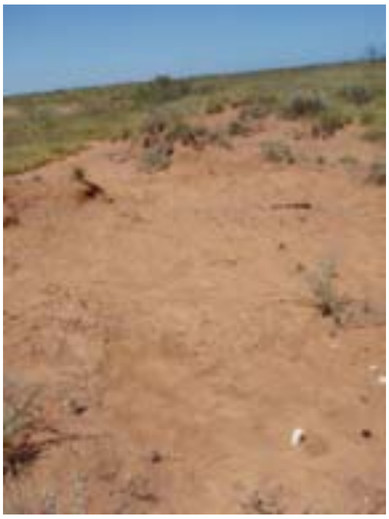

Figure 14 Cutting through sand dune

Figure 15 Metal straps and tram rail *in situ*

Figure 16 Metal fragments on 4 WD track

Figure 17 Timber sleeper on 4WD track

Figure 18 Scatter of metal sheet fragments on tramway causeway

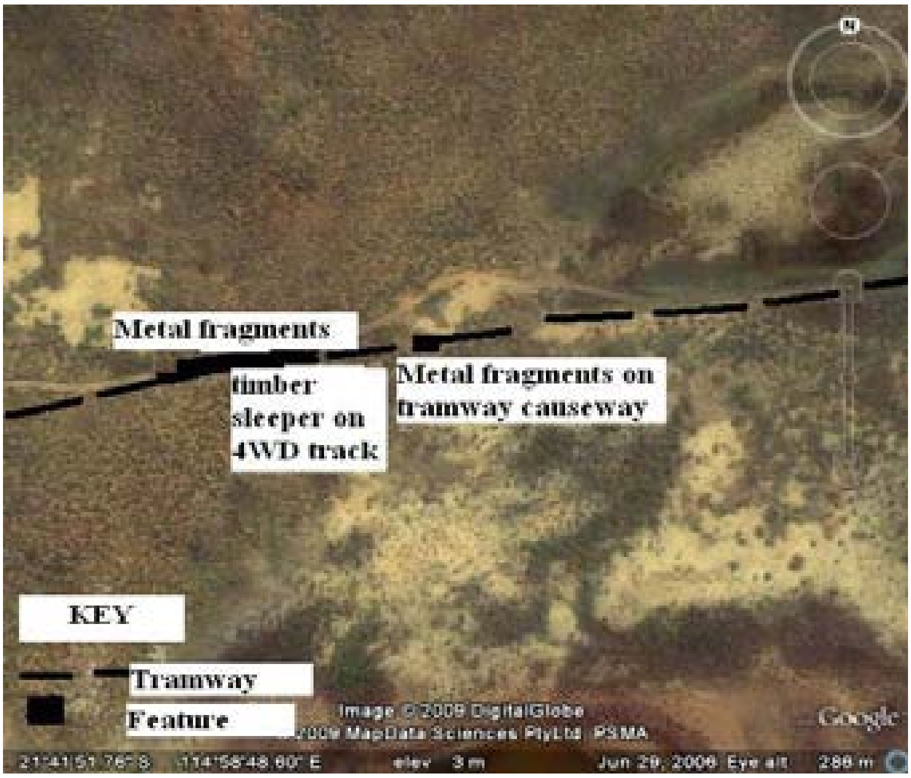

Figure 19 The location of features within area 2A

2008 Area 2A: Tramway and isolated fines or features

Metal scattered on 4WD track: For a distance of approximately 21 metres where the tramway and track converge (Fig. 16). The tramway then runs south of the track for a distance of 208 metres approximately.

Timber sleeper on 4WD track: Degraded fragment of tramway sleeper (Fig. 17) where tramway and 4WD track follow the same route for 21 metres.

Tramway causeway with metal scatter: In Area 2A the tramway runs straight over an area of lower ground on a raised causeway while the 4WD track bends to the north to go around the low area. There are scattered metal tramway related artefacts such as rail spikes on the causeway and a small dense scatter of metal sheet fragments (Fig. 18).

Tram rail used for fence post: One tram rail was found embedded in an upright position as part of an old fence line just to the north of the 4WD track at a point approximately 165 metres east of where the two tracks converge (Fig.21).

Figure 20 Areas 1 and 1A

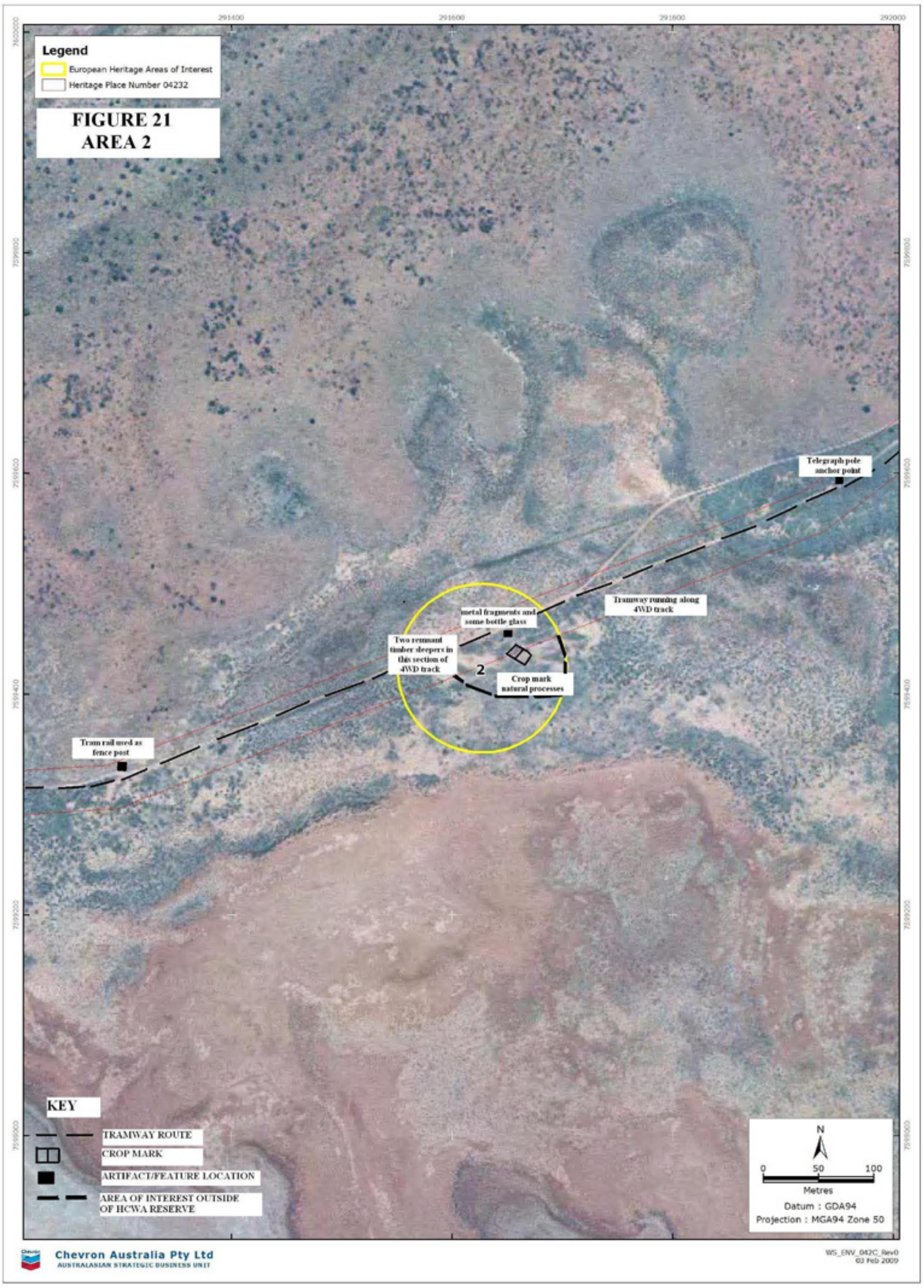

Figure 21 Area 2

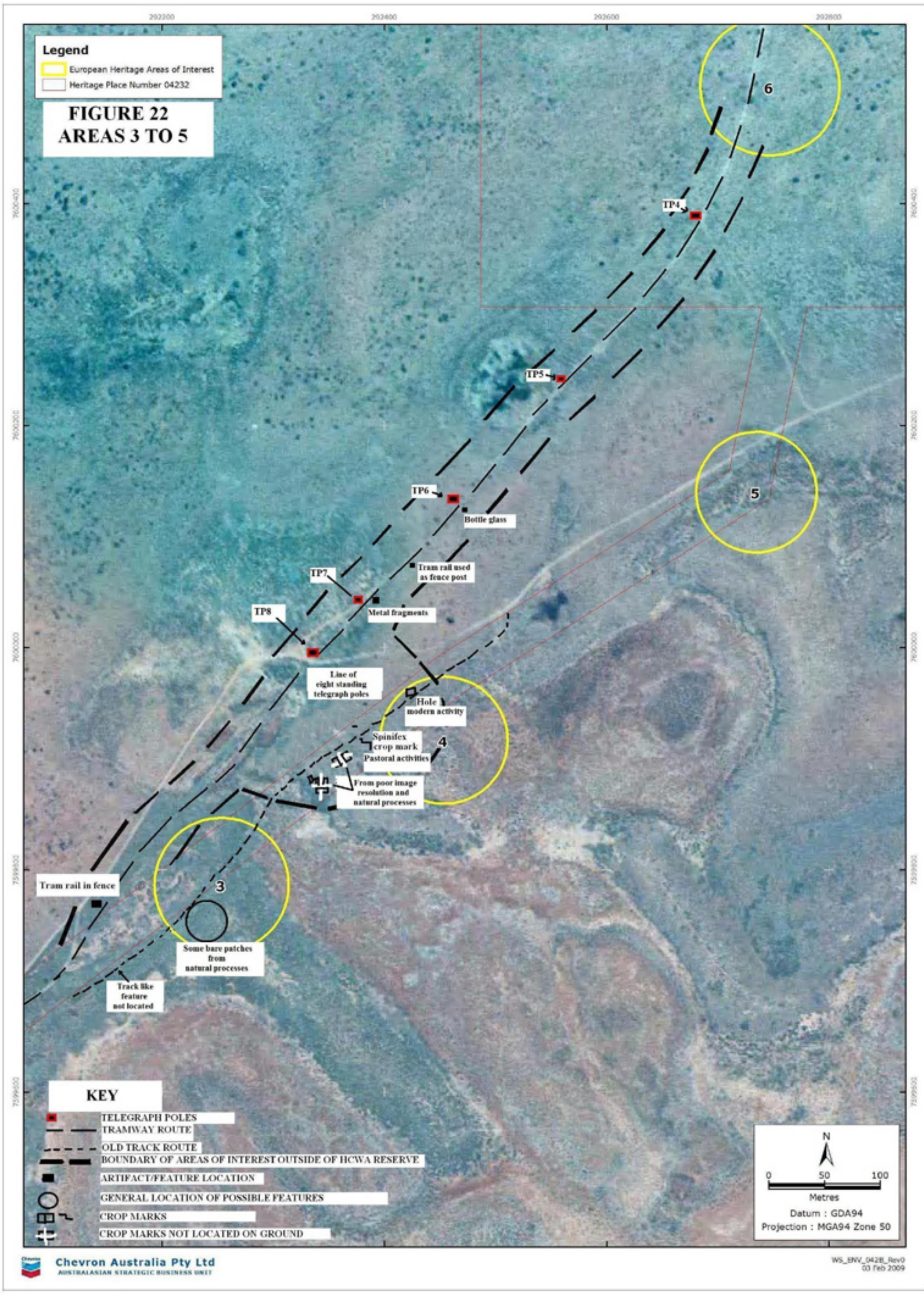

Figure 22 Areas 3 to 5

2008 Area 2: Isolated finds

In Area 2 the current 4WD track follows the route of the tramway except for a slight deviation near the western end of Figure 20. Over this section of its route the tramway was not raised on a causeway but run level with the ground surface except for short distances before and after the 4WD deviation around a low lying area. Consequently most of the evidence for the tramway has been destroyed within this area. Two remnants of timber sleepers were however found across the 4WD track in this section. A tram rail embedded upright to form a fence post within an old fence line was also located to the north of the track just before the deviation of routes.

