The sections below describe the existing marine environment under the following main headings:

- Regional setting;
- Physical marine environment; and
- Biological marine environment.

The descriptions draw on previous and recent studies and surveys undertaken on the immediate and surrounding areas of the proposed dredging location and proposed DMMA (A, B1 and B2 and Spoil Ground 'I').

4.1 REGIONAL SETTING

Port Hedland is a coastal town located in the Pilbara region of Western Australia, approximately 1,660 km north of Perth. The Pilbara region covers an area of 507,896 km² (including offshore islands) and consists of three distinct geographic areas (coastal sand plain, desert and inland ranges). Port Hedland lies within the western portion of the coastal sand plain, where this geographic area encompasses most of the region's population and much of its industry and commerce.

4.1.1 Climate

The Pilbara region is classified as sub-tropical, whilst becoming more arid inland. Maximum temperatures often exceeding 40°C and minimum temperatures around 25°C are often experienced in Port Hedland during the summer months while average temperatures ranging from 12°C minima to 29°C maxima are experienced in winter (BoM 2008).

Pilbara average annual rainfall varies between 250 to 400 mm, with many years reporting no significant rainfall events. The majority of rain falls during the summer months and is generally associated with scattered thunderstorms and tropical cyclones. A secondary peak in rainfall occurs in May resulting from rainfall from tropical cloud bands which intermittently affect the Pilbara region (BoM 2008).

The coast from Port Hedland to Exmouth Gulf is considered the most cyclone prone area in Australia. In general, the cyclone season lasts from November to April, although tropical cyclones do occur outside of this period (BoM 2008).

In general, winds in Port Hedland vary in direction and strength seasonally; with the windiest conditions generally experienced in summer with winds generally prevailing from the northwest (Figure 4.1).
4.2 PHYSICAL MARINE ENVIRONMENT

4.2.1 Oceanography

Bathmetry

Preliminary findings from bathymetric data collected in the vicinity of the Port Hedland Port location (SKM 2007b) indicate that the seabed levels fall gradually with distance from the shore and reach -16 m CD or deeper approximately 13 km offshore from the entrance to the Inner Harbour. The seabed gradually slopes until it reaches the outer edge of the continental shelf. There are local peaks and
troughs throughout the area, comprised of generally shore-parallel ridge lines where the seabed rises to within 6 m of the surface (SKM 2007b).

Historical dredging of the approach channel to the Port Hedland harbour, manoeuvring area and berthing pockets has considerably altered the bathymetry and configuration of the harbour from its natural state (PHPA 2006). Dredging of the Port Hedland harbour commenced in 1965 in association with the development of the iron ore industry in the region. Between 1965 and 1984 substantial dredging was under taken to deepen the port and access channels. Ongoing maintenance dredging and capital dredging projects after 1984 has removed 20 Mm$^3$ of dredged material from the harbour (Table 4.1).

### Table 4.1 - Maintenance and capital dredging of Port Hedland Harbour between 1986 and 2007

<table>
<thead>
<tr>
<th>Year</th>
<th>Dredge Volume</th>
<th>Proponent</th>
<th>Purpose of Dredge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>13,600,000 m$^3$</td>
<td>BHPBIO</td>
<td>Capital Dredging</td>
</tr>
<tr>
<td>1990</td>
<td>350,000 m$^3$</td>
<td>PHPA</td>
<td>Maintenance Dredging</td>
</tr>
<tr>
<td>1994</td>
<td>114,000 m$^3$</td>
<td>PHPA</td>
<td>Maintenance Dredging</td>
</tr>
<tr>
<td>1997</td>
<td>330,000 m$^3$</td>
<td>PHPA</td>
<td>Maintenance Dredging</td>
</tr>
<tr>
<td>2001</td>
<td>580,000 m$^3$</td>
<td>PHPA</td>
<td>Maintenance Dredging</td>
</tr>
<tr>
<td>2002</td>
<td>460,000 m$^3$</td>
<td>BHPBIO</td>
<td>Capital Dredging</td>
</tr>
<tr>
<td>2004</td>
<td>530,000 m$^3$</td>
<td>PHPA</td>
<td>Maintenance Dredging</td>
</tr>
<tr>
<td>2006-07</td>
<td>5,000,000 m$^3$</td>
<td>FMGL</td>
<td>Capital Dredging</td>
</tr>
</tbody>
</table>

Other significant modifications to the bathymetry of the harbour have occurred as a result of reclamation activities in the Port Hedland area. These include:

- Reclamation of East Creek to accommodate developments at Nelson Point; and
- Modification of West Creek through the construction of the Finucane Island causeway.
- Development of the northward projecting spit of sediment immediately to the east of the harbour entrance (i.e. ‘spoil bank’) during deepening of the existing channel
- Reclamation of land between Hunt and Utah Points as part of installation and upgrades to Berths C and D at Finucane Island.

The PHPA now maintains the approach channel to the harbour at a depth of -14.2 m CD and the inner channel to a depth of -14.8 m lowest astronomical tide (LAT). The inner channel is 20 nautical miles (nm) in length and has a minimum width of 183 m (DALSE 2004). The bathymetry of the proposed dredge footprint at Harriet Point ranges from -5 to -15 CD and Spoil Ground ‘I’ is currently -11 to -13 CD. The bathymetry of the proposed dredging footprint and the Spoil Ground ‘I’ are shown in **Figure 4.2** and **Figure 4.3** respectively.
FIGURE 4.2

BATHYMETRY OF PROPOSED AREA TO BE DREDGED

Legend

Bathymetric Surveys 2006-2007

0.5m Contour

5m Contour

Bathymetry Chart Datum

-4 to -2

-6 to -4

-8 to -6

-10 to -8

-12 to -10

-14 to -12

-16 to -14

-18 to -16

-20 to -18

-21 to -20

Harriet Pt Proposed Dredging Footprint

Source:

Orthorectified Aerial Photograph - BHPBio, 15/06/2007
Bathymetry - FMG Berth Dredging Area Survey 18/5/2007;
RGS Finucane Island Bathmetric Survey September 2007;
Port Hedland Port Authority Annual Bathymetric Survey
24/11/2006
Dredge Footprint - MPD JV 14/04/2008

Rev No. 0
Project: WV03418
Drawn: 13/06/2008
Drawing: WV03418_036_0
FIGURE 4.3

Source:
- Spoil Ground I: PHPA (29/10/2007)
- Rail: BHPBI (2007)
- Jurisdiction Boundary: AMBIS (2001)
- Bathymetry: Final Lidar Data (08/05/2008)

 Datum: GDA94
Map Grid: MGA94 Zone 50

Legend
- PHPA Spoil Ground 'I'
- Spot height (m)

Bathymetry (Chart Datum)
- Bathymetry (5m contours)
- Bathymetry (1m contours)
- Terrestrial Contours (CD)
- State/Commonwealth Jurisdiction Boundary
- Existing Railway

BATHYMETRY OF SPOIL GROUND 'I'
Tides, Currents and Circulation

Port Hedland is located within the North West Shelf marine area. Influences on currents and circulation on the North West Shelf include the Indonesian throughflow current, Western Australian current, the Leeuwin current, large tidal ranges and cyclones (GHD 2007).

Tidal flow through the harbour entrance dominates water movement in the inner harbour (Environ 2004). The highest astronomical tide is 7.9 m but typically ranges from 1.5 m during neaps to 5.8 m at springs and are predominantly semi-diurnal (PHPA 2003). Tidal currents within the harbour generally peak at approximately one knot but currents of three knots can occur at some locations (HGM 1997).

Spring tides circulate in a counter-clockwise pattern in the turning basin which results in the deepest part of the basin not being as effectively flushed as the rest of the harbour (HGM 1997). During neap tides the harbour is generally well flushed although stratification is evident as lower water velocities decrease mixing efficiency and increase the residence time of water (HGM 1997).

The natural littoral drift process moves sediment from west to east and the natural current direction in the local area is north westerly to south easterly (GHD 2007).

4.2.2 Water Quality

Port Hedland harbour waters are marine with occasional freshwater inflows via the creeks and drains surrounding the harbour. The main sources of contaminants to Port Hedland Harbour are from shipping and dust from iron ore loading activities. In addition, the harbour catchment is urbanised to the south and east which may contribute some contaminants following rainfall events (Environ 2004).

Baseline water quality data exists for Port Hedland coastal waters, including several sites within Inner Harbour, coastal and offshore sites containing BPPH, and several creek systems, including Salmon Creek, adjacent to the proposed DMMA A. The most recent studies include those undertaken by SKM in 2002, 2007 & 2008 (SKM 2002; 2007c; 2008b), Wenziker et al. (2006), and FMG (2006). While these studies provide a starting point for understanding general water quality conditions within the Port Hedland region, they lack sufficient temporal replication to be able to determine seasonal trends in water quality and chemistry parameters and set seasonally appropriate trigger levels to monitor dredging and disposal operations. To obtain additional data, a baseline water quality program has will be undertaken prior to the commencement of dredging. The objective of the monitoring program is to obtain site-specific data adjacent to the proposed dredging and disposal areas, as well as suitable reference areas, to understand the temporal trends in background water quality.

Existing baseline water quality data most directly relevant to the proposed project was collected in June and July of 2006 by URS at two sites:

i) a site adjacent to a excess water discharge point for the FMG reclamation area (URS 2008), located within South West Creek, approximately 1.5 km southwest of Harriet Point; and

ii) a reference site located outside Port Hedland harbour within Salmon Creek, an oceanographically isolated estuary to the west of the harbour.

This baseline data was used to set trigger Levels for water quality parameters to assess the suitability of excess water discharge from a reclamation area into South West Creek. The results of the 2006 baseline monitoring undertaken after dredging but before excess water discharge in South West Creek are presented in Table 4.2.
Table 4.2 - Baseline water quality monitoring in South West Creek (URS 2008)

<table>
<thead>
<tr>
<th>Date</th>
<th>Tidal Cycle</th>
<th>20%ile</th>
<th>80%ile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>DO (mg/L)</td>
<td>pH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dissolved Oxygen % Saturation²</td>
<td></td>
</tr>
<tr>
<td>22/06/06</td>
<td>Neap+1</td>
<td>76</td>
<td>6.78</td>
</tr>
<tr>
<td>23/06/06</td>
<td>Neap +2</td>
<td>73</td>
<td>6.61</td>
</tr>
<tr>
<td>24/06/06</td>
<td>Neap +3</td>
<td>69</td>
<td>6.30</td>
</tr>
<tr>
<td>25/06/06</td>
<td>Neap +4</td>
<td>66</td>
<td>6.08</td>
</tr>
<tr>
<td>26/06/06</td>
<td>Neap +5</td>
<td>65</td>
<td>5.99</td>
</tr>
<tr>
<td>27/06/06</td>
<td>Neap +6</td>
<td>65</td>
<td>5.93</td>
</tr>
<tr>
<td>28/06/06</td>
<td>Spring</td>
<td>65</td>
<td>5.94</td>
</tr>
<tr>
<td>29/06/06</td>
<td>Spring +1</td>
<td>66</td>
<td>6.07</td>
</tr>
<tr>
<td>30/06/06</td>
<td>Spring +2</td>
<td>68</td>
<td>6.35</td>
</tr>
<tr>
<td>01/07/06</td>
<td>Spring +3</td>
<td>69</td>
<td>6.44</td>
</tr>
<tr>
<td>02/07/06</td>
<td>Spring +4</td>
<td>70</td>
<td>6.51</td>
</tr>
<tr>
<td>03/07/06</td>
<td>Spring +5</td>
<td>72</td>
<td>6.66</td>
</tr>
<tr>
<td>04/07/06</td>
<td>Spring +6</td>
<td>75</td>
<td>6.81</td>
</tr>
</tbody>
</table>

1. The 20th and 80th percentiles were calculated from the baseline data in accordance with threshold limits set for the excess water discharge.
2. Calculated from URS 2008 (at pressure = 1ATM and Salinity = 35 ppt)

FMG were generally able to maintain the quality and chemistry of excess water discharged into South West Creek within 20th and 80th percentiles of background levels. Monitoring of excess water discharged from the reclamation area indicated that dissolved oxygen (DO) did not fall below the Trigger Level at any time during the discharge process and pH was typically just outside the narrow range between the Low and High Trigger Levels. Small exceedences of excess water temperature occurred, however, this was largely due to a high level of variability between morning and afternoon water temperatures, both in excess water and the natural environment. When water temperature trigger Levels were re-calculated using morning and afternoon averages, excess water fell within background ranges.