Two sets of possible crop marks were located by aerial analysis in Area 2. The set located just to the north of the current 4WD track could not be physically located during the survey. This area also did not record any signals during the metal detector survey and any crop marks in this area are thought to be the result of natural processes.

The set located just to the south of the 4WD track were located as patches of bare ground within a fairly low lying area of sandy soils located just outside of the HCWA reserve. This area also did not return any signals during the metal detector survey and any crop marks are thought to be the result of natural processes.

Fragments of sheet metal and some shards of older bottle glass were located in this area near the 4WD track. They should be treated as isolated finds rather than sites.

At the eastern edge of Figure 21 an anchor point for a telegraph pole was located.

2008 Area 3: Tramway and crop marks

In Area 3 the route of the tramway diverges markedly from the HCWA registered corridor. The corridor runs to the northeast before turning abruptly towards the former jetty location. The tramway and associated telegraph line run NNE and enter the HCWA registered jetty area closer to its south western corner then the registered corridor (Fig. 22). Both tramway and telegraph line follow the northern branch of the 4WD track which starts in Area 4, but through Area 3 both mostly lie to the south of the track. An anchor point for the telegraph line was located between areas 2 and 3 at the point when the tramway and telegraph line diverge from the HCWA reserve (Fig. 21).

In the area to the west of Area 3 the tramway continues to follow the southern branch of the 4WD tracks, a course it had followed through Area 2. The tramway and 4WD track diverge at the point where the southern track veers north to rejoin the northern track. The tramway then runs south of the track on a causeway (Fig. 23) until the 4WD track branches again in Area 4. The causeway is on the same general alignment as the remaining telegraph poles which can be seen in the distance in Figure 23. The causeway is well defined in this area and is scattered with metal objects which relate to the tramway function (Fig. 24). A second tram rail set upright as part of an old fence line is located between the tramway and the 4WD track (Fig. 25).

Aerial photographic analysis indicated the possibility of a set of three foundations grouped together to the south of the physical location of the tramway and track. The analysis also indicated the presence of a linear feature close to the foundations that was interpreted as the possible location of the tramway. Inspection of the area revealed some squared bare areas in that general location which may relate to the crop marks seen in the aerial. The features were not definite and did not produce as definite an outline as the crop marks analysis indicated. The linear feature was not obvious on site and there were no visible artefacts associated with the crop marks. The metal detector survey returned no signals from this area therefore any crop marks are thought to be the result of natural processes.

2008 Area 4: Tramway, telegraph line and foundation

GPS Spinifex & foundation 0292405, 7599945 +- 4 m

Area 4 is also the locations of Sites 2 - 5 located during the 1991 archaeological survey. The present survey therefore searched for these sites as well as the crop marks noted during aerial photographic analysis. The 1991 sites were:
Site 2: Telegraph poles
Site 3: Small section of tramway with wooden sleepers and iron bolts still in place.
Site 4: Small Timber Bridge
Site 5: Small artefact midden
(Figs. 26 – 30)

As noted above, the first evidence of the telegraph line was located to the east of area 2, in the form of a telegraph pole anchor point in the western section of Area 2. In Area 4 the 4WD track branches into a northern and eastern branch with the eastern branch having a second spur further to the east which joins up with the northern branch to approach the jetty site (Fig.22). The alignment of the HCWA curtilage generally follows the route of the eastern branch and its northern spur while the northern branch of the 4WD track follows the route of the telegraph line and tramway.

There are eight standing telegraph poles (Figs. 29 & 30) and evidence of telegraph pole bases (Fig. 31), anchor points and a fallen pole between the branch of the 4WD track into a northern and eastern route and the former jetty site. The poles align to the west of the northern branch of the 4WD track and the track itself follows the former route of the tramway. The line of poles starts at the crossroads formed by the northern and eastern 4WD tracks and end at the store site near the former jetty.

The GPS locations of extant telegraph poles were recorded by GPS. They were number one to eight from the jetty site to the crossroads with TP1 being located near the former store site. GPS locations were:

TP1: 0292745, 7600733 +- 4 m
TP2: 0292739, 7600655 +- 3 m
TP 3: 0292732, 7600574 +- 3 m
TP4: 0292654, 7600354 +- 4 m
TP5: 0292497, 700173 +- 3 m
TP6: 0292445, 7600111 +- 3 m
TP7: 0292387, 760052 +- 4 m
TP8: 0292334, 759993 +- 3 m

Figure 23 Tramway causeway

Figure 24 Metal artefacts on causeway

Figure 25 Tram rail used as fence post

Figure 26 1991 site 3 - Tramway

Figure 27 1991 site 4 - Small bridge

Figure 28 1991 site 5 – Midden

Figure 29 1991 site 2 – Telegraph poles

Figure 30 1991 and 2008 photographs of telegraph poles

Figure 31 Telegraph pole base

Figure 32 Area 4 Spinifex plants growing in right angles

The tramway was not raised on a causeway through this section and consequently there is very little evidence left of it. The evidence consists of the occasional railway spike, iron strap with bolts or loose bolts. During the metal detector survey a further area of metal fragments from the tramway was noted to the east of the 4WD track near TP7, also a further metal tram track used as a fence post was located on the same side between TP7 and TP6 and bottle glass was also noted to the east of the 4WD track near TP6. This indicates that in this area the former tramway is only partly overlain by the 4WD track with the edge of the tramway lying to the east of the track.

No evidence was found of the 1991 sites 3 to 5. Figure 26 locates the site on the eastern branch of the 4WD track at the point where the tramway crosses this branch to follow the northern route. Timber sleepers and iron bolts are no longer extant at this point and this site no longer exists.

Figures 2 and 27 locate the small timber bridge on the tramway route but off the 4WD track to the southwest of sites 2 and 3. There is no longer any evidence of the bridge in this general location and it is likely that this feature no longer exists.

Site 5 the small midden with the tram wheel (Fig. 28) also could not be located. The tram wheel is no longer on site and is believed to have been moved by Shire of Ashburton officers to a place of safety in Onslow soon after the field trip in 1991. The wheel is missing from the site photograph taken for the conservation plan in 1998. The remaining midden was a small feature and is likely to have been missed during the current survey rather than the site having been removed since 1998.

Aerial photographic analysis indicated the presence of four sets of crop marks associated with the old track noted in area 3. The northern crop mark was caused by a square hole dug into the sandy clay soil. The second crop mark to the southwest of the first was caused by Spinifex plants which were growing in straight lines and right angles, measuring 2.5, 3, 5 and 4.25 metres (Figs. 22 & 32). This is not a natural growth pattern and would be caused by differences in the soils which are manmade.

Metal detector survey confirmed the presence of buried metal at the site indicating that this is likely to be the location of a small stock pen (GPS 0292405, 7599945. The last two crop marks could not be located during either survey are likely to be the result of natural processes.

2008 Area 5: No sites

No sites were located in Area 5 which is a long way to the east of the tramway and telegraph line location within the area of HCWA reserve which does not follow the tramway route.

2008 Area 6: Tramway, telegraph line and foundation

Aerial photographic analysis indicated that there was at least two crop marks within area 6 with the possibility of up to seven or eight (Figs. 33 & 36). The area lies to the north of telegraph pole 3 (TP 3) and between TP3 and an unnumbered fallen telegraph pole. The largest and most obvious crop mark spans the 4WD track (Fig. 34) which means it also spans the former tramway. The mark was noticeable on the ground as a large bare area which spanned the track, extending for eight metres on either side of the track and for 16 metres along the track. The bare area was associated with a fallen telegraph pole and anchor point near its south west corner (Fig. 35). The pole base was located 5 metres to the west of the former tramway with the anchor point located 3 metres from the tramway. The bare area was not associated with any visible artefacts except three railway spikes scattered on the 4WD track. The size of the feature suggests a stock yard and its location across the former tramway would suggest it is a later feature associated with pastoral activities in the area. It did not return any signals during the metal detector survey indicating that if it is a stock yard wire fencing was not used.

The area to the west of the track between the fallen telegraph pole and the previous pole to the south contained at least one other confirmed crop mark and several unconfirmed features none of which returned signals during the metal detector survey indicating that they are most likely the result of natural processes.

The track and features adjacent to it were surveyed between the fallen telegraph pole and TP3 to the south, a distance of approximately 84 metres (Fig.33). Features noted from north to south were:

35 m south, 8 m east: Tramway rail used as fence post.
37 m south: iron bolt
41 m south: railway spike & bolt
46 m south, 40 cm east: Two iron straps with bolts
65 m south: iron strap with bolt
65 m south, on west side of track: Bare squared patch indicating crop mark extending 11 m south at slight angle away from track x 9 m west. At the southeast corner of feature was a second squared bare patch measuring 3 x 2 metres. There were no visible artefacts associated with the features and they did not return signals during the metal detector survey.
84 m south, 7- 10 m west: Anchor point for telegraph pole at 7 m with standing pole (TP3) at 10 m west of track (Fig. 35).

2008 Area 7: Jetty area

Two surveys were carried out around the former jetty area, one by maritime consultants and the other by the archaeologist. The maritime consultants surveyed a transect from the high water mark to the low water mark at the site of the former jetty. They did not discover any jetty timber or other remnants within the intertidal zone or in the water close to the shoreline. They did note metal objects protruding from the seaward dune face. These artefacts were also noted during the archaeological survey (Fig. 38). The archaeological survey noted several cut or fill features within the dune system.