Turbidity and Suspended Solids
The most recent studies that have measured turbidity (Nephelometric Turbidity Units - NTU) and suspended solids (Total Suspended Solids - TSS) within and outside the Port Hedland Harbour include SKM (2002), Worley (2005), SKM (2007c) and URS (2008). The results are summarised in Table 4.3.
Table 4.3 - Summary of Turbidity (NTU) and Total Suspended Solids (TSS) data from Previous Studies within Port Hedland Inner Harbour

<table>
<thead>
<tr>
<th>Proponent</th>
<th>Date</th>
<th>Study Description</th>
<th>Duration</th>
<th>Observations</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>BHPBIO Ore Product and Capacity Expansion (PACE)</td>
<td>2002</td>
<td>Long-term monitoring pre, during and post dredging. Two data loggers measured data alongside Finucane Island wharf at surface and one metre above seabed</td>
<td>12 months</td>
<td>Turbidity varied from 0 to 80 NTU. Surface and seabed turbidity peaked during maximum tidal movement. Dredging increased seabed turbidity while only marginally affecting surface turbidity. Shipping and loading activities not distinguishable from tidal activity.</td>
<td>SKM (2002)</td>
</tr>
<tr>
<td>Fortescue Metals Group Ltd (FMG)</td>
<td>2005</td>
<td>NTU monitoring pre-dredging Data logger deployed in Port Hedland Harbour for turbidity TSS measured at seven sites (town jetty, boat ramp, mangroves, mangroves mud, mangroves deep, creek and creek mud).</td>
<td>2 weeks</td>
<td>Turbidity varied from 33.8-130.5 NTU range with average 80NTU. One high reading at a very muddy location near mangroves of 380 mg/L. 18-69 mg/L (TSS).</td>
<td>Worley (2005)</td>
</tr>
<tr>
<td>BHPBIO RGP3 works</td>
<td>2007</td>
<td>Weekly measurements of turbidity taken over dredging period at a range of sites in the inner harbour.</td>
<td>Turbidity varied from 2.1-121.6 NTU Dependant on shipping movement, tidal and weather rather than dredging activities.</td>
<td>SKM (2007c)</td>
<td></td>
</tr>
<tr>
<td>FMG</td>
<td>2006-2007</td>
<td>Tailwater monitoring in South West Creek and Salmon creek (reference site), pre- and during dredging Pre-and during tailwater discharge in South West and Salmon creek</td>
<td>10 months</td>
<td>Turbidity varied from 11-18 NTU (80th percentile). 80th percentile Trigger values were calculated using baseline data pre-tailwater discharge. Turbidity levels in the tailwater were always below the trigger value during periodic discharge. Turbidity levels exceeded Trigger levels temporarily on several occasions during continuous discharge.</td>
<td>URS (2008)</td>
</tr>
</tbody>
</table>

Metals

Previous assessments of metal concentrations in coastal marine waters on the North West Shelf region have shown that the concentrations of heavy metals at Port Hedland, measured from one inner harbour site and one outer harbour site, are higher than those measured at sites elsewhere in the North West Shelf region such as the Dampier Archipelago (Wenziker et al. 2006). In particular, high concentrations of zinc and copper have been recorded in the inner harbour of Port Hedland (Wenziker et al. 2006).

Recent water quality investigations of metals were undertaken by SKM in February 2008. A total of ten sites were sampled in the Port Hedland area. These included one site in the inlet north of Harriet...
Point, three sites in the centre of the inner harbour; three sites in the shipping channel and three sites selected as reference sites within Oyster Inlet, approximately 9 km west of the harbour (SKM 2008b). It was noted that all metals were undetectable or below the ANZECC/ ARMCANZ\(^1\) (2000a) guidelines with the exception of copper and zinc.

In the Pilbara Coastal Water Quality Objectives- Environmental Values and Environmental Quality Objectives (DoE 2006c) areas of high and moderate ecological protection are recognised within the project area. Areas of high protection have been described as areas of a very low level of contaminants and where biological indicators will show no detectable change from natural variation (DoE 2006c). Areas that may have elevated levels of contaminants such as those around wharves, jetties and ship turning basins have been allocated a moderate level of protection due to a range of potential, uncontrolled contaminant inputs (e.g. shedding of antifouling paints).

Following the protection levels identified by Pilbara Water Quality Consultation Outcomes a 90% ecological protection level can be applied to most areas of the inner harbour, including waters adjacent to Harriet Point, DMMA B1 and B2 while a 99% ecological protection can be applied to areas outside the harbour within state waters, including the creek system adjacent to DMMA A. Using these guidelines, pre-existing levels of copper were found to exceed both 90% and 99% ecological protection guidelines in waters within and outside the harbour while zinc exceeded the 99% value for waters outside the harbour and lead exceeded 99% values for an inlet feeding into the harbour at Harriet Point (SKM 2008b). Table 4.4 shows the total metal concentrations recorded in the inner and outer harbour waters.

### Table 4.4 – Total Metal Concentrations Recorded in the Inner and Outer Harbour Waters of Port Hedland (SKM 2008b)

<table>
<thead>
<tr>
<th>Metal</th>
<th>Unit</th>
<th>ANZECC Marine Trigger Value 90% ecological protection</th>
<th>ANZECC Marine Trigger Value 99% ecological protection</th>
<th>Inlet L1</th>
<th>Inner Harbour L2</th>
<th>Shipping channel L3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>S5</td>
<td>S6</td>
<td>S7</td>
<td>S8</td>
<td>S9</td>
</tr>
<tr>
<td>Copper</td>
<td>µg/L</td>
<td>3</td>
<td>0.3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Lead</td>
<td>µg/L</td>
<td>6.6</td>
<td>2.2</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>µg/L</td>
<td>23</td>
<td>7</td>
<td>20</td>
<td>14</td>
<td>17</td>
</tr>
</tbody>
</table>

#### 4.2.3 Coastal and Seabed Morphology

Harriet Point lies in low relief areas that are part of the coastal flats of Port Hedland. The coastal flats include tidal mangrove communities, younger beach and dune calcareous sands and extensive flats of mud and silt. These overly consolidated deposits of red brown silty/clayey sands of the Holocene period, which are underlain by variably cemented calcium carbonate rich deposits of the Pleistocene period (Coffey Geotechnics 2004).

**Inner Harbour**

The subtidal zone is characterised by fine mud or shell grit supporting occasional benthic flora and scattered invertebrates. This zone supports filamentous green algae, but little epifauna due to naturally high turbidity and regular disturbance through dredging. *Sargassum* algae beds are present in Stingray Creek on the eastern side of the harbour (Environ 2004).

Generally the intertidal flats within Port Hedland harbour are comprised of surficial sands, silts and clays/muds, which extend to depths of around 2.5 m and support a range of species typical of the region. The habitat has been extensively modified in these areas and comprises bare sandy silty sediments which are not conducive to supporting significant marine flora or corals due to the turbidity of the overlying waters (DALSE 2004).

Sediments within the Port Hedland harbour are relatively homogeneous and are characterised as clayey silts and silty fine sands. Examination of sediment cores collected in Port Hedland harbour since 1964 shows that beneath a shallow layer of soft, depositional material that is approximately 2 m

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\(^1\) Australia and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand
deep, the geology is comprised of stable materials with a low potential for holding contaminants (i.e. sands, quartz, consolidated and cemented materials) (Coffey Geotechnics 2004).

Coffey Geotechnics (2004) reported that the seabed north of Anderson Point near the dredge footprint at Harriet Point is comprised of unconsolidated surficial sediments extending to depths of 0.5 to 2 m CD, overlying consolidated sand/clay/gravel sediments to depths of approximately 8.0 to 10.0 m CD.

Recent geotechnical field investigations (Coffey Geotechnics 2008) within the Harriet Point dredge footprint, have recorded unconsolidated sediments to 1 m below the seabed across all sites. Some sites in the dredge footprint record unconsolidated sediments deeper than 1 m (SKM 2007b).

DMMA B1

DMMA B1 is a small bay sloping steeply on the landward side, with the upper part of the beach comprising coarse sands and detritus brought in by the tide (SKM 2008c). A small natural outcrop of rock at the northern end of the bay forms a sparse intertidal rock area, however the position within the intertidal zone suggests it is frequently exposed. To the east of the bay there lies a tidal flat at the foot of the beach which comprised sand with patches of mud.

This area has been highly modified by both infrastructure development, which includes a rock revetment wall behind the beach and infrastructure behind that, and the presence of the ship loading facilities that effectively create a barrier across the mouth of the bay.

DMMA B2

The intertidal seabed of DMMA B2 largely consists of silty sand with rocks and broken shell. The area is devoid of mangroves.

The area comprises a sandy strip of beach on the landward side. Approximately 300m from the shore in the middle of the bay is an area of hard rock pavement. On the south eastern side of the rock there is an intertidal zone approximately 50 to 75 m² in area with small depressions that allow pools of water to be trapped at low tide. The availability of permanent water as well as some hard substrate within this small area has enabled a sparse community of flora and fauna to exist, including hard and soft corals, macroalgae, sponges, anemones, sea cucumbers, feather stars, molluscs and zooanthids. However, the sessile invertebrates present are of very low relief (a few cm) within the shallow pools, suggesting that other parts of the hard substrate are uninhabitable by most invertebrates due to exposure at low tide. The area with sessile invertebrates present will be located approximately 7 m from the proposed seawall and outside DMMA B2.

DMMA A

DMMA A has been highly modified as a consequence of the construction of the Finucane Island causeway across the upper areas of the intertidal zone (SKM 2007a). The causeway has interrupted the flow of water across low points on the peninsula that linked tidal waters inside the harbour with tidal waters flowing west. Substantial alterations of tidal flow can alter existing vegetation assemblages and therefore vegetation present in DMMA A is likely to be different to that present prior to construction of the causeway (SKM 2007a).

Field investigations indicated that the area is largely made up of tidal mudflats which consist of silty to thick mud (SKM 2007a). Detailed description of the substrate and benthic habitats within DMMA A are provided in Appendix A.

Spoil Ground ‘I’

Spoil Ground ‘I’ is an existing spoil ground used by Port Hedland Port Authority (PHPA) and ranges in depth from -11 to -13 m CD. A survey of the benthic habitats of offshore and near shore reefs and adjacent islands within the Port Hedland region was undertaken between January and February 2008 by marine scientific divers (SKM 2008d). A representative area immediately adjacent to the PHPA Spoil Ground ‘I’ was surveyed in January 2008. Sediments in the survey area were predominately coarse material, consisting of broken shell fragments, with the northwest of the region characterised by fine silty sediments (Dr P Morrison, pers. comm.).
### Table 4.5 - Summary of Existing Sediment Chemistry Investigations in Port Hedland Harbour

<table>
<thead>
<tr>
<th>Proponent</th>
<th>Date</th>
<th>Study Description</th>
<th>Observations</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHPA</td>
<td>1990-2002</td>
<td>Sediments tested every 2 years for heavy metals</td>
<td>Arsenic, Cadmium, Chromium, Copper, Lead, Nickel and TBT at sites near the wharves, the tug slip way or in Stingray Creek exceeded ANZECC/ARMCANZ (2000a) trigger values.</td>
<td>PHPA</td>
</tr>
<tr>
<td>BHPBIO</td>
<td>2000, 2002</td>
<td>Sampling for BHPBIO's Products And Capacity Expansion projects</td>
<td>Nickel and chromium in sites near BHP’s port facilities were above the National Ocean Disposal Guidelines for Dredged Material (NODGDM) screening levels, but possible due to naturally high concentrations of these metals in the region. Elevated levels of iron were also recorded most likely as a result of iron ore loading in the harbour.</td>
<td>SKM</td>
</tr>
<tr>
<td>PHPA</td>
<td>2003</td>
<td>Sampling and analysis of sediments surrounding Anderson Point in the channel and intertidal zone for 14 metals, TBT, total petroleum hydrocarbons (TPH)</td>
<td>Elevated levels of iron, manganese, nickel and zinc as well as elevated TBT concentrations within sediment samples taken from sites in the channel close to Harriet Point.</td>
<td>URS</td>
</tr>
<tr>
<td>PHPA</td>
<td>2004</td>
<td>Sampling of inner harbour sediments</td>
<td>Elevated levels of petroleum hydrocarbons, but identified as typical of those associated with ‘general lubricating oil’, indicating shipping practices as the most likely source.</td>
<td>URS</td>
</tr>
<tr>
<td>FMG</td>
<td>2005</td>
<td>Sampling of sediments within FMG’s proposed dredging footprint at Anderson Point</td>
<td>Elevated levels of nickel and chromium above the NODGDM screening levels in the top 1 m of sediment. Bioavailability testing found that the bioavailability of these metals was acceptably low against ANZECC/ARMCANZ (2000a) guideline levels.</td>
<td>Oceanica</td>
</tr>
<tr>
<td>PHPA</td>
<td>2006</td>
<td>Sampling of sediments adjacent to PHPA berths no. 1, 2 and 3 at Nelson Point</td>
<td>Relatively low concentrations of heavy metals but high concentrations of TBT.</td>
<td>PHPA</td>
</tr>
</tbody>
</table>

As part of the baseline investigations carried out for the RGP5 project, sediment sampling of the unconsolidated material was carried out during September 2007 at 26 sites within the Harriet Point proposed dredge footprint (Figure 4.4).

Additional sampling was done on sediments taken from boreholes drilled during the geotechnical survey within the Harriet Point dredge footprint (Coffey Geotechnics 2008).

**Unconsolidated Sediment Results**

It was not possible to sample surficial sediments to deeper than 0.5 m due to corer refusal. Sediment samples were analysed for particle size distribution (PSD), metals, polycyclic aromatic hydrocarbons (PAHs), tributyltin (TBT), total organic carbon (TOC), elutriates and acid sulphate soils (ASS).
HARRIET POINT SEDIMENT SAMPLING SITES

Legend
- Sample Site
- Geotechnical Borehole Site
- Harriet Pt Proposed Dredging Footprint

Source:
Orthorectified Aerial Photograph - BHPBIO (15/06/2007)
Harriet Pt Footprint: F112-C-00148 Rec D 14/04/2008 (MPD JV)
Borehole Sample Sites: MPD JV 2007
Geotechnical Boreholes: MPD JV 2008

FIGURE 4.4
Sediments analysed from surface samples within the top 0.5 m of the Harriet Point dredge footprint did not exceed National Ocean Disposal Guidelines for Dredged Material (NODGDM) (Environment Australia 2002c) based on calculation of the 95% Upper Confidence Limit (UCL) of the results. The sediment layer sampled (to 0.5 m) corresponded to the point of corer refusal (where the corer met with resistance from underlying, semi-consolidated and consolidated material). Therefore, samples obtained were representative of the layer of unconsolidated surficial sediments proposed for offshore disposal. A summary of the results of this investigation is presented below (Table 4.6) and can be regarded as uncontaminated in accordance with the NODGDM.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>NODGM</th>
<th>95% UCL (0-50cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Screening</td>
<td>Maximum</td>
</tr>
<tr>
<td>Antimony</td>
<td>mg/kg</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Arsenic</td>
<td>mg/kg</td>
<td>20</td>
<td>70</td>
</tr>
<tr>
<td>Cadmium</td>
<td>mg/kg</td>
<td>1.5</td>
<td>10</td>
</tr>
<tr>
<td>Chromium</td>
<td>mg/kg</td>
<td>80</td>
<td>370</td>
</tr>
<tr>
<td>Copper</td>
<td>mg/kg</td>
<td>65</td>
<td>270</td>
</tr>
<tr>
<td>Lead</td>
<td>mg/kg</td>
<td>50</td>
<td>220</td>
</tr>
<tr>
<td>Mercury</td>
<td>mg/kg</td>
<td>0.15</td>
<td>1</td>
</tr>
<tr>
<td>Nickel</td>
<td>mg/kg</td>
<td>21</td>
<td>52</td>
</tr>
<tr>
<td>Silver</td>
<td>mg/kg</td>
<td>1</td>
<td>3.7</td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/kg</td>
<td>200</td>
<td>410</td>
</tr>
<tr>
<td>Tributyltin</td>
<td>µg/kg</td>
<td>5</td>
<td>70</td>
</tr>
<tr>
<td>Acenaphthene</td>
<td>µg/kg</td>
<td>16</td>
<td>500</td>
</tr>
<tr>
<td>Acenaphthylene</td>
<td>µg/kg</td>
<td>44</td>
<td>640</td>
</tr>
<tr>
<td>Anthracene</td>
<td>µg/kg</td>
<td>85</td>
<td>110</td>
</tr>
<tr>
<td>Fluorene</td>
<td>µg/kg</td>
<td>19</td>
<td>540</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>µg/kg</td>
<td>160</td>
<td>2100</td>
</tr>
<tr>
<td>Phenanthrene</td>
<td>µg/kg</td>
<td>240</td>
<td>1500</td>
</tr>
<tr>
<td>Low Molecular Weight PAHs</td>
<td>µg/kg</td>
<td>552</td>
<td>3160</td>
</tr>
<tr>
<td>Benzo[a]anthracene</td>
<td>µg/kg</td>
<td>261</td>
<td>1600</td>
</tr>
<tr>
<td>Benzo[a]pyrene</td>
<td>µg/kg</td>
<td>430</td>
<td>1600</td>
</tr>
<tr>
<td>Dibenzo[ah]anthracene</td>
<td>µg/kg</td>
<td>63</td>
<td>260</td>
</tr>
<tr>
<td>Chrysene</td>
<td>µg/kg</td>
<td>384</td>
<td>2800</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>µg/kg</td>
<td>600</td>
<td>5100</td>
</tr>
<tr>
<td>2-methylnaphthalene</td>
<td>µg/kg</td>
<td>70</td>
<td>670</td>
</tr>
<tr>
<td>Pyrene</td>
<td>µg/kg</td>
<td>665</td>
<td>2600</td>
</tr>
<tr>
<td>High Molecular Weight PAHs</td>
<td>µg/kg</td>
<td>1700</td>
<td>9600</td>
</tr>
<tr>
<td>Total PAH</td>
<td>µg/kg</td>
<td>4000</td>
<td>45000</td>
</tr>
</tbody>
</table>
Particle Size Distribution

Particle size within the top 0.5 m of sediment at Harriet Point can generally be described as bi-modal, with coarse sand to fine sands and a large fraction (20%) of medium silt material (Figure 4.5).

![Particle size distributions with standard error bars in the top 0.5 m of seabed from sediment samples taken within the Harriet Point dredge footprint (SKM 2007b)](image)

**Figure 4.5 - Particle size distributions with standard error bars in the top 0.5 m of seabed from sediment samples taken within the Harriet Point dredge footprint (SKM 2007b)**

Geotechnical Sediment Core Results

Historically surveys of sediment in the Port Hedland area have found unconsolidated sediment up to about 2 m. Recent investigations undertaken within Harriet Point dredge footprint have since found that unconsolidated materials is located within 1.5m of the sediment surface at most sites.

Given that sediments from the 0 to 1.5 m depth will be disposed of offshore, the analysis of sediments for land disposal was restricted to sediments greater than 1.5m depth. A summary of the results of this investigation is presented below (Table 4.7).
Table 4.7 - Summary of Geotechnical Sediment Chemistry Investigations in Harriet Point Dredge Footprint.

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Units</th>
<th>DoE Soil/Sed EIL</th>
<th>DoE Soil/Sed HIL (F)</th>
<th>ANZECC/ARMCANZ guidelines</th>
<th>1.5-14.5m</th>
<th>14.5-18.5m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ISQG-Low (Trigger value)</td>
<td>[Mean]</td>
<td>[Max]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ISQG-High</td>
<td>[Mean]</td>
<td>[Max]</td>
</tr>
<tr>
<td>Arsenic</td>
<td>mg/kg</td>
<td>20</td>
<td>500</td>
<td>20</td>
<td>70</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.0</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.3</td>
</tr>
<tr>
<td>Cadmium</td>
<td>mg/kg</td>
<td>3</td>
<td>100</td>
<td>1.5</td>
<td>10</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>Chromium</td>
<td>mg/kg</td>
<td>50</td>
<td>-</td>
<td>80</td>
<td>370</td>
<td>49.0</td>
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<tr>
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<td></td>
<td></td>
<td></td>
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<td>90.0a</td>
<td>39.4</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>51.3</td>
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<tr>
<td>Copper</td>
<td>mg/kg</td>
<td>60</td>
<td>5000</td>
<td>65</td>
<td>270</td>
<td>8.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28.0</td>
<td>9.7</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>12.4</td>
</tr>
<tr>
<td>Lead</td>
<td>mg/kg</td>
<td>300</td>
<td>1500</td>
<td>50</td>
<td>220</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.0</td>
<td>5.9</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9.0</td>
</tr>
<tr>
<td>Mercury</td>
<td>mg/kg</td>
<td>1</td>
<td>75</td>
<td>0.15</td>
<td>1</td>
<td>0.0</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td>Nickel</td>
<td>mg/kg</td>
<td>60</td>
<td>3000</td>
<td>21</td>
<td>52</td>
<td>21.6</td>
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<td></td>
<td></td>
<td>50.0a</td>
<td>19.1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23.7a</td>
</tr>
<tr>
<td>Silver</td>
<td>mg/kg</td>
<td>1</td>
<td></td>
<td>1</td>
<td>3.7</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>0.1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/kg</td>
<td>200</td>
<td>3500</td>
<td>200</td>
<td>410</td>
<td>11.9</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.1</td>
</tr>
<tr>
<td>Tributyltin</td>
<td>µg Sn/kg</td>
<td>5</td>
<td>70</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.5</td>
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</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>Total Organic Carbon</td>
<td>%w/w</td>
<td>-</td>
<td>-</td>
<td>0.1</td>
<td>1.0</td>
<td>0.1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
<td>0.025</td>
</tr>
</tbody>
</table>

* ANZECC/ARMCANZ ISQG-low trigger value exceeded.
* ANZECC/ARMCANZ ISQG-high trigger value exceeded.

Grey shading indicates DoE screening levels exceeded.

Sediments analysed from samples collected during the geotechnical survey were analysed for metals, TBT and TOC. The ANZECC/ARMCANZ (2000a) lower screening guideline for Nickel was exceeded at several sites across all depth strata, however the Ecological Investigation Levels (EIL) were not exceeded. Chromium exceeded the EIL at several sites across all depth strata.

These results are consistent with previous studies that found similar concentrations of Nickel and Chromium throughout Port Hedland harbour sediments and the surrounding area (URS 2004; Oceanica 2005; KG 2007).