Site 1-Land backed wharf and jetty site

GPS 0292776, 7600870 +- 6 m

One of these (Site 1) was associated with the metal bolts protruding from the face of the dune produced by a large cut feature. The feature was a rectangular area cut away

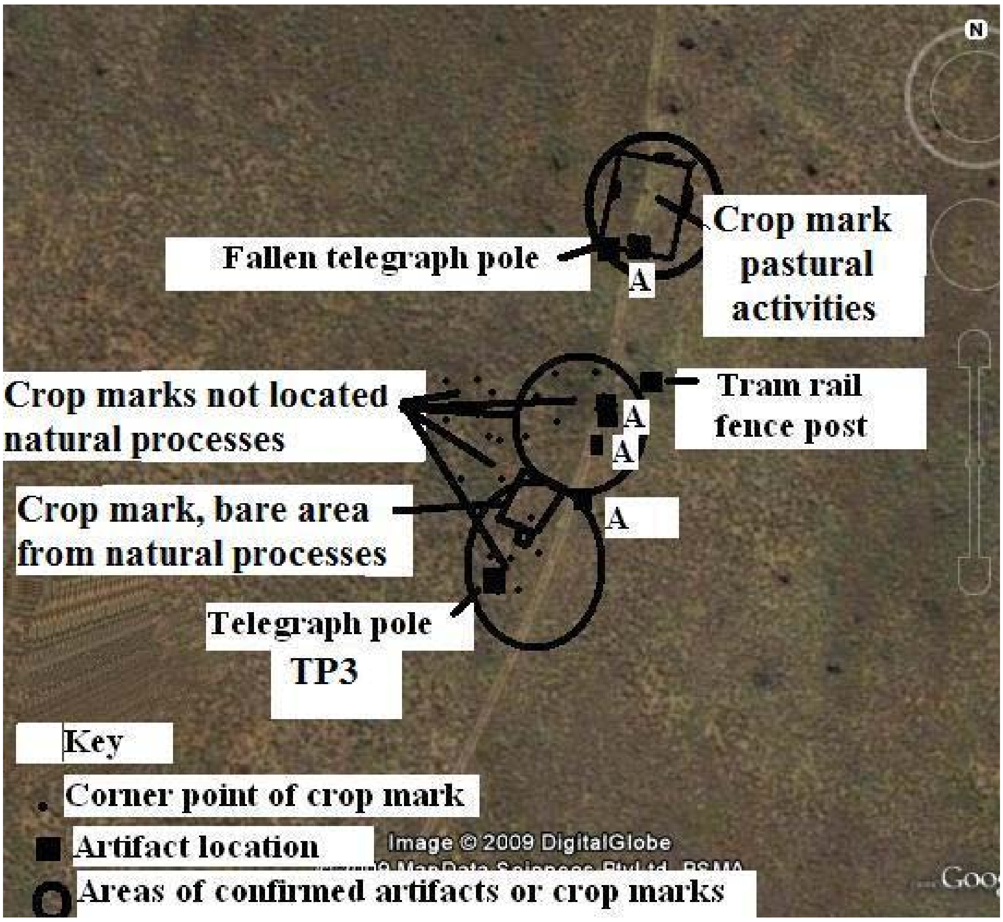

Figure 33 Archaeological features Area 6

Figure 34 Large crop mark Area 6

Figure 35 Fallen telegraph pole & anchor Area 6

Figure 36 Areas 6-8 in Jetty Area

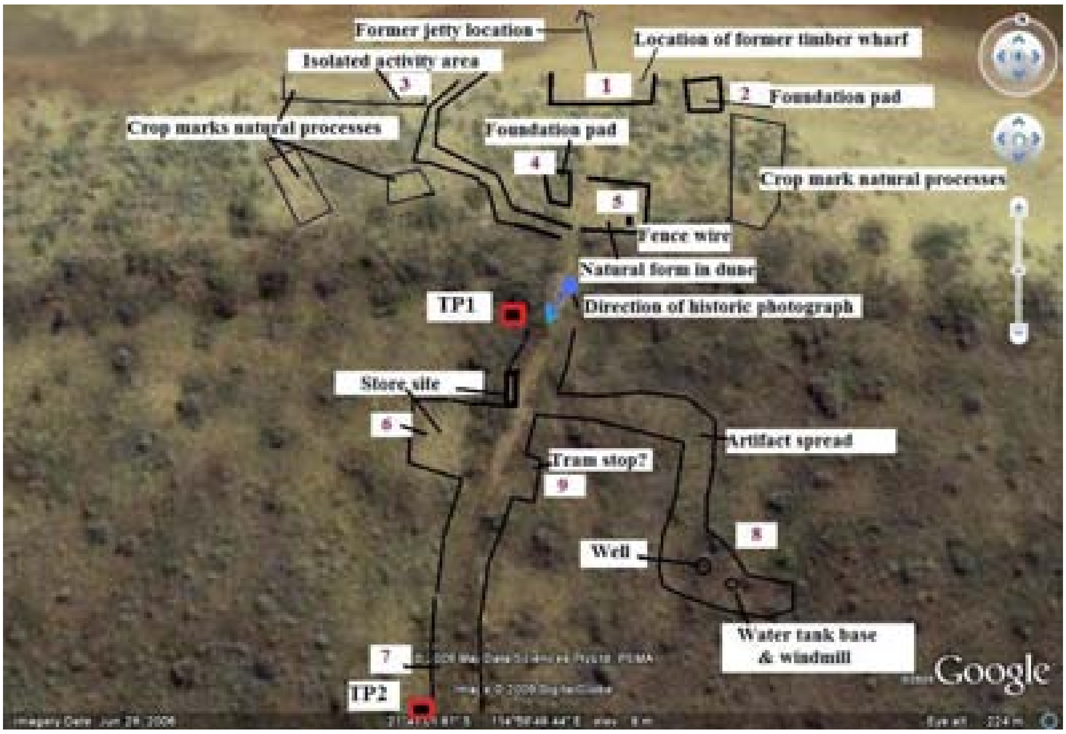

Figure 37 Area 7

Figure 38 Metal bolt protruding from face of dune at site 1

Figure 39 Site 1, cut land associated with land backed

Figure 40 Site of jetty and land backed wharf

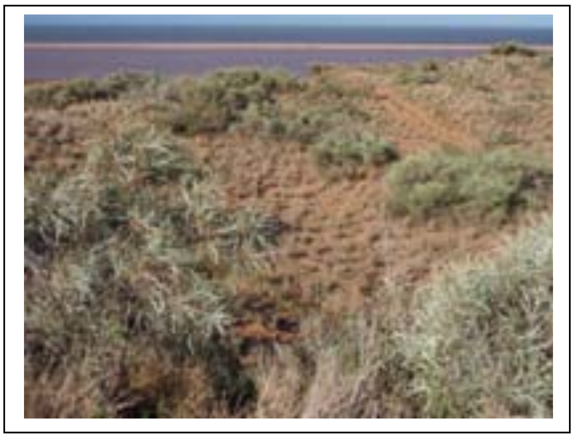

Figure 41 Overview of site 4, path, tramway end and rear of site 3

Figure 42 Concrete pad, part of site 6

from the seaward face of the back beach dune (Figs. 37, 38 & 39). It was approximately 30 metres long by 8 metres wides and associated with a cut through the dune system currently used by a 4WD track. An historical photograph (Fig. 5) of the jetty shows that it terminated in a land back timber wharf which was at the same height as the back beach dune. The wharf was supported on timber poles erected within an area cut out of the seaward face of the dune.

This cut feature at the termination of the 4WD track is identified as the cut area over which the timber wharf was constructed. The metal detector survey indicated the presence of buried metal scattered across the area which would have been under the land backed wharf indicating other material from jetty activities may still be extant in the area.

The jetty remnant noted in 1991 no longer exists (Fig. 40 taken at the same location as Fig. 6 taken in 1991). No evidence of either the remnant section of jetty or of timber jetty piles was visible in the beach or shallow water. The metal detector survey produced isolated strong signals from an area 50 metres long by approximately 9 meters wide. The area stretched from the cut feature across the beach towards the ocean at a slight angle NNW. The signals were found at the edges of the area and they were widely spaced. The indicated metal is almost certainly evidence of the location of former jetty piles. There were not enough signals to indicate that all or a majority of piles may still be extant in the area and the signals may indicate only the presence of a bolt rather than a pile still *in situ*.

Site 1 was associated with two sand platforms (sites 2 & 3) located on either side of the features (Fig. 37) which were created largely by filling a section of the back beach dune system.

Site 2-Location of former small storage shed

GPS: 0292797, 7600877 +- 6m

This was a raised flat rectangular area to the east of site 1 located on top of the seaward face of the back beach dune (Fig. 37). It could be easily traced on site for a distance of 13 metres with either a second flat area adjacent to it or the feature continuing. Crop mark analysis suggests the total features measures 20 by 11 metres and it is associated with a similarly sized rectangular area oriented north south and located behind it. This second crop mark was not identified on site during the first visit. The metal detector survey returned sparse scattered small signals across the area of site 2 but not beyond it or on the crop mark behind it which was located on the top of the dune system. This suggests this is an archaeological site, probably of a small building which had very limited activity around it. This suggests a storage function and access from the timber land backed wharf rather than from the beach or dune system.

Site 3-Isolated activity area

GPS 0292739, 7600861 +- 3 m

This site was a raised flat rectangular area to the west of site 1 located on top of the seaward face of the back beach dune (Fig. 37). It measured 40 by 8 metres. Crop mark analysis indicated the site may be associated with two other rectangular shaped areas to the rear which are approximately 18 and 16 metres long respectively. These crop marks were not identified on sites. The metal detector survey returned scattered large signals from the eastern end of the feature only, no activity was indicated across the rest of the area. The archaeological signature of this site does not indicate the site of a former building; the metal is more likely to be from isolated activity in the area.

Site 3 is also associated with a cut down feature interpreted as a path (Figs. 37 & 41) which was located between sites 1 and 3. The path meandered from the 4WD track route pass site 4, the two possible crop marks to the rear of site 3 and onto the beach between sites 3 and 4.

Site 4- Location of former structure with floor

This feature was located 5 metres to the west of the 4WD track just before the cut through the final back beach dune (Fig 37). The feature is located behind this front dune. It measures approximately 11 by 7 metres and is formed by cutting away part of the rear of the back beach dune. The metal detector survey returned large signals but only from around the outside of the feature. This indicates that there was a structure in this location and the signals are coming from construction materials such as nails or bolts. However, the structure appears to have had a floor which prevented archaeological deposits building up underneath it. It also appears not to have been the scene of intensive activity as there is not a scatter of material around the outside of the location of the structure.

This site may not be associated with the tramway itself, which photograph evidence (Fig. 7) suggests terminated at the store, but is likely to have been associated with the access route to the timber wharf and jetty.

Site 5- Hollow area

This feature is located on the eastern side of the 4WD track and measures approximately 16 by 12 metres. It is noticeable on site as a large flat area close to the track. This hollow within the dune system may be a natural feature as the metal detector survey did not indicate it was the site of a former building or any other activity. The only evidence of activity found within the area was wire from a fence.

Site 6- Store complex

GPS: 0292739, 7600699 +- 4 m. Concrete pad : 0292750, 7600720 +- 5 m

The historical photograph of the store shows that it is located on flat land and is associated both with the end of the tramway route and the end of the telegraph line (Fig. 7). Site 6 is located on a large semi circular area of flat land at the rear of the dune system which accords well with the evidence of the historic photograph. The last evidence for the telegraph line is also located within site 6 which also accords well with the historic photograph. However the photograph shows three telegraph poles ranging from the end of the tramway to the seaward front of the store. Only two standing poles, (TP1 & TP2), were located in this area during the survey.

Given the orientation of the telegraph line in the photograph and the lack of a visible dune system the photograph appears to have been taken looking southwest towards the store from the other side of the access route to the jetty (Fig 37). This would put the main body of the store to the west and southwest of the last telegraph pole within a large area which crop mark analysis indicates is an activity area.