The presence of Chromium and Nickel in the deep consolidated strata samples (>1.5 m) suggests that these levels are of natural origin, as already identified in previous studies within the harbour (Table 4.5). FMG (2006) investigated the background level of metals in Port Hedland sediments by normalising their results to a reference element Aluminium, an element that has no anthropogenic enrichments sources. They found that Nickel and Chromium levels were likely to represent background concentrations in the area. These results were comparable in the concentration of Chromium and Nickel to those reported in the geotechnical cores. The bioavailability of Nickel and Chromium was investigated by Oceanica (2005) during the Pilbara Iron Ore and Infrastructure project. Oceanica stated that Chromium and Nickel levels could be classified as ‘non toxic’ to biota.

Due to the observed exceedences in sediment assessment levels elutriate testing was done to examine the bioavailability of the metals.

**Elutriate testing**

Elutriate tests use a dilution of 1:4 sediment to seawater, which overestimates water quality impacts as dilution during the dredge process is approximately 1:7 (Environment Australia 2002c). As such, the procedures in Section 3.10.3 of the NODGDM have been applied to the raw elutriate data (see...
laboratory reports in Table 4.8) to predict the dilution resulting from initial mixing using the program STFATE (USEPA 1991).

Results of the elutriate tests are shown in Table 4.8. Elutriate samples were aged in the laboratory to test whether time has an impact on the elutriate metal concentrations (0 hour, 1 hour and 7 days settled).

In order to reconcile the elutriate data to the potential concentrations of metals in excess water discharged from DMMA, an overall dilution factor of 1:7 was used, corresponding to a standard level of dilution of sediment to water achieved during cutter-suction dredge operations (Environment Australia 2002c) and pumping of dredged material to DMMA. Since elutriate analyses were conducted on samples diluted at a ratio of 1:4, an overall conversion factor of 1.75 was used to convert elutriate concentrations to those expected in the excess water discharged from DMMA. All metal concentrations were below screening levels for a 90% level of ecological protection and all metals except copper were below screening levels for a 99% level of ecological protection. The excess water from DMMA A will require a further twofold dilution during excess water discharge from DMMA A in order to meet the 99% ecological protection screening guidelines for copper (ANZECC/ARMCANZ 2000a). This level of dilution is expected to occur within a very narrow mixing zone throughout most tidal cycles due to the large tidal range within Port Hedland (generally 1.5m range during neaps to 5.8m range during springs; PHPA 2003). In addition, a previous study of the water quality in and around Port Hedland Harbour, including tidal creeks (Oyster Inlet) found that background levels of copper are already high, in exceedence of both 90% and 99% ecological protection guidelines (SKM 2008b, Table 4.4). Therefore, although a twofold dilution of discharged water is achievable within a narrow mixing zone to meet 99% ecological protection guidelines, copper concentrations in water discharged from DMMA are likely to fall within background levels without any dilution.

Table 4.8 - Elutriate Analysis for Geotechnical Sediment Samples Collected from Harriet Point

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>PQL</th>
<th>HPH 1.5-14.5M</th>
<th>HPH 14.5-18.5</th>
<th>ANZECC/ARMCANZ guidelines</th>
<th>99%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 Hrs</td>
<td>1 hr</td>
<td>7 day</td>
<td>0 Hrs</td>
<td>1 Hr</td>
</tr>
<tr>
<td>Arsenic</td>
<td>µg/L</td>
<td>0.5</td>
<td>0.7</td>
<td>0.25</td>
<td>0.6</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Cadmium</td>
<td>µg/L</td>
<td>0.2</td>
<td>0.4</td>
<td>0.4</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Chromium</td>
<td>µg/L</td>
<td>0.5</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Copper</td>
<td>µg/L</td>
<td>1</td>
<td>0.5</td>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Lead</td>
<td>µg/L</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Mercury</td>
<td>µg/L</td>
<td>0.1</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Nickel</td>
<td>µg/L</td>
<td>0.5</td>
<td>0.25</td>
<td>0.5</td>
<td>0.25</td>
<td>1.9</td>
<td>2.2</td>
</tr>
<tr>
<td>Silver</td>
<td>µg/L</td>
<td>0.1</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Zinc</td>
<td>µg/L</td>
<td>5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Grey shading indicates ANZECC/ARMCANZ 99% ecological protection guideline levels exceeded.

Leachate testing

No leachate concentrations exceeded the concentration limits identified by the Landfill Waste Classification and Waste Definitions (1996). Therefore, the dredged material is suitable for land disposal. Results from the leachate tests are shown in Table 4.9.
Table 4.9 - Leachate Analyses of Geotechnical Cores using Acetic Acid Leachate and DI Water Leachate Preparation.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>PQL</th>
<th>Landfill waste class limits</th>
<th>HPBH07 1.5-14.5</th>
<th>HPBH07 14.5-18.5</th>
<th>HPBH13A 1.5-14.5</th>
<th>HPBH13A 14.5-18.5</th>
<th>HPBH10A 14.5-18.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic acid leachate preparation</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arsenic</td>
<td>mg/L</td>
<td>0.005</td>
<td>0.5</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Cadmium</td>
<td>mg/L</td>
<td>0.001</td>
<td>1</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Chromium</td>
<td>mg/L</td>
<td>0.01</td>
<td>0.5</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Copper</td>
<td>mg/L</td>
<td>0.01</td>
<td>NA</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Nickel</td>
<td>mg/L</td>
<td>0.01</td>
<td>0.2</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Lead</td>
<td>mg/L</td>
<td>0.01</td>
<td>0.5</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Antimony</td>
<td>mg/L</td>
<td>0.01</td>
<td>NA</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/L</td>
<td>0.1</td>
<td>NA</td>
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<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Silver</td>
<td>mg/L</td>
<td>0.01</td>
<td>1</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Mercury</td>
<td>mg/L</td>
<td>0.001</td>
<td>0.01</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
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<tr>
<td>DI water leachate preparation</td>
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</tr>
<tr>
<td>Arsenic</td>
<td>mg/L</td>
<td>0.001</td>
<td>NA</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Cadmium</td>
<td>mg/L</td>
<td>0.001</td>
<td>0.5</td>
<td>0.002</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.002</td>
</tr>
<tr>
<td>Chromium</td>
<td>mg/L</td>
<td>0.001</td>
<td>0.5</td>
<td>0.008</td>
<td>0.001</td>
<td>0.023</td>
<td>0.007</td>
<td>0.005</td>
</tr>
<tr>
<td>Copper</td>
<td>mg/L</td>
<td>0.001</td>
<td>NA</td>
<td>0.001</td>
<td>0.001</td>
<td>0.002</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Nickel</td>
<td>mg/L</td>
<td>0.001</td>
<td>0.5</td>
<td>0.002</td>
<td>0.001</td>
<td>0.002</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Lead</td>
<td>mg/L</td>
<td>0.001</td>
<td>NA</td>
<td>0.017</td>
<td>0.003</td>
<td>0.013</td>
<td>0.007</td>
<td>0.009</td>
</tr>
<tr>
<td>Antimony</td>
<td>mg/L</td>
<td>0.0001</td>
<td>0.01</td>
<td>0.0002</td>
<td>0.0001</td>
<td>0.0002</td>
<td>0.0001</td>
<td>0.0002</td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/L</td>
<td>0.001</td>
<td>0.2</td>
<td>0.008</td>
<td>0.001</td>
<td>0.016</td>
<td>0.006</td>
<td>0.004</td>
</tr>
<tr>
<td>Silver</td>
<td>mg/L</td>
<td>0.01</td>
<td>1</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Mercury</td>
<td>mg/L</td>
<td>0.005</td>
<td>NA</td>
<td>0.058</td>
<td>0.018</td>
<td>0.069</td>
<td>0.049</td>
<td>0.031</td>
</tr>
</tbody>
</table>

4.2.5 Acid Sulphate Soils

Desktop information collected from historical investigations conducted in the area and documentation available in the public domain (e.g. the Acid Sulphate Soil Risk Maps developed by the West Australian Planning Commission, Planning Bulletin 64), indicates that PASS may be present within the project footprint.

The WAPC Planning Bulletin 64 is not intended to provide site specific ASS information and the depth to ASS layer can vary greatly from site to site (Figure 4.6).
ACID SULPHATE SOIL RISK MAPPING WITHIN THE VICINITY OF MANAGEMENT AREAS FOR DREDGED MATERIAL

Legend
- Dredged Material Management Area
- DMMA Construction Footprint

Acid Sulphate Soils
- High to moderate risk
- Moderate to low risk
- No known risk

Source:
- Orthorectified Aerial Photograph: BHPBIO (15/06/2007)
- Acid Sulphate Soils: DEC (27/05/2008)
- Reclamation Areas (MPD JV):
  - A: F112-C-00151 Rev C (Modified 19/06/2008)
  - B2 Seawall: F112-CSK-01004_B (Modified 25/06/2008)

Rev No. 2
Project: WV03418
Drawn: 01/07/2008
Drawing: WV03418_G_051_2
Historically, limited information has been gathered regarding the presence, extent and distribution of PASS in dredged material from Port Hedland. Results from previous investigations (SKM 2002; Oceanica 2005; URS 2006a and 2006b; Coffey Geotechnics 2008), have confirmed the presence of PASS in the marine harbour sediments. Specifically, PASS appears to be isolated to the most recent Holocene (the last 10,000 years) deposits. For the Inner Harbour area at Port Hedland, these Holocene deposits generally represent the top 1 to 2 m of the seabed.

Field investigations were undertaken on surficial sediments (0.5 m), which identified the presence of PASS within the Harriet Point dredging footprint. Samples were also taken at depth during geotechnical investigations by Coffey Geotechnics. These identified the presence of PASS in the Harriet Point dredging footprint.

The Coffey Geotechnics investigations included sediment sampling at various intervals from 8 boreholes located in the dredging footprint area at Harriet Point and were analysed for the Chromium Reducible Sulphur ($S_{Cr}$) Suite. This suite identifies both PASS and AASS.

The data indicated that for the most part, PASS is contained within the upper few metres of the sediment profile in the Holocene mud; however, some PASS was recorded at depths of up to 4 m below seabed. No actual acidity within the soil profiles was recorded, possibly indicating that any actual acidity that had been generated was dispersed or neutralised in situ over time by the calcareous nature of the sediments.

Assessment of the acid neutralising capacity (ANC) of the surficial mud and the consolidated NASS materials beneath these has been made. The ANC of the soil samples ranged from near 0 to 21.7 (expressed as percent sulphur w/w). These values were associated with the shallower sands and mud at depths of 2 m or less. The depth distribution is shown in Figure 4.7.

![Figure 4.7 - Depth Distribution of Acid Neutralising Capacity s-ANCe](image)

The results show that the calcium carbonate concentrations of the samples are as high as 21.7 indicating that if calcium carbonate is of adequate particle size then this would neutralise any excess acidity generated. If the particle size of the calcium carbonate is large, then the effectiveness of the neutralisation would be reduced. The effectiveness of the calcium carbonate (determined by ANC in the laboratory) may be higher than experienced during dredging operations. This is due to the fact that the laboratory methods utilised for determined ANC involves the crushing of the calcareous material resulting in a smaller PSD than would be experienced during dredging operations. It is also expected that sea water will provide some neutralising capacity.
Core logs

In general, the core descriptions from the Coffey Geotechnics investigations indicated a generalised shallow subsurface profile which is presented in Table 4.10 below:

Table 4.10 - Generalised Sub-Surface Profile

<table>
<thead>
<tr>
<th>Layer/Unit</th>
<th>Typical Elevation of Top of Layer (m CD)</th>
<th>Typical Layer Thickness (m)</th>
<th>Description/Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 to 6</td>
<td>0.3</td>
<td>Marine Mud, typically dark brown to grey, sandy with some shell fragments, locally fine to medium sand.</td>
</tr>
<tr>
<td>2</td>
<td>6.4</td>
<td>6.5</td>
<td>Red beds – predominantly very weak to weak, red brown, weakly cemented calcareous sandstone, locally siltstone or claystone, locally with palygorskite.</td>
</tr>
<tr>
<td>3</td>
<td>13.9</td>
<td>5.5</td>
<td>Calcareous Conglomerate – medium to high strength, pinkish brown, very highly cemented, medium to coarse grained with predominantly clay matrix, variable authigenic carbonate concentration, locally with palygorskite.</td>
</tr>
<tr>
<td>4</td>
<td>19.4</td>
<td>Undetermined</td>
<td>Calcareous Sandstone – medium to high strength, reddish brown, highly cemented, fine to coarse grained, localised authigenic carbonate concentration.</td>
</tr>
</tbody>
</table>

(Adapted from Coffey Geotechnics 'Interim Geotechnical Report', 2008)

Laboratory Analyses

Laboratory analysis (conducted by NATA accredited laboratory) of samples taken from cored holes and near surface samples within the proposed dredge area footprint, have been assessed for the presence of ASS. Of the boreholes and locations sampled, a number of occurrences of PASS were detected, with some Chromium Reducible Sulphur (SCr) PASS values ranging from 0.057% to 0.73% (these levels are above the DEC action criteria of 0.03% w/w, for storage of ASS in above ground stockpiles). No AASS were detected in any of the sediment samples.

It should be noted that a sample recorded oxidisable sulphur content above the action criteria, below 2.0 m. This sample was reportedly taken at a depth of 4.0 m below sea bottom. The sampling location was re-sampled to confirm if this result was an anomaly due to its inconsistency with the other results. The re-sampling indicated that the sample did not exceed the action criteria and all PASS results that exceeded the action criteria were within the top 2.0 m of the seabed.

Figure 4.8 outlines the vertical distribution of PASS reported for all of the boreholes.
4.3 BIOLOGICAL MARINE ENVIRONMENT

4.3.1 Marine Habitats

The marine habitats found in Port Hedland are typical of those found on arid coastlines. Typically, the dense stands of mangroves only occupy those areas of the intertidal zone where tidal inundation is sufficiently frequent to maintain adequate sediment water content and levels of salinity for colonisation by mangroves. As distance from the waterline increases, the height and cover of vegetation decreases and mangroves usually disappear altogether, giving way to salt marsh and then bare tidal flats as sediments become dryer and more saline (Saenger 2002). Some areas between the mangrove and samphire dominated habitats of the upper intertidal zone may support cyanobacterial mats under suitable conditions (Paling et al. 1989; Paling 2003). At the upper limit of the intertidal zone, where there is some hinterland relief, (e.g. created by dunes or limestone ridges), there is often a thin band of mangroves supported by groundwater discharge.

The distribution of mangroves, salt marsh plants and bare tidal flats in the upper intertidal areas of Port Hedland Harbour is a mosaic that reflects a variety of factors and these have been described in detail by Semeniuk (1994; 1996). Interspersed among the intertidal habitats are many ‘islands’ of supratidal vegetation (Paling et al. 2003) where the elevation is sufficiently high to allow colonisation by terrestrial plants (Section 5).

Mangroves

The Inner Harbour and the Port Hedland area in general, are surrounded by large areas of arid zone mangroves associated with tidal creeks flowing into the harbour and along the coastline. These mangroves are the dominant BPPH recorded in the Port Hedland area and currently comprise an area of approximately 16.37 km² within the harbour (VCSRG 2007).

Seven mangrove species occur within the Port Hedland area including:

- *Avicennia marina*;
• Aegialitis annulata;
• Aegiceras corniculatum;
• Bruguiera exaristata;
• Ceriops tagal;
• Osbornia octodonta [only occurs in specific localised habitats within the Port Hedland region (VCSRG 2007)]; and
• Rhizophora stylosa.

The general assemblages of mangroves in the Port Hedland region are:
• A. marina low forest to scrub;
• Mixed A. marina and R. stylosa low forest to scrub;
• R. stylosa low forest to scrub;
• A. marina scrub to open heath, grading to low heath and low open heath;
• C. tagal scrub to closed heath to open heath;
• Mixed C. tagal and A. marina scrub and heath;
• Scrub, to heath to open heath of mixed A. marina, R. stylosa, B. exaristata, C. tagal, A. annulata and locally O. octodonta; and
• Mixed A. annulata, A. corniculatum and A. marina (VCSRG 2007).

Salt marshes (samphires) / supratidal mudflats
A salt marsh is a type of marsh that is a transitional intertidal between land and salty or brackish water (e.g. in bays and estuaries). It is dominated by halophytic (salt tolerant) herbaceous plants (e.g. samphires).

Generally, field observations undertaken to support the Harriet Point Dredging Program indicated that the drier conditions support the saline salt marshes and samphires with a progression to mangroves in wetter conditions and closer to creek beds.

Salt marsh species are located within DMMA A. The salt marsh habitat within DMMA A was dominated by the samphire species Halosarcia halocnemoides while Halosarcia indica was present in areas where the substrate was drier.2

Cyanobacterial mats
Paling et al. (2003) noted that some areas, such as between the mangrove and samphire dominated zones of the upper intertidal, may support cyanobacterial mats under suitable conditions. Field investigations supported this conclusion and observed that there were relatively small patches of cyanobacterial mats located among samphires in wet conditions primarily in DMMA A.

Additionally patches of cyanobacterial mats were also identified within DMMA B1 and B2. In particular within DMMA B1, a consistent 5-10 m wide band of cyanobacterial mat was observed in the middle of the bay, running parallel to the shore.

Coral
Corals are very sparsely distributed in close proximity to the harbour area of Port Hedland. The closest corals exist within rocky outcrops and platforms fringing the north-eastern shore of Finucane Island, and a small area outside DMMA B2.

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2 The genus which includes samphires has been recently reclassified. Tecticornia indica and Tecticornia halocnemoides were previously identified as Halosarcia indica and Halosarcia halocnemoides. In 2007, the genus Halosarcia, along with three other Australian genera (Pachycornia, Sclerostegia and Tegicornia) was incorporated into the genus Tecticornia (APNI 2008). However, the genus Halosarcia is still current within the DEC FloraBase database (Florabase 2007). Therefore we apply the older generic name Halosarcia.
A qualitative survey by URS (2005) described the habitat along northeast Finucane Island, as a rocky reef with the corals aggregated around large bommies. The intertidal rocky platform was characterised by sinkholes of various sizes and depths. Within many of the holes were coral colonies, typically Turbinaria with favids and medium-sized Porites bommies. Small colonies of ascidians and hydrozoans were also present in low densities and algae and sponges were growing on protruding rocks and substrate between the bommies.

Recent baseline surveys undertaken as part of the proposed BHPBIO Outer Harbour Development indicate that the benthic habitat offshore from Port Hedland is characterised by extensive plains of sand/silt substratum and ridge lines of hard pavement (often covered in a layer of sand/silt). Offshore ridge lines support occasional patches of sparse biota, including macro-algal beds, hard corals, sponges and soft corals (e.g. gorgonians, sea whips). Hard coral habitat, dominated by the genus Turbinaria has been found on hard substrate, principally offshore (beyond the 10 m contour), and also nearshore (between shore and the 10 m contour). The genera Porites and Acropora were also found at some of these locations. Nearer to the coastline, a few small colonies of Turbinaria were observed in highly turbid water near Weerdee and Downes Islands. Extensive diving surveys carried out as part of the proposed BHPBIO Outer Harbour Development indicated that a sand/silt plain extended several kilometres in all directions from Spoil Ground ‘I’.

Seagrass

Walker and Prince (1987) have recorded four seagrass species in areas adjacent to Port Hedland, namely: Thalassia hemprichii, Halodule uninervis, Halophila ovalis and Halophila decipiens. However, during benthic habitat surveys carried out by SKM offshore from Port Hedland, only low-density patches of seagrass were found, dominated by Halophila sp. and H. uninervis. Both of these species are temporarily variable with high turnover rates. No significant seagrass beds (>10% cover) were observed at any of the sites surveyed (SKM 2007a). In addition, surveys of inshore areas potentially affected by proposed dredging activities, including DMMA B1 and B2 as well as the estuary adjacent to DMMA A revealed no significant seagrass beds (SKM 2007a).

Macroalgae

The macroalgae of northwest Western Australia are not well known (Huisman 2004). One of the most prolific groups of macroalgae present in the Pilbara region is the genus Sargassum (Huisman 2004). These plants exhibit a pattern of annual growth followed by senescence, with individual plants attaining lengths of 3 m by late summer before breaking off above the holdfast in early winter. The detached Sargassum form large floating rafts, some of which drift ashore while others are carried offshore by tidal and wind induced surface currents. These algae are known to occur on the shoals offshore from Port Hedland (LeProvost et al. 1984). During field investigations undertaken by SKM (2008c) it was noted that a small amounts of macroalgae were also present within DMMA B2 and described in more detail in Section 4.3.2 below. In addition, some macroalgae were present on the rocky reef community at northeast Finucane Island.

4.3.2 Marine Habitats within the Project Area

The proposed Harriet Point Dredging program will operate across a range of intertidal and subtidal areas. The following description of the existing habitats has concentrated on areas that may potentially be affected by the proposed dredging and disposal activities. Figure 4.9 to Figure 4.12 provide an overview of the marine BPPH in the project area.

Intertidal habitats within DMMA include mangroves, salt marsh (e.g. samphires), cyanobacterial mats and bare tidal flats. Spoil Ground ‘I’ is located approximately 11 km offshore in 13 m of water where the seabed consists of combination of rock and sandy habitat. For the purposes of this study, mangroves, samphires, and cyanobacterial mats are referred to as BPPH due to their role as primary producers in their local environment.

Dredge Footprint at Harriet Point

The Harriet Point dredge footprint is approximately 29 ha and comprises:

- 0.44 ha of landward A. marina forest;
- 1.64 ha of seaward A. marina forest;
- 0.06 ha of scattered A. marina;
• 0.89 ha of *R. stylosa* forest; and
• 0.05 ha of mixed *A. marina/R. stylosa*.

Field investigations indicated that this area is dominated by mangroves species *A. marina* and *R. stylosa* ranging from closed canopy to open heath scrub with transitional areas between the two assemblage types. *A. marina* ranged in size mainly from 0.5 m to a taller forest at the most seaward edge with trees to 7 m. *R. stylosa* ranged from 1 to 6 m. Other less dominant mangroves included a fringe of *A. corniculatum* rising up to 2.5 m at site 8 (Figure 4.9) and a few small *C. australis* (0.3 to 0.5 m) at sites 4 and 13.

Examination of aerial photography showed that the mangroves on Harriet Point range from closed canopy stands fringing the channels on both sides of the point, to less dense coverage moving further landward. The aerial photography also showed apparent changes in species composition between the edge of the channel and the landward extent of mangroves and was validated in the field.