Only one site associated with this area was positively identified during the initial survey as this survey focused more heavily on sites within the dune system. This was a small formed concrete foundation adjacent to the 4WD track (GPS 0292750, 7600720 +- 5 m). The foundation was 5 by 2.5 metres with the edge closest to the track showing it was formed against an upright sheet of corrugated iron (Fig. 42). The concrete pad was located 13 metres from the last telegraph pole (TP1).

Area 6 was surveyed more intensively during the metal detector survey. Signals showed a band of activity adjacent to the current 4WD track (former jetty access route) which stretched the length of the track from TP1 to TP2 and extended for 4 metres to both the east and west of the current track.

Between 22 metres and 35 metres south of TP1 is a concentration of metal detector signals and visible historic artefacts such as tin sheeting and bottle glass which extends for 18 metres west of the 4WD track. The extended area (GPS 0292739, 7600699 +- 4 m) is located immediately south of the concrete pad described above and the two are obviously part of the same site, that of the store complex.

Site 7- Tram stop or small store building

Site 7 is a crop mark approximately 18 by 8 metres located to the north of the second telegraph pole (TP2) still standing within this area (Fig 37). Figure 7 indicates that this is likely to be the location of the small building beyond the store next to the end of the tramway. The location suggests that this site represents either the tram station or a small building associated with the store. However the metal detector survey did not return a scatter of signals across this area. Signals were confined to within four metres of the track suggesting that the crop mark does not mark the foundations of the structure but a cleared area associated with it. Figure 7 shows the structure to be closely aligned to the track and therefore evidence for it appears to be confined within the strip of activity scatter associated with the track itself.

Site 8- Windmill and well

GPS 0292804, 7600703 +-4 m

This site was discovered during the survey within the land behind the dune system to the east of the 4WD track. The location of the site was not accurately surveyed during the initial survey and the feature itself is not visible on available aerials. This is partly because of the quality of the available photographs and partly because it was obscured by vegetation. During the metal detector survey a GPS reading was taken and the site was surveyed in relation to TP1 and the road. The location of the well being 37 metres south of TP1 and 46 metres east of the road.

The site consists of the remains of an iron windmill, concrete tank base, concrete water trough and a well (Figs 37 & 43). The concrete water trough is located near the northwest corner of the well with a 3 metre diameter earth and corrugated iron base for a water tank situated 4.5 metres to the southwest. An iron upright for a windmill is located next to the tank base. The metal detector survey returned signals indicating a scatter of buried artefacts around the site which stretched for 8 metres towards the

Figure 43 Site 8, well and windmill site

road to the west of the site, 6 metres to the south and 14 metres to the east covering an area extending past the windmill and water tank in this area.

To the north of the well visible and buried artefacts stretched in a linear path northwards which then curved and met the track just south of TP1 at 5 to 22 metres south. The artefact trail averages between 4 to 5 metres wide and extends for 24 metres before curving south towards the well. This evidence is obviously associated with access and use of the well.

Site 9- Tram stop or unknown structure

GPS 0292768, 7600721 +- 3 m

The metal detector survey located a previously unknown site within Area 7 adjacent to the eastern side of the track opposite the store complex (Fig 37). This location is not visible in Figure 7. The site consists of a visible and buried scatter of artefacts located between 30 and 35 metres south of TP1 and extending 12 metres to the east of the track. Visible artefacts included a tram rail lying parallel to the 4WD track at a distance of approximately 2 metres. The presence of the rail, apparently still *in situ*, and the absence of a visible tram line in Figure 7 suggests this may be the tram stop and that it was located slightly to the east of the access track to the jetty.

2008 Area 8: Crop marks

An area of possible activity was identified to the west of the main jetty site (Fig 36). This area was investigated during the survey to try to locate features noted during aerial photographic analysis carried out prior to field work.

The main feature within this area is a large thin rectangular area which appears to be cut out of the seaward face of the back beach dune which is approximately 50 metres long by 5 metres wide. Aerial analysis indicates that this feature may actually be caused by a line of four foundations but this division is less obvious on site.

The feature is associated with two crop marks located behind it, which were both visible on site as areas of dune deflection and less obviously squared then they appear as crop marks. There is one further crop mark noted in the area, a squared crop mark approximately 15 by 10 metres which is noticeable on site as a flat squared area.

The metal detector survey did not return any signals across this entire area suggesting strongly that the crop marks are formed by natural processes.

2009 Area 9: Pastoral activity: possibly temporary stock pen or tent location

During inspections for compliance to HCWA approval conditions the Project archaeologist was asked to archaeologically clear sites and access routes to two bore locations within the HCWA reserve. Both the bore sites and east west access routes to them were inspected and the areas to be impacted did not contain any visible archaeological sites.

However a series of six square bare patches of flat ant dirt were noted between the two access routes. There were no visible artefacts associated with these patches but their shapes were very regular and it is unlikely that they are the result of natural causes. The features are similar in nature, if better defined, to others found along the tramway route and deemed to be the result of pastoral activities.

GPS locations were taken of the feature. These are:
GPS 0292801, 7600599 +- 4 m: Two small flat square ant earth pads.
GSP 0293029, 7600564 +- 3 m: One rectangular flat ant earth patch 2 by 3 metres.
GPS 02933032, 7600572 +- 3 m: One rectangular flat ant earth patch 1 by 1.5 metres.
GPS 0293048, 7600586 + - 3 m: One rectangular flat ant earth pad 2 by 2.5 metres.
GPS 0293113, 7600638 +- 3 m: One rectangular flat ant earth pad 2 by 3 metres.

Additional site - Quarry

The site of a quarry was noted during the survey. The quarry was located within the eastern side of Ashburton North SIA, well away from the HCWA reserve. While obviously man made and not recent the quarry had been excavated using heavy earth moving machinery and is likely to post date Old Onslow Town.

Maritime sites

The word maritime includes the land based evidence for maritime activities such as port buildings, jetties and landing places and historic shipwrecks. Other than evidence pertaining to the 1893 jetty construction land based sites within the study area date from 1901 and are not currently protected under the *Maritime Archaeology Act 1973*. These sites are protected under the *Heritage of Western Australia Act 1990*.

Investigation carried out for Chevron Australia has confirmed the location of shore based maritime features which are detailed above as Area 7. Archaeological and marine surveys have confirmed that the shore and intertidal based evidence for the two jetties has been almost completely removed by cyclonic activity with only sporadic evidence for the presence of large metal objects, probably bolts associated with pile locations. Given that the jetties were blown away by natural forces not removed by the people of Onslow it is unlikely that any jetty piles remain under the beach or in the seabed, unless the timber of the pile snapped to leave the bottom section in place.

Less likely to be affected by cyclonic activity is the artefactual evidence for use of the area dropped overboard or on the beach from the 1901-1925 jetty and tethered vessels while loading or unloading. The evidence from the Long Jetty, Fremantle and the Long Jetty, Albany shows that artefact spreads around jetties can be quite extensive. The metal detector survey indicates that there is not an extensive spread of artefacts associated with the beach section of the jetty. However, the presence or absence of artefact spreads in the sea bed associated with the jetty cannot be confirmed without survey and sampling of the relevant section of seabed.

Historical shipwrecks over 75 years of age are protected by the Historic Shipwrecks Act 1976, those lost before 1900 are also protected under the Maritime Archaeology Act 1973. The first recorded maritime activity on the west coast of Australia is shipwrecks with at least four Dutch and one English vessel wrecked while using the southern route to the Spice Islands. However, none of the known shipwrecks from this period lie within the study area.

Ships sailing to supply the New South Wales and Swan River colonies took the Great Circle route which skirted the southern coast of Australia; therefore they did not come to the northwest coast. However the colonial settlement of the northwest in 1863 started a coastal trade which passed the study area. The first shipwrecks from this trade were the New Perseverance wrecked at Cossack in 1866 and the Emma, wrecked in 1867 at Coral Bay.

Between 1868 and 1971 the Western Australian shipwreck database records eight vessels lost in the Onslow area. Henderson's and Cairn's Unfinished Voyages added another three to this list.

None of these shipwrecks have been located but the general area of loss is known for many. *Rose*, *Bell* and an *unidentified lugger* were part of the pearling fleet that was caught in a cyclone in 1893. Most of the fleet were lost in Exmouth Gulf, these three however appear to have been lost further north with maps placing them at either the mouth of the Ashburton or at the mouth of Beadon Creek, sites which bracket the study area. The supposed location of the wrecks in the river mouths is because they offered the only form of shelter on this stretch of coast and a captain is likely to have sought such shelter. However, as the wrecks have not been found they could have actually been driven ashore anywhere along the coast.

The *Ellen* noted as being lost at Onslow in 1905 may be located within the study area as the port for Onslow between 1901 and 1925 was located in the study area. There is currently no further information available on the loss of the Ellen to determine if it was near the Onslow jetty at the time of loss.

There was therefore a very slight possibility that one or more historic shipwrecks lie off the coast of the study area within the area to be impacted. However, after analysis of their survey results the presence of shipwrecks has not been flagged by the marine survey team. There is a greater possibility that artefacts associated with the 1901 Onslow jetty lie within the seabed within the area to be impacted.

ASSESSMENT OF SITES WITHIN INDUSTRIAL AREA

The original assessment of the heritage significance of sites within Ashburton North SIA was based on a brief drive by archaeological survey carried out in 1991 and the historical and archaeological significance of the main Old Onslow Townsite. Work carried out for the Wheatstone European Heritage Impact Project has allowed a more detailed assessment of the extent of surviving materials within the industrial area therefore allowing a refinement of assessment of significance.

All sites within areas 1 to 6 and areas 8 & 9 have been assessed as either being part of the tramway and telegraph line, sites associated with pastoral activities or features produced by natural processes. Of these only the sites and artefacts associated with the tramway and telegraph line have any heritage significance.

Isolated artefacts associated with the tramway are scattered remanets with little heritage significance.

Remanent sections of tramway causeway and directly associated artefacts have a higher significance as concentrated evidence of the tramway construction and location. Similarly standing telegraph poles, surviving bases and telegraph pole anchors have a higher significance as evidence of the construction and location of the telegraph line. The individual features associated with the telegraph line do not have associated archaeological deposits to illuminate construction or activity further, therefore the significance is confined to the physical evidence of the structures themselves.

Sites within area 7 have a high degree of significance as the main evidence for the period of use of the area as the port for Old Onslow. This area has considerable significance but does not have the exceptional level of significance of the Old Onslow Townsite or the earlier river landing port area. This is because use of the area only happened late in the story of the settlement and growth of Old Onslow. It is, however, an important part of the Old Onslow story and the struggle to keep the town alive at its original location. The failure of the port within Ashburton North SIA led directly to the relocation of Old Onslow to the new site at Beadon Creek.

Any artefact deposits located within the sea bed or beach associated with the use of the jetty would also be of considerable significance.

If an historic shipwreck was found within the study area this too would also be of considerable significance.

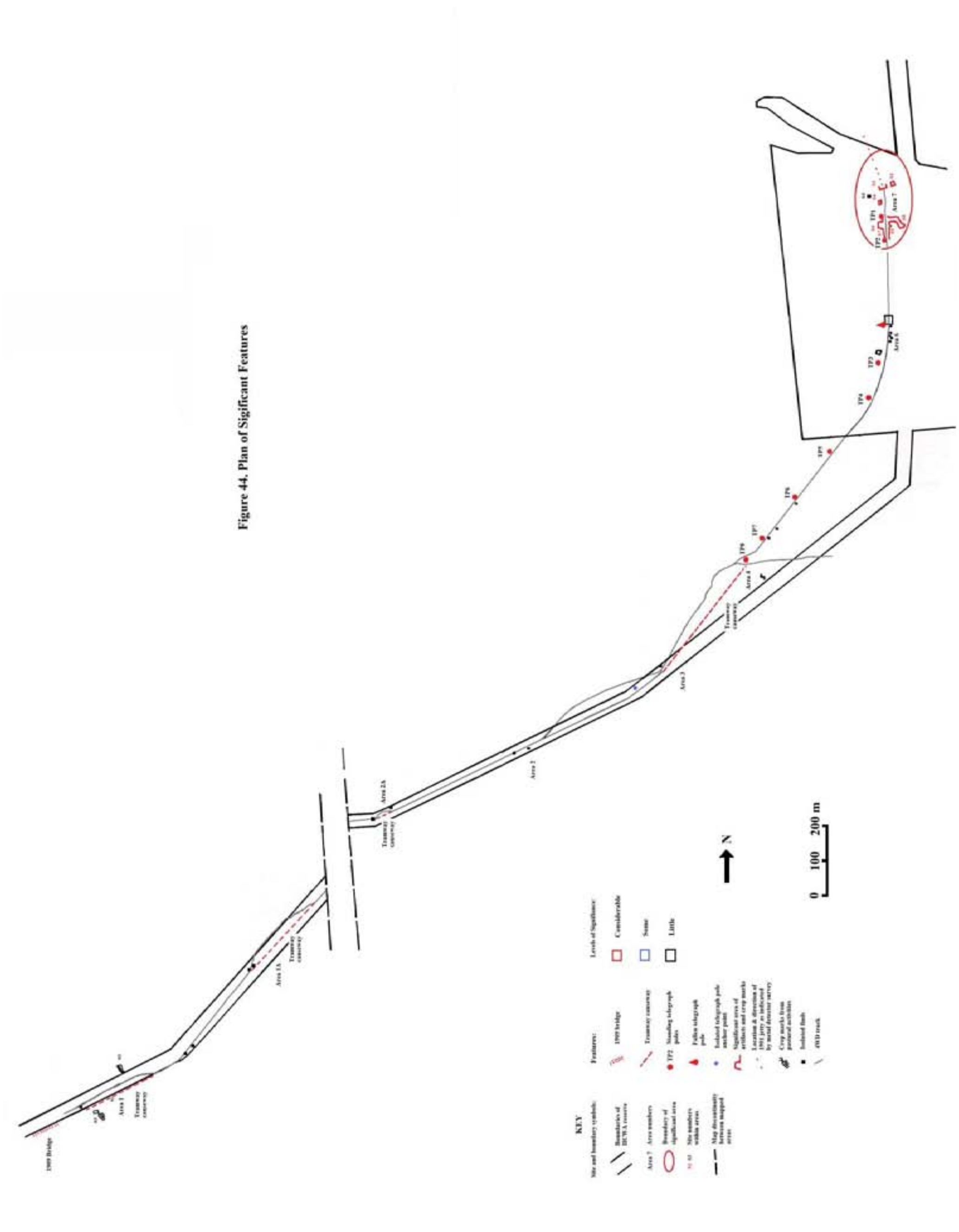

Figure 44 Plan of significant features

Level of Significance

Considerable

Port Area: Area 7 (sites 1, 2, 6, 7, 8 & 9)
Telegraph Poles & Anchor Points: Areas 4, 6 & 7
Tramway Causeway: Areas 1, 1A, 2A & 3
Large Timber Bridge: 1991 site 6

If located
Any artifact spread associated with jetty
Any historic shipwreck located within study area

Some

Telegraph Pole Anchor Point: Area 3

Little

Pastoral sites: Area 1 (sites 2, 3, 4), Areas 4, 6 & 9
Isolated finds: Areas 1, 1A, 2A, 2, 3, 6 and 7 (sites 3 & 4)

IMPACT OF CONSTRUCTION ON EUROPEAN HERITAGE SITES

Chevron Australia is in the early stages of planning therefore the Project sites plans are subject to change. However, two Project plans have been supplied to the consultant for the purposes of this report (Figs 45 & 46). Figure 45 shows the possible location and size of the LNG plant but this is subject to change and plans will not be finalised until after Chevron Australia has all the relevant data. Figure 46 shows the maximum extent of the area which could be impacted by the plant. This area includes the entire range of European heritage features located within the Ashburton North SIA.

The proposed method of developing the area is to construct a retaining wall around the edge of the construction area and fill the contained area to two to three metres in depth. This development method will have four different impacts:

1. The construction of the retaining wall will destroy any European heritage sites located within the work area of the wall construction. Also any part of the plant which requires foundations dug below the depth of the sand fill will destroy any European heritage sites located within the work area for the foundation.
2. It will bury some European heritage sites under sufficient depth of fill to protect them from the construction of the LNG plant.
3. It will bury the existing telegraph poles for all or most of their depth possibly leaving the tops sticking out of the sand pad. These features will not be buried to a sufficient depth to protect them.

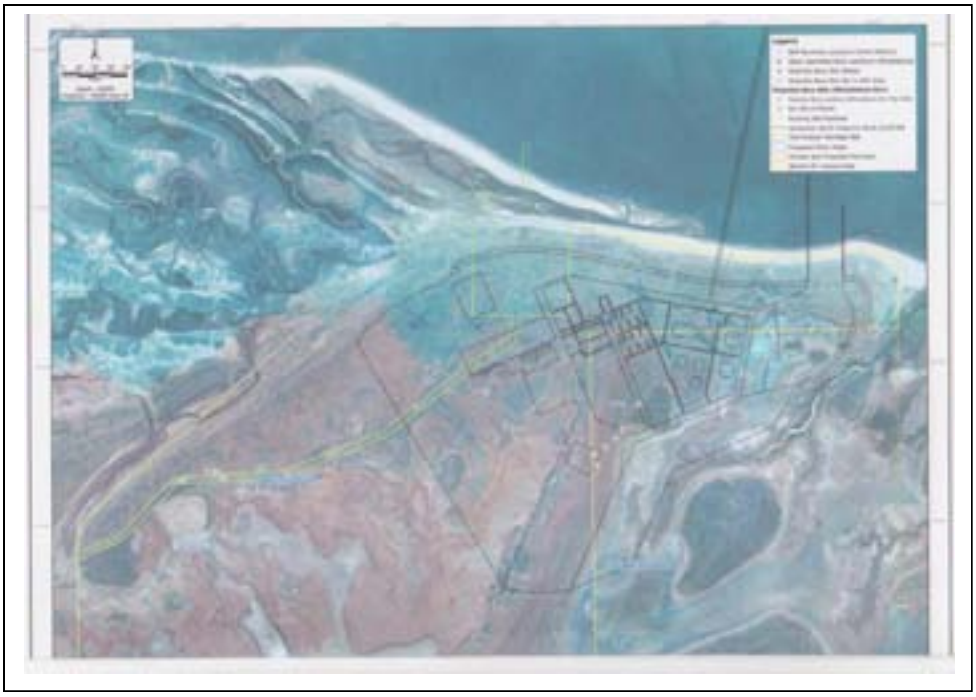

Figure 45 Proposed site development plan shown in relation to HCWA conservation area

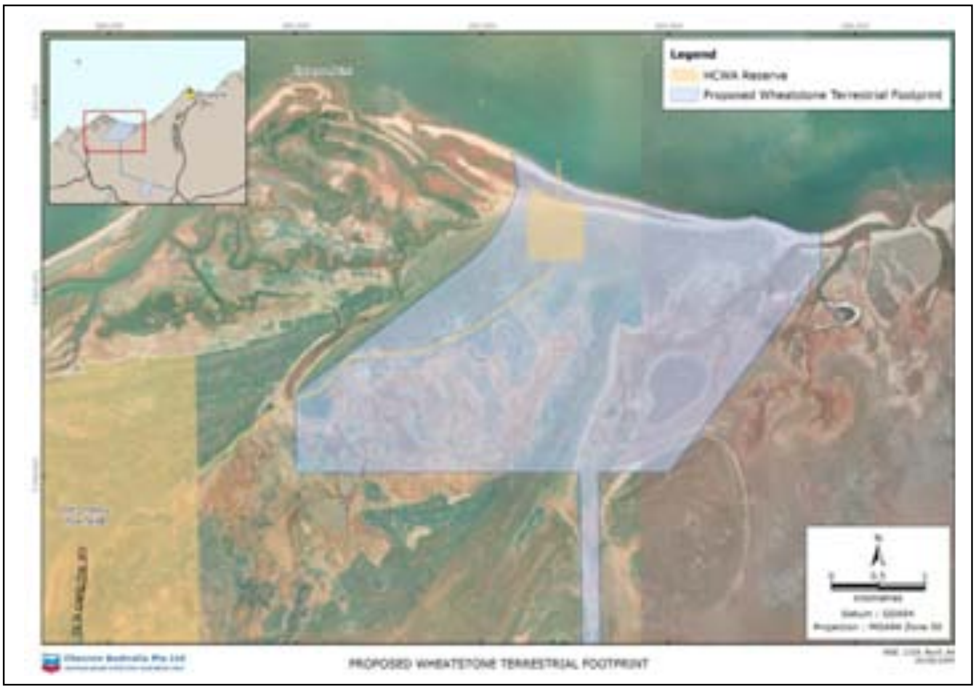

Figure 46 Expanded development footprint in relation to HCWA conservation area

4. Construction would also impact the sea bed adjacent to the area both as part of construction of a new jetty and by dredging to allow deep on shore access to the new jetty. This may impact artefactual evidence of the use of the 1901-1925 jetty and possibly may discover evidence the location of ships known to have been lost within the general Onslow area.

Impacts on sites within the development area are therefore likely to be severe either destroying them or burying them and ending their role as a heritage object until some point in the future when the plant is demolished and the sand pad removed.

The Old Onslow conservation plan assesses these sites as being of exceptional significance as part of a complex (the jetty/tramway complex) of exceptional significance and formulated a policy stating that should they be retained and conserved. It is highly unlikely that development of the plant in this location would be compatible with this policy.

The conservation plan policy was formulated on very little physical information on the archaeological potential of the area. This Project has allowed a much more detailed examination of the surviving evidence and the assessment of the significance of surviving features has been downgraded to considerable, some and little on the basis of this further information. However, alteration of the significance assessment has not yet been approved by HCWA.

It is however, still assessed that the development will destroy or remove from current generations sites of considerable and some heritage significance which tell important stories regarding the fight to save Old Onslow as a viable town, the operations of the port and store and the material culture associated with this final phase of the pioneering town.

Recommendations

Sites registered under the *Heritage of Western Australia Act 1990* cannot be adversely impacted or destroyed without the permission of HCWA. Two previously identified sites within the registration area which are in danger of adverse impact have been individually assessed as sites of exceptional significance; therefore it is foreseeable that such permission is unlikely to be granted.

Recent work detailed in this report has provided a more thorough knowledge of the current extent of surface features and artefacts and insight into the extent of buried evidence allowing a re-evaluation of significance to considerable, some and little. This revaluation has not yet been approved by HCWA.