The classification scheme developed by VCSRG (2007) was used for the SKM (2007a) survey results from the Harriet Point dredge area as it included a comprehensive mapping exercise of Harriet Point. The classification developed for Harriet Point and nearby areas developed by VCSRG (2007) and confirmed by the field survey is shown in Figure 4.9.
FIGURE 4.9

MARINE HABITAT TYPES FOR HARRIET POINT

Legend

- Ground Truthing Locations (SKM, 2008)
- Harriet Pt Dredge Footprint
- Habitat (Seminiuk 2007a, SKM 2008a)
  - Closed Forest/Scrub, Rhizophora stylosa
  - Disturbed Terrain (mainly sand)
  - Forest/Scrub, Avicennia marina
  - Open Heath/Scrub, Avicennia marina
  - R. Stylosa and Avicennia marina
  - Salt flat (mud on limestone pavement)
  - Sand Bar
  - Sand veneer on Limestone
  - Limestone Ridge

A.marina and extensive bioturbation at HP-3

HP-5 showing development of closed canopy A.marina forest

HP-5 looking to north west with stand of R.stylosa forest

An emergent limestone ridge on the seawards edge of the mangrove between HP-7 and HP-3

Typical large A.marina at HP-7

View back toward HP-7

A.marina grove with thick carpet of pneumatophores

Scrub forest of R.stylosa between HP-9 and HP-10

Transitional area with R.stylosa and A.marina

Edge of bare tidal flat with A.marina and C.Australis at HP-13

Legend

- Ground Truthing Locations (SKM, 2008)
- Harriet Pt Dredge Footprint
- Habitat (Seminiuk 2007a, SKM 2008a)
  - Closed Forest/Scrub, Rhizophora stylosa
  - Disturbed Terrain (mainly sand)
  - Forest/Scrub, Avicennia marina
  - Open Heath/Scrub, Avicennia marina
  - R. Stylosa and Avicennia marina
  - Salt flat (mud on limestone pavement)
  - Sand Bar
  - Sand veneer on Limestone
  - Limestone Ridge

A.marina and extensive bioturbation at HP-3

HP-5 showing development of closed canopy A.marina forest

HP-5 looking to north west with stand of R.stylosa forest

An emergent limestone ridge on the seawards edge of the mangrove between HP-7 and HP-3

Typical large A.marina at HP-7

View back toward HP-7

A.marina grove with thick carpet of pneumatophores

Scrub forest of R.stylosa between HP-9 and HP-10

Transitional area with R.stylosa and A.marina

Edge of bare tidal flat with A.marina and C.Australis at HP-13

Legend

- Ground Truthing Locations (SKM, 2008)
- Harriet Pt Dredge Footprint
- Habitat (Seminiuk 2007a, SKM 2008a)
  - Closed Forest/Scrub, Rhizophora stylosa
  - Disturbed Terrain (mainly sand)
  - Forest/Scrub, Avicennia marina
  - Open Heath/Scrub, Avicennia marina
  - R. Stylosa and Avicennia marina
  - Salt flat (mud on limestone pavement)
  - Sand Bar
  - Sand veneer on Limestone
  - Limestone Ridge

A.marina and extensive bioturbation at HP-3

HP-5 showing development of closed canopy A.marina forest

HP-5 looking to north west with stand of R.stylosa forest

An emergent limestone ridge on the seawards edge of the mangrove between HP-7 and HP-3

Typical large A.marina at HP-7

View back toward HP-7

A.marina grove with thick carpet of pneumatophores

Scrub forest of R.stylosa between HP-9 and HP-10

Transitional area with R.stylosa and A.marina

Edge of bare tidal flat with A.marina and C.Australis at HP-13

Legend

- Ground Truthing Locations (SKM, 2008)
- Harriet Pt Dredge Footprint
- Habitat (Seminiuk 2007a, SKM 2008a)
  - Closed Forest/Scrub, Rhizophora stylosa
  - Disturbed Terrain (mainly sand)
  - Forest/Scrub, Avicennia marina
  - Open Heath/Scrub, Avicennia marina
  - R. Stylosa and Avicennia marina
  - Salt flat (mud on limestone pavement)
  - Sand Bar
  - Sand veneer on Limestone
  - Limestone Ridge

A.marina and extensive bioturbation at HP-3

HP-5 showing development of closed canopy A.marina forest

HP-5 looking to north west with stand of R.stylosa forest

An emergent limestone ridge on the seawards edge of the mangrove between HP-7 and HP-3

Typical large A.marina at HP-7

View back toward HP-7

A.marina grove with thick carpet of pneumatophores

Scrub forest of R.stylosa between HP-9 and HP-10

Transitional area with R.stylosa and A.marina

Edge of bare tidal flat with A.marina and C.Australis at HP-13

Legend

- Ground Truthing Locations (SKM, 2008)
- Harriet Pt Dredge Footprint
- Habitat (Seminiuk 2007a, SKM 2008a)
  - Closed Forest/Scrub, Rhizophora stylosa
  - Disturbed Terrain (mainly sand)
  - Forest/Scrub, Avicennia marina
  - Open Heath/Scrub, Avicennia marina
  - R. Stylosa and Avicennia marina
  - Salt flat (mud on limestone pavement)
  - Sand Bar
  - Sand veneer on Limestone
  - Limestone Ridge
DMMA A

The construction footprint of DMMA A comprises approximately 85 ha and is located on the western side of BHPBIO’s existing infrastructure corridor to Finucane Island. Data and photographs were recorded at 11 sampling points within DMMA A to document the occurrence of intertidal BPPH. Investigations found that there is approximately 3.12 ha of sparse mangrove *Avicennia marina*, approximately 0.05ha of closed forest of *A. marina* and approximately 11.19 ha of samphire-dominated saltmarsh found within the proposed footprint.

Within DMMA A, *A. marina* shrubs are up to 2 m in height interspersed with samphires. The dominant samphire species present are *Halosarcia halocnemoides ssp. tenuis* with *Halosarcia indica* present in areas where the substrate was drier.

Water flow to DMMA A has been substantially modified due to the construction of the Finucane Island causeway and the construction of a large drainage channel to the south-west. This is likely to have influenced the present vegetation composition in DMMA A in comparison to the type of vegetation that might have existed previously. However, due to being located on the western side of the causeway and outside the inner harbour area, DMMA A is relatively undisturbed in comparison to other areas within the Port Hedland region (SKM 2007a).

More details of the findings from each of these sampling locations are described in the BPPH assessment carried out by SKM in Appendix A.

For the mapping BPPH within DMMA A the following vegetation associations and habitats were developed.

- tidal flat – comprising areas either devoid of vegetation altogether, or with vegetation occurring at very low densities and no evidence of the presence of cyanobacterial mats;
- samphire dominated – comprising areas predominantly of *Halosarcia halocnemoides* with some associated species such as *Halosarcia indica* and in which scattered individuals of the mangrove *Avicennia marina* may also be present;
- sparse *A. marina* – comprising scattered individuals of the mangrove *A. marina*, often with scattered samphires;
- supratidal – comprising the supratidal islands described by Paling et al. (2003) and typically vegetated with one or more of the vegetation types described by Craig (1983);
- forest / scrub *A. marina* – comprising of the mangrove *A. marina*; and
- modified creek channel – featuring no vegetation.

A habitat map for DMMA A produced using this vegetation classification system is shown in Figure 4.10.
FIGURE 4.10
MARINE HABITAT TYPES FOR DREDGED MATERIAL MANAGEMENT AREA A

Legend
- Boundary locations of Area A
- DMBA A Construction Footprint
- Dredged Material Management Area A

Habitat Classification (SKM 2008)
- Forest/scrub, Avicennia marina
- Samphire dominated
- Sparse Avicennia marina
- Supratidal
- Total flat
- Modified Creek Channel

Source:
Orthorectified Aerial Photograph 15/06/2007 (BHPBIO)
Reclamation Areas (MPD JV) A: F112-C-00151 Rev C, Modified 20/06/2008
Construction Footprint: 11/07/2008 (MPD JV)
Datum: GDA94
Map Grid: MGA94 Zone 50

Photographs taken at boundary locations of construction footprint of Area A are indicative of habitat types within Area A.

A. marina (A8 view SE)
C. marina (AB view SE)
Isolated A. marina (A1)
Mangroves along creek channel (A1 view west)
Sparse A. marina (Pedestrian footbridge across conveyor system)
Samphires (A9)
Samphires (A11)
Isolated A. marina (A1)
A. marina along edge of rocks (A1)
Mangroves along creek channel (A1 view west)
DMMA B1

DMMA B1 comprises approximately 26 ha of essentially highly modified tidal flats with very little mangrove or other BPPH. It is a small bay with a steeply sloping sandy shoreline on the eastern end of Finucane Island and is surrounded by infrastructure associated with BHPBIO’s existing port operations.

During recent field investigations undertaken by SKM in May 2008, 17 sites were surveyed for BPPH. The shoreline consisted of a rock pavement/rubble and muddy sand with a small strip of sandy beach on the landward side. Patches of cyanobacterial algal mat were observed in the area with a consistent band running in the middle of the bay extending for 5 to 10 m running parallel to the shore. No significant development of BPPH or encrusting fauna was observed on the rock pavement area most likely due to the position within the intertidal zone where it is frequently exposed.

A small grove of *Avicennia marina*, approximately 0.24 ha, was observed in the southern end of the bay consisting of about a dozen well developed trees. According to local sources, these have established themselves within the last decade or so (Appendix A). A habitat map for DMMA B1 is shown in Figure 4.11.
FIGURE 4.1

HABITAT TYPES OF DREDGED MATERIAL MANAGEMENT AREA B1

Datum: GDA94
Map Grid: MGA94 Zone 50

Scale @ A4: 1:4,000

Source:
Orthorectified Aerial Photograph: 15/06/2007 (BHPBIO)
Reclamation Areas (MPD JV)

B1: DES Seawall_Recl Both_Opt1 3d.dxf, 29/04/2008

Rock Pavement (Shoreline)

Red Algae: approximately 5-10 m band running parallel to shoreline

Macroalgae - Small Patch

Rock Shoreline with Sand, Gravel Beach to North

Sandy Beach with Rock

Macroalgae - Mangrove to South West

Sandy Mud with Broken Shell, Single Mangrove to West

Macroalgae - Mangrove to South West

Sears Mgd with Broken Shell, Single Mangrove to West
DMMA B2

DMMA B2 is a small bay which comprises an area of approximately 19 ha located north of DMMA B1. An assessment of benthic habitat was undertaken in DMMA B2 by SKM in May 2008 at 26 locations. It was generally noted that the area was comprised of silty mud at its southern end, sand in the middle and northern sections and pavement and rock at the northern end. The area also included a sandy strip of beach on the landward side but was devoid of mangroves.

In the middle of the bay approximately 300 m from the shore, an area of hard jagged rock approximately 500 to 600 m² in area and rising about two to three metres above the low tide mark was observed. This area is locally known as ‘flat rock’ and is essentially an outcrop that is approximately 25 m in diameter. The rock area was encrusted by barnacles, rock oysters and molluscs and some cyanobacterial algal mats and macroalgae.

On the south eastern side of ‘flat rock’ there is an intertidal zone approximately 50 to 75 m² in area with small depressions that allow pools of water to be trapped at low tide. This area will be located approximately 7m outside the proposed seawall construction footprint for DMMA B2. The availability of permanent water within shallow pools in the substratum has enabled some flora and fauna to exist, including hard and soft corals, macroalgae, sponges, anemones, sea cucumbers, feather stars, molluscs and zooanthids. The dominant corals were mostly members of the families Portidae and Faviidae and were generally small (less than 10 cm in diameter). The small size of the colonies present indicated a high level of turnover, probably related to susceptibility to mortality from the particularly harsh environment - very shallow, turbid water close to an estuary outflow and likely to be inundated by freshwater plumes during wet weather events. Little biota was identified on any of the hard substratum outside of these pools. This suggests that, while larger areas of hard substratum exist adjacent to DMMA B2, only the small area where shallow depressions in the hard substratum allow water to pool at low tide would be considered BPPH. A habitat map for DMMA B2 is shown in Figure 4.12.
FIGURE 4.12

HABITAT TYPES OF DREDGED MATERIAL MANAGEMENT AREA B2

Source: Orthorectified Aerial Photograph: 15/06/2007 (BHPBIO)
Reclamation Area (MPD JV)
B2: DES Seawall Recl Both Opt1 3d.dxf, 29/04/2008
Datum: GDA94
Map Grid: MGA94 Zone 50
Scale @ A4: 1:4,000
Offshore Spoil Ground ‘I’

Spoil Ground ‘I’ is located approximately 11 km offshore in 13 m of water where the seabed consists of a combination of rock and sandy habitat. Due to the disposal ground’s historical and continued use as an area for disposal of dredged material, this area does not support any BPP of significance due to the lack of available hard substrate for colonisation by corals and macroalgae, and the shifting nature of the sediments which pose a significant challenge for colonisation by seagrasses (GHD 2007). The majority of biota present within Spoil Ground ‘I’ are invertebrate infauna (GHD 2007). A representative area immediately adjacent to PHPA Spoil Ground ‘I’ was surveyed by SKM divers in January 2008 (SKM 2008c). The areas surveyed were typically barren with limited benthic biota observed. In addition, no notable BPPH or feeding grounds for higher trophic level organisms were recorded.