It is recommended that all impacts on European heritage are managed through a Wheatstone European Heritage Mitigation Strategies document (EHMS) the provisions of which should be prepared in consultation with HCWA the Shire of Ashburton and the Western Australian Maritime Museum as the major stakeholders in the heritage of the place.

The EHMS should be divided into two sections, one dealing with mitigation of direct development impacts on the heritage of the Old Onslow Township registered place including the seabed component of the maritime heritage. The second section should deal with offset measures to ensure that the loss of *in situ* heritage is balanced with measures designed to enhance the heritage of the Old Onslow Township registered place and help promote heritage tourism within the shire.

REFERENCES

Jean, Bosworth, Goulder and Hayes 1998 Old Onslow Townsite, Pilbara, Western Australia: A Conservation Plan. Report for the Shire of Ashburton and Heritage Council of Western Australian in conjunction with the Australian Heritage Commission

Nayton G. 1991 An archaeological survey of Cossack and Old Onslow. Report for the Heritage Council of Western Australia

Nayton G. 2008 Wheatstone Project European Heritage Impact Project: Desktop Survey. Report for Chevron Australia Pty Ltd.

APPENDIX 1

REPORT ON BOTTLE HUNTING ACTIVITIES AT OLD ONSLOW

Brief

The archaeologist was asked to physically inspect the Old Onslow Townsite and compare the current extent of bottle hunting activities at the site to that present and recorded in 1991. Two archaeological survey maps prepared in 1991 were used to form the basis for the comparison. These were:

A detailed plan of archaeological features within the central core of the town formed by Clandon Street, Denzil Street, Merrow Street and Campbell Street.
A less detailed plan of archaeological sites located off Clandon Street from Merrow Street to the edge of the township.

The extent of the site shown in the two plans was walked over and inspected for bottle hunter activity. The river landing was also inspected and the area identified by a plaque as Jap Town.

Results

Bottle hunter activity was confined to the central core of the town formed by Clandon Street, Denzil Street, Merrow Street and Campbell Street. The position of impact holes was drawn onto the 1991 plan (Fig. 1) and GPS readings taken of locations which were not in or adjacent to features mapped in 1991. Features were also photographed.

D1 – Deep hole approximately two metres square excavated between the gaol (site 9a, 1991), underwater tank (site 9c, 1991) and concrete feature (site 9d, 1991) mapped in 1991 (Fig 2). The hole is not from recent activity.

D2 – Small recent hole approximately 50x25 cm by 20 cm deep within a midden from a bottle hunter hole (site 15, 1991) mapped in 1991 (Fig. 3).

D3 – Small recent hole approximately 50 cm square by x 20 cm deep adjacent to the same 1991 bottle hunter midden feature (site 15, 1991) as D2 (Fig. 4).

D4 – Very small recent hole approximately 20 cm square by 10 cm deep to the east of D2 and near the 1991 bottle hunter midden (site 15, 1991). No picture was taken.

D5 - GPS 0287803, 7597562 +- 4 metres. Recent bottle hunter hole 1.50 metres x 80 cm wide by 80 cm deep (Fig 5). The hole is approximately six metres from a concrete and mortar wall feature which looked like it might be a stand for something (Fig. 6). The concrete feature was partly underneath a stand of palm trees (Fig 7). Given the stand of palms which often mark well locations the concrete feature may have originally been a pump stand. This feature was not mapped in 1991, it was probably obscured by the palm trees at that time, but an iron pump was mapped lying *out of situ* some 20 metres away (site 16, 1991).

D6 – GPS 0287811, 7597521 +- 3 metres. Post 1991 bottle hunter hole 2 x 1.5 metres wide by 20 cm deep located 8 metres to the southwest of the post and telegraph building (site 10, 1991). This impact was not recent but has occurred after the 1991 map was created. Photograph not taken.

D7 – GPS 0287803, 7597562 +- 3 metres. Small recent hole (Fig. 8) dug into 1991 bottle hunter midden (site 18, 1991).

D8 – GPS 0287646, 7597556 +- 4 metres. Post 1991 bottle hunter hole 2 x 1 metres wide by 50 cm deep dug into a bottle midden (site 13, 1991) mapped in 1991. This midden was the result of site occupation not bottle hunter activity. Photograph not taken.

Other changes noted while on site

Site 22, a very large machine dug bottle hunter's hole has been filled in since 1991.

The post and telegraph building appears to have deteriorated since 1991 (Fig. 9) and the condition of this place should be checked in more detail.

J. Clark's House also appears to have deteriorated since 1991 (Fig. 10) with the walls becoming much less defined. The condition of this place should also be checked in more detail.

The condition of the cemetery has deteriorated significantly since 1991 when it was a tidy well kept place. The place is now very overgrown with many stone markers now in serious need of conservation with stones broken and deteriorated. An iron cross on site (Fig. 11) is also in need of conservation before the inscription disappears completely.

Vandalism not just neglect appears to have taken place and fossicking of the shell decorations on the graves seems to have occurred. In 1991 it was noted that many of the graves had been personalised by placing shells on the graves, some simply placed in pleasing arrangements, some concreted into a pattern. The grave of Winnie Lillycrapp aged 8 was given as an example as her grave was extensively decorated with shell and set with plastic flowers. There is no longer any visual evidence of shell decorations on the graves suggesting an extent of fossicking of the remains as well as burial of the grave surface with windblown sand.

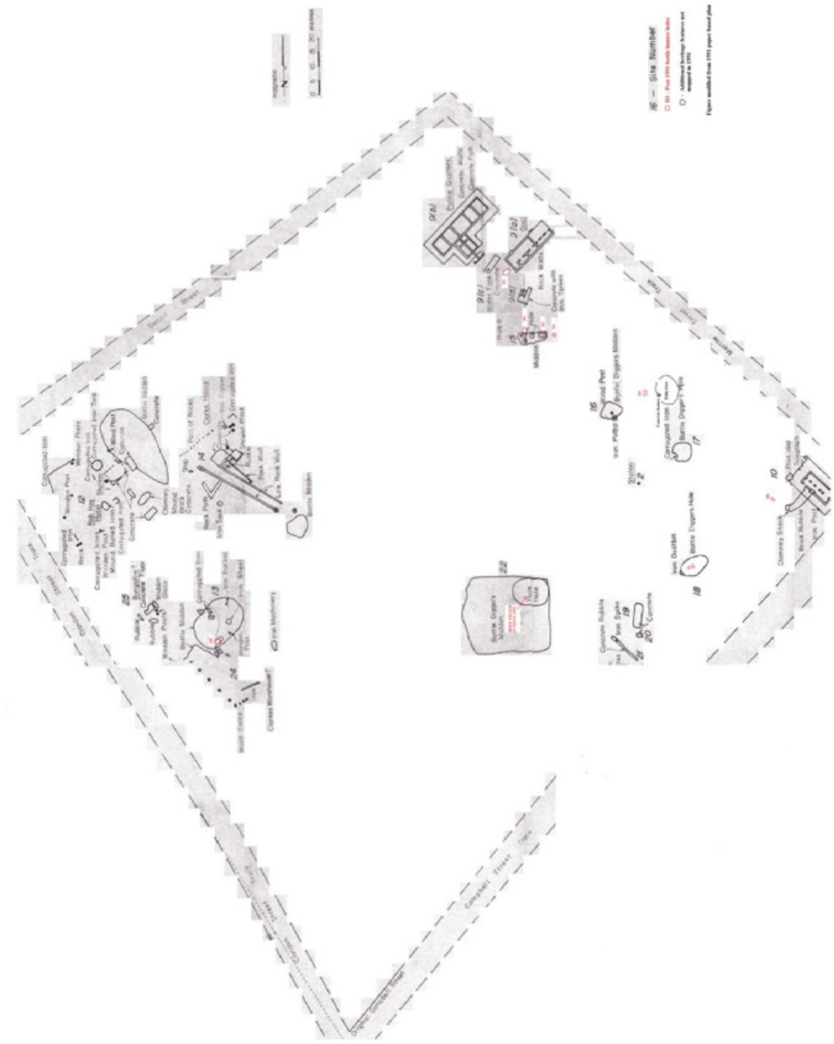

Figure 1: Site plan of central township area showing recent bottle hunter impact

Fig. 2: D1

Fig. 3: D2

Fig. 4: D3

Fig 5: D5

Fig.6: Concrete wall feature

Fig. 7: Palm trees, concrete features & D5

Fig. 8: D7

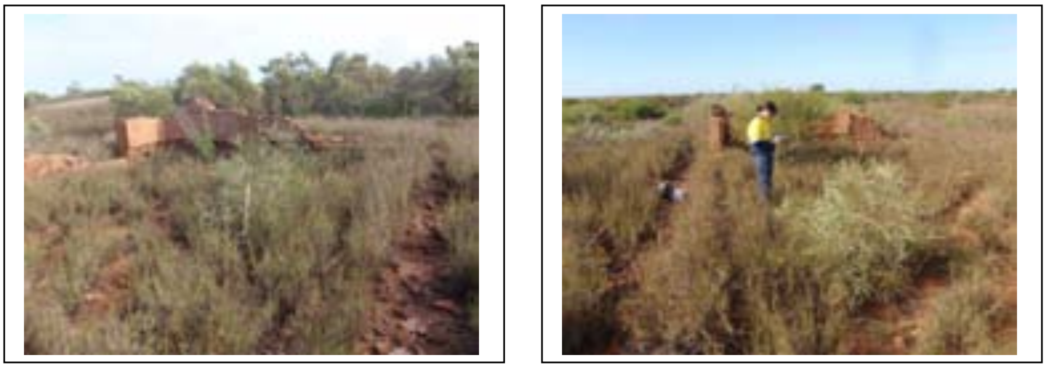

Fig. 9 Post & Telegraph Building

Fig. 10: J Clark's stone house

Fig. 11: Iron cross in overgrown cemetery

Appendix W1

DEWHA and EPA Requirements by Chapter

1.0 GENERAL REQUIREMENTS

General Content, Format and Style / Confidential Information	
DEWHA requirements:	**EIS/ERMP Reference:**
The EIS should be a stand-alone document that contains sufficient information to avoid the need to search out previous or supplementary reports. Information included should be sufficient to allow the Minister to make an informed decision on whether or not to approve, under Part 9 of the EPBC Act, the taking of the action for the purposes of each controlling provision.	Agreed
The proponent should ensure that the EIS addresses the matters stated in Schedule 4 of the EPBC Regulations - *Matters to be addressed by draft Environmental Impact Statement*.	Chapter 7
The EIS should enable interested stakeholders and the Minister for the Environment, Heritage and the Arts to understand the environmental consequences of the proposed development.	Executive Summary Chapters 8, 9, 10 and 12
Information provided in the EIS should be objective, clear, and succinct and, where appropriate, be supported by maps, plans, diagrams or other descriptive detail.	Agreed
The body of the EIS is to be written in a clear and concise style that is easily understood by the general reader. Technical jargon should be avoided wherever possible.	Agreed
Cross-referencing should be used to avoid unnecessary duplication of text.	Agreed
Detailed technical information, studies or investigations necessary to support the main text should be included as appendices to the EIS. It is recommended that any additional supporting documentation and studies, reports or literature not normally available to the public from which information has been extracted be made available at appropriate locations during the period of public display of the EIS.	Appendices
The proponent should make the EIS available on the Internet.	Agreed
If it is necessary to make use of material that is considered to be of a confidential nature, the Proponent should consult with Department of the Environment, Water, Heritage and the Arts on the preferred presentation of that material, before submission to the Minister for approval for publication.	Agreed
The EIS should comprise three elements, namely:	Agreed

• The executive summary; • The main text of the document, and • Appendices containing detailed technical information and other information that can be made publicly available.	
The EIS should be written so that any conclusions reached can be independently assessed. To this end all sources must be appropriately referenced using the Harvard standard. The reference list should include the address of any Internet "web" pages used as data sources. The main text of the EIS should include a list of abbreviations, a glossary of terms and appendices containing: • A copy of these guidelines; • A list of persons and agencies consulted during the EIS; • Contact details for the Proponent; and • The names of and work done by the persons involved in preparing the EIS.	Appendix A Appendix B Section 1.1.2 All documentation has been prepared by or on behalf of Chevron Australia Pty Ltd.
The EIS should be produced on A4 size paper capable of being photocopied, with maps and diagrams on A4 or A3 size and in colour where possible.	Agreed
Information about species listed under the EPBC Act should be provided in electronic format to DEWHA. The provision of this information will help facilitate decision making under the EPBC Act and assist in the protection and recovery of species and communities.	Executive Summary Chapters 8, 9, 10 and 12
Other	
DEWHA Requirements	**EIS/ERMP Reference:**
9 Information Sources Provided in this EIS For information given in a draft Environmental Impact Statement, the draft must state: (a) the source of the information;	Reference List
(b) how recent the information is;	Reference List
(c) how the reliability of the information was tested; and	Chapter 7, Section 7.3.6 Chapters 8, 9 and 10 (Confidence Levels in Tables)
(d) what uncertainties (if any) are in the information.	Chapter 7, Section 7.3.6 Chapters 8, 9 and 10 (Confidence Levels in Tables)
DEWHA Requirements	**EIS/ERMP Reference**

10 Environmental Record of Person(s) Proposing to Take the Action Details of any proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources against: (a) the person proposing to take the action; and	Chapter 1 Chevron is not subject to any proceedings under Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources
(b) for an action for which a person has applied for a permit, the person making the application. If the person proposing to take the action is a corporation, also include details of the corporation's environmental policy and planning framework.	See above Chapters 1 and 12

2.0 EXECUTIVE SUMMARY REQUIREMENTS

Executive Summary	
DEWHA Requirements:	**EIS/ERMP Reference:**
An executive summary that outlines the key findings of the EIS should be provided. The executive summary should briefly: State the background and the need for the proposal; EPA 9c The proponent should provide a summary table of the above information for all environmental factors, under the three categories of biophysical, pollution management and social surroundings • if not, what environmental management is proposed to ensure the EPA's objective is met; and the predicted outcome.	Executive Summary
Conclusion	
DEWHA Requirements:	**EIS/ERMP Reference:**
An overall conclusion as to the environmental acceptability of the proposal should be provided, including discussion on compliance with principles of ESD and the objects and requirements of the EPBC Act. Reasons justifying undertaking the proposal in the manner proposed should also be outlined. Measures proposed or required by way of offset for any unavoidable impacts on NES matters, and the relative degree of compensation, should be highlighted.	Executive Summary - Conclusion
EPA Requirements:	**EIS/ERMP Reference:**
EPA 13 Conclusion ♦ The environmental review document should indicate the proponent's view of the environmental costs and benefits of the proposal. This should be a synthesis of the preceding relevant information and aim to show how the proposal would achieve an overall net environmental benefit. ♦ When presenting this synthesis, the proponent should note that the proponent's own commercial arrangements and aspects such as employment opportunities, including economic benefits that might accrue as a result of these, are not matters that the EPA can consider in its assessment. ♦ Where relevant, the implications of the adoption in the proposal design and operation of best practicable measures to minimise environmental impacts should be mentioned. ♦ Proponents should also note how the proposal addresses the objectives and Principles set out in s4A of the EP Act. ♦ Proponents are also requested to outline the basis upon which they believe the EPA should conclude that the proposal is environmentally acceptable.	Executive Summary and Conclusion

3.0 INTRODUCTION REQUIREMENTS

1. Introduction	
DEWHA Requirements:	**EIS/ERMP Reference:**
General Information The background of the action, including: (a) the title of the action	Section 1.1.1
(b) the full name and postal address of the designated Proponent	Section 1.1.2
(c) a clear outline of the objective of the action	Section 1.1.4
(d) the location of the action	Section 1.6
(e) the background to the development of the action	Section 1.3
(f) how the action relates 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	Section 1.8
(g) the current status of the action; and	Section 1.4
(h) the consequences of not proceeding with the action.	Section 1.5
Other Approvals and Conditions Information given on any other requirements for approval or conditions that apply, or that the Proponent reasonably believes are likely to apply, to the proposed action must include: (a) details of any local or State Government planning scheme, or plan or policy under any local or State Government planning system that deals with the proposed action, including: ♦ what environmental assessment of the proposed action has been, or is being, carried out under the scheme, plan or policy; and ♦ how the scheme provides for the prevention, minimisation and management of any relevant impacts;	Section 1.12 – Section 1.13 Chapters 8, 9, 10 and 12
(b) a description of any approval that has been obtained from a State, Territory or Commonwealth agency or authority (other than an approval under the Act), including any conditions that apply to the action;	Not applicable
(c) a statement identifying any additional approval that is required; and	Section 1.13
(d) a description of the monitoring, enforcement and review procedures that apply, or are proposed to apply, to the action.	Chapters 8, 9, 10 and 12
EPA Requirements:	**EIS/ERMP Reference:**
EPA 3. The environmental review document should provide a comprehensive description of the proposal including its location (address and certificate of title details where relevant).	Chapter 1

Specific matters requiring attention are: (a) the identification of the proponent and proposal location;	Section 1.1.2 and 1.6 respectively
(b) justification and objectives for the proposed development;	Section 1.1.4 and 1.5
(c) the legal framework, including existing zoning and environmental approvals, and decision making authorities and involved agencies.	Section 1.11 and Chapter 1 in general
(d) alternatives considered, including location options.	Chapter 3
EPA 2b Objectives of the environmental review	Sections 1.1.4 and 1.2

4.0 PROJECT DESCRIPTION REQUIREMENTS

2. Project Description	
DEWHA Requirements:	**EIS/ERMP Reference:**
Description of Action All construction components of the action, should be described in detail. This should include: • the precise location of all works to be undertaken; • structures to be built; or, • elements of the action that may have impacts on matters of national environmental significance. The above information must include details on how the works are to be undertaken (including stages of development and their timing) and design parameters for those aspects of the structures or elements of the action that may have relevant impacts.	Chapter 2 Section 2.1 Sections 2.1 & 2.2 Chapters 8, 9 and 10 Sections 2.3, 2.4. 2.5 and 2.6. (Timing Chapter 1) Chapters 8, 9 and 10
2 Description 2.01 A description of the action, including: (a) all the components of the action;	Section 2.1 & 2.2
(b) the precise location of any works to be undertaken, structures to be built or elements of the action that may have relevant impacts;	Section 2.1 & 2.2
(c) how the works are to be undertaken and design parameters for those aspects of the structures or elements of the action that may have relevant impacts;	Sections 2.3, 2.4. 2.5 and 2.6 Chapters 4, 8, 9 and 10
EPA requirements:	
EPA 4. A description of the proposal and location, in sufficient detail to enable readers to clearly understand the nature and scale of the proposal, and to support later discussion of impacts. This should include an outline of the various components of the proposal (including how this proposal relates to other operations or proposals).	Chapters 1 and 2 Sections 1.8, 2.1 & 2.2
EPA 7 ("Other logistics") Timing and staging of project.	Chapter 1 and Sections 2.3, 2.4. 2.5 and 2.6
EPA 2b Objectives of the environmental review: to adequately describe all components of the proposal, so that the Minister for the Environment can consider ♦ approval of a well-defined project	Whole document, particularly Chapters 2, 4, 8, 9, 10, 11 and 12
EPA 2e Objectives of the environmental review: ♦ to provide a document which clearly sets out the reasons why the proposal should be judged by the EPA and the Minister for the Environment to be environmentally acceptable.	Whole document, particularly Chapters 2, 3, 4, 8, 9, 10, 11 and 12
EPA 7b ownership and liability for other aspects related to the proposal, such as waste during transport, disposal operations and long-term disposal (where appropriate to the proposal).	Whole document, particularly Chapters 2, 3, 4, 8, 9, 10, 11

	and 12
Include a description of the key components of the proposal, including the nature and extent of works proposed.	Section 2.1

5.0 PROJECT ALTERNATIVES AND SITE SELECTION REQUIREMENTS

3. Project Alternatives and Site Selection	
DEWHA Requirements:	**EIS/ERMP Reference:**
Feasible Alternatives Any feasible alternatives to the action to the extent reasonably practicable, including: (a) if relevant, the alternative of taking no action;	Chapter 1, Section 1.5 Chapter 3, Section 3.2
(b) a comparative description of the impacts of each alternative on the NES matter protected by Part 3 of the EPBC Act; and	Section 3.6
(c) sufficient detail to make clear why any alternative is preferred to another.	Chapter 3
Short, medium and long-term advantages and disadvantages of the options should be discussed.	Table 3.1
EPA requirements	**EIS/ERMP Reference:**
EPA 3 General requirements. The environmental review document should provide a comprehensive description of the proposal including its location (address and certificate of title details where relevant). Specific matters requiring attention are: ♦ alternatives considered, including location options.	Chapter 1 Chapter 3

6.0 STAKEHOLDER CONSULTATION REQUIREMENTS

5. Stakeholder Consultation	
DEWHA Requirements:	**EIS/ERMP Reference:**
Any consultation about the action, including: (a) any consultation that has already taken place	Chapter 5, Appendix B and Chapter 7
(b) proposed consultation about relevant impacts of the action;	Sections 5.5, 5.6 and 5.7
(c) if there has been consultation about the proposed action, any documented response to, or result of, the consultation; and	Sections 5.6 and 5.8
(d) identification of affected parties, including a statement mentioning any communities that may be affected and describing their views.	Section 5.3, 5.4, 5.6, 5.7 and 5.8
DEWHA 2.01 (h) any consultation about the action, including: (i) any consultation that has already taken place (ii) proposed consultation about relevant impacts of the action (iii) if there has been consultation about the proposed action — any documented response to, or result of, the consultation 2.01 (i) identification of affected parties, including a statement mentioning any communities that may be affected and describing their views.	Chapter 5, Appendix B and Chapter 7 Sections 5.5, 5.6 and 5.7 Sections 5.6 and 5.8
EPA Requirements:	**EIS/ERMP Reference:**
EPA 2d Objectives of the environmental review: ♦ to communicate clearly with stakeholders (including the public and government agencies), so that the EPA can obtain informed comment to assist in providing advice to government.	Sections 5.3 to 5.8, Appendix B and Chapter 7
EPA 12 Public consultation A description of the public participation and consultation activities undertaken by the proponent in preparing the environmental review should be provided. It should describe the activities undertaken, the dates, the groups/individuals involved and the objectives of the activities. Cross-reference should be made with the description of environmental management of the factors which should clearly indicate how community concerns have been addressed. Those concerns which are dealt with outside the EPA process can be noted and referenced.	Chapter 5, Appendix B and Chapter 7 Cross reference made in Table 5.5 and Section 5.6