4.3.3 Marine Fauna

The Port Hedland harbour lies at the southern edge of the great biogeographical region of the tropical Indo-West Pacific. Marine fauna species located within the Port Hedland harbour are characteristic of this region; however, the diversity of species present reflects the highly disturbed nature of the harbour.

A search of the DEWHA Protected Matters Search Tool was carried out within Port Hedland harbour and along a path to Spoil Ground ‘I’. The search identified a number of marine species that potentially could occur in these areas both inside and outside the harbour. The results are presented in Table 4.11 and Table 4.12 in the following sections. Further details of the search report and the area can be seen in Appendix G.

Mangrove areas support much of the marine fauna present in the harbour. The mangroves typically provide nurseries for juvenile fish and crustaceans (CSIRO 2001). Nektont (mainly fish), reptiles, invertebrate benthos and avifauna invade the mangrove zone at high tide to feed (VCSRG 2007). Invertebrates that are strongly associated with the mangrove communities include mud whelks (Terebralia spp.), fiddler crabs (Uca coactarta flammula) and a variety of insects and spiders (Hutchings and Recher 1982). Mangrove sediment infauna includes polychaete worms, annelid worms, flatworms and a range of molluscs (Hutchings and Recher 1982).

Marine Reptiles

Table 4.11 - Reptile Species identified in the Environment Protection and Biodiversity Conservation Act (EPBC Act) Protected Matters Search Tool to occur within the Port Hedland Harbour and the Route to Spoil Ground ‘I’

<table>
<thead>
<tr>
<th>Species</th>
<th>Status</th>
<th>Type of Presence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caretta caretta</td>
<td>Endangered / Migratory</td>
<td>Species or species habitat may occur within area</td>
</tr>
<tr>
<td>Loggerhead Turtle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chelonia mydas</td>
<td>Vulnerable / Migratory</td>
<td>Species or species habitat may occur within area</td>
</tr>
<tr>
<td>Green Turtle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dermochelys coriacea</td>
<td>Vulnerable / Migratory</td>
<td>Species or species habitat may occur within area</td>
</tr>
<tr>
<td>Leatherback Turtle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eretmochelys imbricata</td>
<td>Vulnerable / Migratory</td>
<td>Species or species habitat may occur within area</td>
</tr>
<tr>
<td>Hawksbill Turtle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natator depressus</td>
<td>Vulnerable / Migratory</td>
<td>Breeding likely to occur within area</td>
</tr>
<tr>
<td>Flatback Turtle</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Marine reptiles that could potentially occur in the study area include turtles, sea snakes and the salt water crocodile (*Crocodylus porosus*). Crocodiles, however, are considered uncommon in the Port Hedland area.

Five species of marine turtles are known from the Pilbara region and are all protected under the EPBC Act 1999:
- *Chelonia mydas* (green);
- *Caretta caretta* (loggerhead);
Within the Port Hedland area, Cemetery Beach, Pretty Pool and Cooke Point have been identified as flatback turtle nesting habitats by recent investigation undertaken by Pendoley Environmental Pty Ltd. However there are no sandy nesting habitats for flatback, green or hawksbill turtles within the harbour (Pendoley Environmental 2008). The estimated nesting population for flatback turtles at Port Hedland is very small (<6 % of Pilbara breeding unit) in comparison to other rookeries at Montebello Islands, Barrow Island, 80 Mile Beach, Mundabullangana Station, and the Dampier Archipelago (Pendoley Environmental 2008).

Green or flatback turtle hatchlings do not actively swim in the harbour or use mangroves as nursery habitat. Green turtle hatchlings have been found to use offshore pelagic habitat as nursery habitat (Pendoley Environmental 2008). It is unlikely that adult green turtles utilise harbour waters for foraging due to the lack of seagrass and algae beds. Similarly, flatback and hawksbill turtles favour seapen, hard and soft coral habitat and as harbour waters are unlikely to support these it is unlikely that adult flatback and hawksbill turtles would use the harbour for foraging (Pendoley Environmental 2008).

Limited anecdotal reports indicate that juvenile flatback turtles do not use the waters within the harbour but these are yet to be confirmed by qualified scientists (Pendoley Environmental 2008). Juvenile hawksbill turtles are not expected to occur in the harbour as they typically use coral reef habitat which does not occur within the harbour. Juvenile green turtles, however, have been observed to routinely forage in the waters of the harbour and the surrounding mangrove creeks. They utilise the seaward fringes of the mangrove habitat, remaining on the periphery of the root system, presumably to avoid the risk of entanglement and drowning in the densely tangled mangrove root systems (Pendoley Environmental 2008).

The proximity of the ship loading berth, the stockpiles and conveyor system suggest that it is unlikely the beach adjacent DMMA B2 is utilised by marine turtles for nesting purposes. The rock revetment at the back of the beach effectively sits on the area that, historically, may have been used for nesting prior to the installation of these existing facilities.

Of the 22 species of seasnakes found in Western Australian waters, at least 11 have been reported from the Pilbara region (Storr et al. 2002). Their abundance and distribution in the Port Hedland area has not previously been described. However, significant numbers of Stokes Sea Snakes (Astrotia stokesii) have been observed during recent offshore marine surveys undertaken by SKM.

**Marine Mammals**

Thirty-six species of whales and dolphins are known from Western Australia’s tropical and sub-tropical waters (CALM 2000). Although the distribution and abundance of these species are not well known in Port Hedland area, the EPBC Act Protected Matters Search Tool has identified the marine mammal species in Table 4.12 as potentially occurring and/or migrating through the Port Hedland surrounds.
Table 4.12 - Marine Mammals Identified by the EPBC Act Protected Matters Search Tool to occur within the Port Hedland Harbour and the Path to Spoil Ground 'I'

<table>
<thead>
<tr>
<th>Species</th>
<th>Status</th>
<th>Type of Presence</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Megaptera novaengliae</em> Humpback Whale</td>
<td>Vulnerable</td>
<td>Species or species habitat known to occur within area</td>
</tr>
<tr>
<td><em>Balaenoptera musculus</em> Blue Whale *</td>
<td>Endangered</td>
<td>Species or species habitat may occur within area</td>
</tr>
<tr>
<td><em>Sousa chinensis</em> Indo-Pacific Humpback Dolphin</td>
<td>Migratory</td>
<td>Species or species habitat may occur within area</td>
</tr>
<tr>
<td><em>Tursiops aduncus</em> (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin</td>
<td>Migratory</td>
<td>Species or species habitat likely to occur within area</td>
</tr>
<tr>
<td><em>Balaenoptera edeni</em> Bryde’s Whale</td>
<td>Migratory</td>
<td>Species or species habitat may occur within area</td>
</tr>
<tr>
<td><em>Dugong dugon</em> Dugong</td>
<td>Migratory</td>
<td>Species or species habitat likely to occur within area</td>
</tr>
<tr>
<td><em>Orcinus Orca</em> Killer Whale, Orca</td>
<td>Migratory</td>
<td>Species or species habitat may occur within area</td>
</tr>
</tbody>
</table>

* listed only as occurring in path to Spoil Ground ‘I’

Of the large cetaceans found off the Pilbara coast, humpback whales are of most interest for the proposal as they undertake regular migration offshore from the Pilbara. Each year humpback whales (*Megaptera novaengliae*) migrate from Southern Ocean summer feeding grounds to sub-tropical winter calving grounds. However, the Port Hedland area is not a known calving or aggregation area (NHT 2005). The peak migration periods for humpback whales offshore from Port Hedland are late June to mid July (northward) and mid September to mid October (southward) (NHT 2005). Furthermore, Prince (2001) suggested that large cetaceans off the Pilbara coast are unlikely to be found in waters less than 20 m deep, and therefore not expected in the vicinity of Spoil Ground ‘I’, which lies in a maximum of 13 m of water.

Prince (2001) reported that Pilbara coastal waters support small populations of dolphins. It was suggested that the majority are *Tursiops sp.* (bottlenose) and *Sousa sp.* (humpbacked) dolphins. Beasley et al. (2005) noted that there was no evidence of the Australian snubfin dolphin (*Orcaella heinsohni*), closely related to the Irrawaddy dolphin, occurring in inshore Pilbara waters.

Dugongs (*Dugong dugon*) are known in Pilbara inshore waters. Prince (2001) estimated 2,046 dugongs to be widely distributed from the northern end of Exmouth Gulf to Bedout Island, east of Port Hedland. This represents an average density of 0.10 dugong per km². Port Hedland is not considered an important aggregation area for dugongs (Prince 2001) and the lack of extensive seagrass meadows within the project area would suggest that it is not an important feeding area. However, during an aerial survey in April 2000, a single dugong was observed within the Port Hedland Inner Harbour (Prince 2001). From aerial surveys completed by James Cook University from 1984 to 2001, the density of dugongs within the Port Hedland area was found to be “low density”. The lack of protected embayments and offshore islands may limit the distribution of dugong in the Port Hedland area.

**Fish**

A variety of fish are known to occur in the Port Hedland region. Within the harbour, 106 species of fish have been identified (Ecoscape 2004).

The EPBC Act Protected Matters Search tool identified one shark species, the whale shark (*Rhincodon typus*), which is listed as vulnerable under the Act and may occur within the study area.

Seasonal aggregations of the whale shark are thought to be linked to localised seasonal ‘pulses’ of food productivity (DEH 2005). There are no known feeding, breeding or aggregation sites of this species within or in close proximity to the study area offshore from Port Hedland (Environment Australia 2002a; DoF 2005). This species is likely to be an infrequent visitor to the study area and is
more likely to remain in deep water off the Pilbara coastline (i.e. >20 m and therefore distant to Spoil Ground ‘I’). Further, dredging is not considered a key threatening process to this species (Environment Australia 2002a; 2002b).

Pipefish and seahorses are also listed under the EPBC Act as species or species habitat that may occur in the Port Hedland harbour and the path to Spoil Ground ‘I’. These, however, are not identified as threatened. In addition, there is no significant seagrass or algal habitat within the project area that would provide suitable habitat for these species to occur.

Fish species that inhabit mangrove-lined estuaries have been investigated by Robertson and Alongi (1992) in the Dampier region. The dominant species captured in these areas are summarised in Table 4.13.

Port Hedland contains similar estuarine habitats to those investigated by Robertson and Alongi (1992) and it is therefore anticipated that the described assemblages from the Dampier region would have considerable overlap with fish assemblages in estuarine areas that may potentially be affected by project activities, such as Salmon Creek the Inner Harbour.