7.0 OVERVIEW OF EXISTING ENVIRONMENT REQUIREMENTS

6. Overview of Existing Environment	
DEWHA Requirements:	**EIS/ERMP Reference:**
Description of the Environment A description of the environment of the proposal site and the surrounding areas that may be affected by the action must be provided. (a) Listed threatened and migratory species (including marine species) that are likely to be present in the vicinity of the proposal should be identified and the following information provided. ♦ Baseline data on listed threatened and migratory species that may be present in the vicinity of the proposal including regional status, population size and distribution within the project site and adjacent habitat that may be impacted by the project. ♦ Details of the scope, timing (survey season/s) and methodology for studies or surveys undertaken to provide information and baseline data on the listed threatened and migratory species and their habitat in and surrounding the site. These details must be determined in consultation with recognised experts for the listed threatened and migratory species. ♦ Baseline data and details as mentioned above regarding any additional listed threatened and migratory species which may be impacted by the proposal and which were listed after the making of these draft EIS Guidelines.	Chapter 6 Sections 6.3, 6.4 and 8.4 Sections 6.3.9 6.3.10 6.4.9 6.4.10
(b) Develop and undertake a Sampling and Analysis Plan (SAP) to determine suitability and characteristics of dredge spoil. ♦ Ensure the SAP and the SAP Report are developed in accordance with the National Assessment Guidelines for Dredging (NAGD 2009).	Section 8.2.3.2 Appendix Q – Draft Sediment Quality Assessment Appendix S – DSDMP
(c) Develop and undertake additional offshore disposal site selections for dredge material in accordance with the National Assessment Guidelines for Dredging (NAGD 2009).	Chapter 8 Sections 8.3 and 8.5
(d) A description of the Commonwealth Marine environment that is likely to be impacted by the proposal, including but not restricted to: ♦ significant regional habitat for listed threatened and migratory marine species.	Sections 6.3, 6.4 and 8.4
EPA requirements:	
EPA 1b The review requires the proponent to: ♦ describe the receiving environment. EPA 2a (Objectives of the environmental review). ♦ to place this proposal in the context of the local and regional environment.	Chapter 6. Sections 6.2, 6.3, 6.4 and 6.5
EPA 8a-d	Chapter 6

Provide a description of the existing environment in a local and regional context, with an emphasis on those aspects that may affect or be affected by the proposal, including: key ecosystem processes, biodiversity, existing site condition, other environmental issues that may be constraints or fatal flaws to the proposal context, with an emphasis on those aspects that may affect or be affected by the proposal, including: key ecosystem processes, biodiversity, existing site condition, other environmental issues that may be constraints or fatal flaws to the proposal.	

8.0 RISK ASSESSMENT REQUIREMENTS

7. Risk-Based Approach to Impact Assessment 8. Marine Risk Assessment and Management 9. Terrestrial Risk Assessment and Management 10. Social Risk Assessment and Management	
DEWHA Requirements:	**EIS/ERMP Reference:**
Relevant Impacts (a) The EIS must include a description of all the potential relevant impacts of the action on the ecology, hydrology and geomorphology of the project area as it relates to the NES matters protected under Part 3 of the EPBC Act, including but not restricted to:	Chapters 4, 8, 9 and 10
♦ a detailed assessment, developed in consultation with appropriate recognised experts, of the nature and extent of the likely short-term, long-term and consequential relevant impacts on all relevant NES matters.	Chapters 7, 8, 9, 10 and 11
♦ the Commonwealth marine environment such as: i) the potential direct, indirect and consequential impacts on regional habitat and the Commonwealth marine environment; ii) impacts on other users of the area; iii) the potential impacts on important amenities, navigation, culturally and historically significant sites, threatened or migratory species or sensitive habitats; iv) potential impact on listed marine species; v) the potential risk of pest species becoming established in the Commonwealth marine area; vi) changes in air and water quality.	Chapters 4, 6 and 8 Chapters 8 and 10 Chapter 8 and 10 Section 8.4 Section 8.4 Chapter 4 and Chapter 8 - Section 8.2
a statement whether any relevant impacts are likely to be unknown, unpredictable or irreversible;	Chapter 7 – Section 7.3.6 Chapters 8, 9 and 10, particularly references to Confidence Levels (included in tables)
analysis of the significance of the relevant impacts; and	Chapters 8, 9 and 10
any technical data and other information used or needed to make a detailed assessment of the relevant impacts.	Appendices to chapters 8, 9 and 10
EPA Requirements:	**EIS/ERMP Reference:**
EPA 1c. Outline the potential impacts of the proposal on factors of the environment	Chapters 4, 8, 9 and 10

EPA 4.3d Reference to relevant Position Statements and demonstration of compliance with associated Guidance for the Assessment of Environmental Factors should be included in the discussion about environmental issues/ factors.	Chapters 4, 7, 8, 9 and 10
EPA 4.3h The EPA will expect to see a discussion of the extent to which best practice will be applied to the proposal and also an explanation of how the principles of environmental protection have been given attention, where appropriate.	Chapters 1, 3 and 7
Discussion under each environmental issue/factor should include:	
• a description of where the factor fits into the broader environmental / ecological context (only if relevant – may not be applicable to all factors);	Chapter 6
• a clear definition of the area of assessment for this factor;	Chapters 2, 8, 9 and 10
• the EPA objective for this factor;	Chapters 8, 9, 10 and 12
• a description of what is being affected – why this factor is relevant to the proposal and how is it significant;	Chapters 8, 9 and 10
• a description of how this factor is being affected by the proposal – the predicted extent of impact;	Chapters 4, 8, 9 and 10
• a straightforward description or explanation of any relevant standards/regulations/policy;	Chapters 1, 2, 4, 8, 9 and 10
• environmental evaluation – does the proposal apply best practice and does it meet the EPA's objective as defined above;	Introduction and Chapter 7
• if not, what environmental management is proposed to ensure the EPA's objective is met; and	Chapter 12
• predicted outcome.	Chapters 4, 8, 9, 10, 11 and 12
EPA 9d vii) Environmental evaluation - does the proposal apply best practice and does it meet the EPA's objective as defined above.	Chapters 1 and 7

9.0 CUMULATIVE EFFECTS REQUIREMENTS

11. Cumulative Effects	
EPA requirements:	**EIS/ERMP Reference:**
EPA 2c Objectives of the environmental review are to provide the basis of the proponent's environmental management program, which shows that the environmental impacts resulting from the proposal, including cumulative impact, are minimised and can be acceptably managed	Chapter 11

10.0 ENVIRONMENTAL MANAGEMENT PROGRAM REQUIREMENTS

12. Environmental Management Program	
DEWHA Requirements:	**EIS/ERMP Reference:**
6 PROPOSED SAFEGUARDS AND MITIGATION MEASURES The EIS must provide information on mitigation measures, with a particular focus on matters protected under Part 3 of the EPBC Act.	Chapters, 4, 8, 9, 10 and 12
Specific and detailed measures must be provided and substantiated, based on best available practices and must include the following elements.	Chapters, 4, 8, 9, 10 and 12
(a) A consolidated list of mitigation measures proposed to be undertaken to prevent, minimise or compensate for the relevant impact on the action, including: • a description of proposed safeguards and mitigation measures to deal with relevant impacts of the action including mitigation measures proposed to be taken by State Governments, Local Governments or the proponent; • assessment of the expected or predicted effectiveness of mitigation measures; • any statutory or policy basis for the mitigation measures; and the cost of the mitigation measures; and • the cost of the mitigation measures.	Chapters, 4, 8, 9, 10 and 12 Chapters, 4, 8, 9, 10 and 12 Chapter 12 (Section 12.2, 12.3, 12.4) No discussion of Cost
(b) A detailed Environmental Management Plan (EMP) that sets out the framework for management, mitigation and monitoring of relevant impacts of the action, including any provisions for independent environmental auditing.	Introduction to EMPS in Section 12.4 Draft EMPS in Appendices S, T & U
The EMP needs to address the construction phase. It must state the environmental objectives, performance criteria, monitoring, reporting, corrective action, responsibility and timing for each environmental issue.	Section 12.3 and Appendix U – Construction Management Plan
(c) The EMP should also describe contingencies for events that may impact on the proposal.	Sections 12.3 and 12.4
6 (c) The name of the agency/s responsible for endorsing or approving each mitigation measure or monitoring program should be included.	Section 12.2
4(a) a description, and an assessment of the expected or predicted effectiveness of the mitigation measures.	Chapter 7, 8, 9 and 10
7 OTHER APPROVALS AND CONDITIONS Information given on any other requirements for approval or conditions that apply, or that the Proponent reasonably	Chapter 1 Sections 1.14 and 1.16

believes are likely to apply, to the proposed action must include: (a) details of any local or State Government planning scheme, or plan or policy under any local or State Government planning system that deals with the proposed action, including: • what environmental assessment of the proposed action has been, or is being, carried out under the scheme, plan or policy; and • how the scheme provides for the prevention, minimisation and management of any relevant impact.	Chapter 12 Section 12.5
(b) a description of any approval that has been obtained from a State, Territory or Commonwealth agency or authority (other than an approval under the Act), including any conditions that apply to the action;	Not Applicable - No other applications under the EPBC Act
(c) a statement identifying any additional approval that is required; and	Chapter 1, Section 1.16
(d) a description of the monitoring, enforcement and review procedures that apply, or are proposed to apply, to the action.	Chapter 12, Section 12.3
EPA requirements (as per Draft Environmental Assessment Guideline No. 4 – Towards Outcome-based Conditions, December 2009):	**EIS/ERMP Reference:**
1. Introduction and background Outcome-based conditions will be highly specific to each proposal. They will describe the required environmental outcome (or acceptable level of impact) as it relates to the environmental issue (factor) and include instructions on how the achievement of the outcome is to be demonstrated.	Section 12.3
3. Policy and legislative context Environmental Management Programmes provide a framework for the proposed environmental management measures. These should be developed during the assessment of a proposal to allow the EPA to develop confidence that proposed management measures will protect the environment. Environmental Management Plans will likely still be required by proponents to detail the implementation of the proposal, however these Plans will not be required to be submitted for individual approval.	Sections 12.4
4. Methodology* The development of outcome-based conditions should be undertaken via a four step process as follows: Step 1 – OUTCOME Identify the environmental outctome to be achieved Step 2 – MONITOR	Section 12.3.1

Identify how the outcome is to be demonstrated Ensure transparent link between indicators and the outcome Step 3 - REPORT Identify reporting requirements Step 4 – CONTINGENCY Identify what is to be done if the outcome is not being met *See Draft Guidelines for definitions	
6. Other Considerations Conditions must be valid and enforceable, which means that they must: • reasonably relate to the proposal; • be for the purposes of achieving the objective of the *Environmental Protection Act 1986* and relevant government policy; • be reasonable; • be final and certain; • be unambiguous and clear; and • be placed only on the proponent. 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*.	Section 12.3

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