Table 4.13 – Dominant Fish Species Captured in Habitats at Sites within Dampier (Robertson & Alongi 1992)

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Dominant species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open water channels</td>
<td>Carangids: Scomberoides commersonianus, Caranx ignobilis and Gnarathanodon speciosus</td>
</tr>
<tr>
<td></td>
<td>Sparids: Mylio latus</td>
</tr>
<tr>
<td></td>
<td>Mullets: Valamugil buchanini, Liza subviridis, L. vaigiensis and Mugil cephalus</td>
</tr>
<tr>
<td></td>
<td>Juvenile sharks: Carcharhinus limbatis</td>
</tr>
<tr>
<td></td>
<td>Catfish: Arius sp.2 and Arius proximus</td>
</tr>
<tr>
<td>Intertidal mud banks adjacent to mangrove</td>
<td>Mullets: Valamugil buchanini, V. cunnesius, Liza. Macrolepis, L. subviridis, and Mugil cephalus</td>
</tr>
<tr>
<td>forest</td>
<td>Sillagninds: Sillago analis and S. Maculate</td>
</tr>
<tr>
<td></td>
<td>Gerrids: Gerres oyena and G. Subfuscatus</td>
</tr>
<tr>
<td></td>
<td>Perchlet: Ambassias gymnocephalus</td>
</tr>
<tr>
<td></td>
<td>Antherinids: Allanetta mugiloides and Craterocephalus pauciradiatus</td>
</tr>
<tr>
<td>Small mangrove creeks</td>
<td>Perchlet: Ambassias gymnocephalus</td>
</tr>
<tr>
<td></td>
<td>Gobies: Acentrogobious molanus</td>
</tr>
</tbody>
</table>

The following observations were also noted:

- Considerable seasonal variation in fish abundance and species composition was recorded in the open water channels.
- Large individuals of Mylio latus, M. palmaris and the flathead Platycephalus indicus entered the creeks at high tide.
- The large tidal range in the Dampier mangroves influences the distribution and movement of many species where large numbers of fish move into channels, over mudbanks and into small creeks on the rising tide. Conversely, on the ebbing tide small fish are forced to retreat to shallow intertidal areas largely outside the mangrove system or to remain in isolated pools.

Marine Invertebrates

HGM (1997) identified a total of 183 infauna species in the harbour of which approximately 55% are polychaete worms, 24% molluscs and 18% crustaceans. Since then, two infauna studies have been carried out in the vicinity of the Finucane Island Berths (SKM 2002). Studies have shown that the diversity of infauna species is greater at a distance from the existing wharfs where there are appreciable numbers of echinoderms, cnidarians, sipunculids, echiuroids and chordates in addition to molluscs, crustaceans and annelids (SKM 2002). In general, infauna species that are more tolerant of turbidity are located at sites closest to the wharfs (SKM 2002).

A recent BPPH field investigation within the dredge footprint at Harriet Point noted the presence, type and degree of bioturbation (e.g. mounds and burrows) in addition to those observed at 13 survey...
locations. Evidence of species present and those observed in situ was recorded (SKM 2007a). These included the following:

- bivalves - *Anadara granosa*;
- potamid gastropods - *Terebralia semistriata* and *Telescopium telescopium*;
- fiddler crabs - *Uca flammula* and *U. capricornis*;
- sesarmid crabs - *Parasesarma* sp.;
- decapod crab - *Neosarmatium meinerti*;
- mud lobster - *Thalassina anomala*;
- mudskipper - *Periopthalmus* sp.; and
- pulmonate mollusc - *Onchidium daemilli*.

For more information on the abundance and types of epifauna observed at specific sites please see the Benthic Primary Producer Habitat Report in Appendix A.

**Seabirds**

Details on species of seabirds are discussed in Section 5.

### 4.3.4 Marine Pest Species

Port Hedland is currently recognised as an “at risk” port within Australia for the introduction and establishment of marine pest species.

This assessment is largely based on the level of activity that occurs within the port environment and is primarily related to vessel mediated incursions. These incursion pathways take one of two common pathways, ballast water or biofouling. The latter includes external fouling and internal seawater system fouling. These two processes are historically responsible for many of the introduced marine species (IMS) introductions around the world.

Considering the level of commercial activity that occurs within Port Hedland the number of known IMS and cryptogenic species is lower than expected (CSIRO 1999). A summary of known IMS confirmed within Port Hedland is provided in Table 4.14. The species termed ‘cryptogenic’, mean the status as an introduced or native species cannot be definitely or demonstrably categorised. Cosmopolitan species are those species known to have a wide global distribution where part or all of their distribution may be considered to be cryptogenic.

The species that are known to be present within the Port Hedland harbour are either well known cosmopolitan, common fouling species or species with less obvious impacts or inconspicuous by nature.
Table 4.14 – Introduced Marine Species within Port Hedland (Huisman et al. (in press) 2008)

<table>
<thead>
<tr>
<th>Species</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Beania mirabilis</em> (Johnston 1840)</td>
<td>A widespread inconspicuous species, occurring throughout warm-warm temperate seas.</td>
</tr>
<tr>
<td><em>Bulgula stolonifera</em> (Ryland 1960)</td>
<td>Similar fouling species to <em>B neritina</em>, with lower tolerances to warmer waters.</td>
</tr>
<tr>
<td><em>Tricellaria inopinata</em> (Hondt and Occhipinti 1985)</td>
<td>Cosmopolitan* species, previously overlooked in many cases due to the existence of similar closely related taxa.</td>
</tr>
<tr>
<td><em>Synnotum aegyptiacum</em> (Audouin 1826)</td>
<td>Cosmopolitan bryozoans distributed throughout warm waters. Distribution in Australia is from Vic to NSW and recorded in Port Hedland (West Australian Marine voucher specimen (WAM) 30551).</td>
</tr>
<tr>
<td><em>Savignyella lafontii</em> (Audouin, 1826)</td>
<td>Widely distributed in warmer waters (WAM 30556; 32310)</td>
</tr>
<tr>
<td><em>Amathia distans</em> (Busk 1886)</td>
<td>Cosmopolitan species known to occur at various location in warmer waters around Australia including Port Hedland.</td>
</tr>
<tr>
<td><em>Amathia vidocici</em> (Heller 1867)</td>
<td>Cosmopolitan species recorded in Port Hedland (WAM 30629)</td>
</tr>
<tr>
<td><em>Bowerbankia gracilis</em> (Leidy 1855)</td>
<td>Cosmopolitan species known to occur from South Australia recorded in Port Hedland (WAM 30552)</td>
</tr>
<tr>
<td><em>Zoobotryon verticillatum</em> (Della Chiaje 1828)</td>
<td>Cosmopolitan species, known in Australia from various location from South Australia, NSW to Port Hedland</td>
</tr>
<tr>
<td><em>Amphibalanus amphitrite</em> (Darwin 1854)</td>
<td>Cosmopolitan species, recorded from WA, SA, Vic, NSW, Qld and the NT.</td>
</tr>
<tr>
<td><em>Megabalanus rosa</em> (Pilsby 1916)</td>
<td>Known to occur at various locations around Australia often associated with international shipping locations.</td>
</tr>
<tr>
<td><em>Megabalanus tintinnabulum</em> (Linnaeus, 1758)</td>
<td>Cosmopolitan species, well established throughout Australia, distribution associated with shipping activities.</td>
</tr>
<tr>
<td><em>Gymnangium gracilicaule</em> (Jaderholm 1903)</td>
<td>Widely distributed in the tropical and subtropical Indian Ocean and Indo-West Pacific</td>
</tr>
<tr>
<td><em>Antennella secundaria</em> (Gmelin 1791)</td>
<td>Cosmopolitan in temperate and tropical seas, widely distributed throughout Australia.</td>
</tr>
</tbody>
</table>
4.4 ENVIRONMENTAL VALUES AND ENVIRONMENTAL QUALITY OBJECTIVES

The EPA has developed an Environmental Quality Management Framework (EQMF) for the marine waters of Western Australia and has endorsed the implementation of this EQMF for all of the State’s marine waters on a priority basis (DoE 2006c).

Port Hedland is located within these marine waters and therefore is required to be assessed within this framework. The key elements of the EQMF are the setting of Environmental Values (EV), Environmental Quality Objectives (EQO) and Environmental Quality Criteria (EQC) to aid management and protection of the marine environment from the effects of waste inputs and pollution. EV and EQO are shown in Table 4.15.

<table>
<thead>
<tr>
<th>Environmental Values</th>
<th>Environmental Quality Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecosystem Health</td>
<td>Maintain ecosystem integrity</td>
</tr>
<tr>
<td>(ecological value)</td>
<td>This means maintaining the structure (e.g. the variety and quantity of life forms) and functions (e.g. the food chains and nutrient cycles) of marine ecosystems.</td>
</tr>
<tr>
<td>Recreational and Aesthetics</td>
<td>Water quality is safe for recreational activities in the water (e.g. swimming). Water quality is safe for recreational activities in the water (e.g. boating). Aesthetic values of the marine environment are protected.</td>
</tr>
<tr>
<td>(social use value)</td>
<td></td>
</tr>
<tr>
<td>Cultural and Spiritual</td>
<td>Cultural and spiritual values of the marine environment are protected.</td>
</tr>
<tr>
<td>(social use value)</td>
<td></td>
</tr>
<tr>
<td>Fishing and Aquaculture</td>
<td>Seafood (caught or grown) is of a quality safe for eating. Water quality is suitable for aquaculture purposes.</td>
</tr>
<tr>
<td>(social use value)</td>
<td></td>
</tr>
<tr>
<td>Industrial Water Supply</td>
<td>Water quality is suitable for industrial supply purposes.</td>
</tr>
<tr>
<td>(social use value)</td>
<td></td>
</tr>
</tbody>
</table>

Source: Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006c).

The EQO for the ‘maintenance of ecosystem integrity’ identifies four different Levels of Ecological Protection (LEP) for Pilbara coastal waters which have been developed through extensive stakeholder and community consultation (Table 4.16).

<table>
<thead>
<tr>
<th>Level of Ecological Protection</th>
<th>Environmental Quality Condition (Limit of Acceptable Change)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Contaminant Concentration Indicators</td>
</tr>
<tr>
<td>Maximum</td>
<td>No contaminants — pristine</td>
</tr>
<tr>
<td>High</td>
<td>Very low levels of contaminants</td>
</tr>
<tr>
<td>Moderate</td>
<td>Elevated levels of contaminants</td>
</tr>
<tr>
<td>Low</td>
<td>High levels of contaminants</td>
</tr>
</tbody>
</table>

Source: Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006c).

The State EQMF and those EVs and EQOs developed for the Pilbara coastal waters have been taken into consideration in the assessment of potential environmental impacts as a result of the RGP5 project.

Figure 4.13 presents the currently defined LEP boundaries identified by the Pilbara Coastal Water Quality Consultation Outcomes Document (2006). A moderate LEP (90% ecological protection) has been applied to areas around wharves, jetties and ship turning basins. A High LEP has been applied to all other areas in Port Hedland region (DoE 2006c).
BHPBIO proposes a realignment of the moderate LEP boundary to include an area extending out radially 250m from the proposed BHPBIO berths at Harriet Point (associated with this ERD) and the approved FMG berths at Utah Point (also outlined in Figure 4.13).

The proposed modifications to the moderate LEP boundary have been developed in accordance with:

1) Guidance on Boundary Revisions within the Pilbara Coastal Water Quality Consultation Outcomes: Environmental Outcomes and Environmental Quality Objectives (EPA 2006)


It can be noted in Figure 4.13 the project areas including the proposed Harriet Point dredge footprint, DMMA B1 and B2 would, therefore, fall within a moderate LEP while DMMA A would fall within a high LEP.
FIGURE 4.13 ENVIRONMENTAL QUALITY OBJECTIVES FOR PORT HEDLAND AND THE PROPOSED RGP 5 PROJECT

Legend
- Dredged Material Management Area
- DMMA Construction Footprint

Ecological Protection Level
- 99% Habitat Protection
- 90% Habitat Protection

Existing and Proposed Berths
- BHPBIO Berth - RGP 5 Proposed
- BHPBIO Berth - Existing
- FMG Berth - Existing
- FMG Berth - Proposed
- PHPA Berth - Existing
- PHPA Berth - Proposed

Spoil Ground 'I'

State/Commonwealth Jurisdiction Boundary

Source:
Ortho-rectified Aerial Photograph: 15/06/2007 (BHP B Billiton)
BHPBIO - Bluff ociation: 11/2/2008 (BHP B Billiton)

Reclamati on Areas (MPD JV):
A: 1/12/2008 B: 2/2/2008

Protection Areas: Pilbara Coastal Water Quality Have Your Say 07/2004 (DOC)


FINUCANE ISLAND

PORT HEDLAND

INDIAN OCEAN

Scale @ A4: 1:75,000
Datum: GDA04
Map Grid: MGA04 Zone 50