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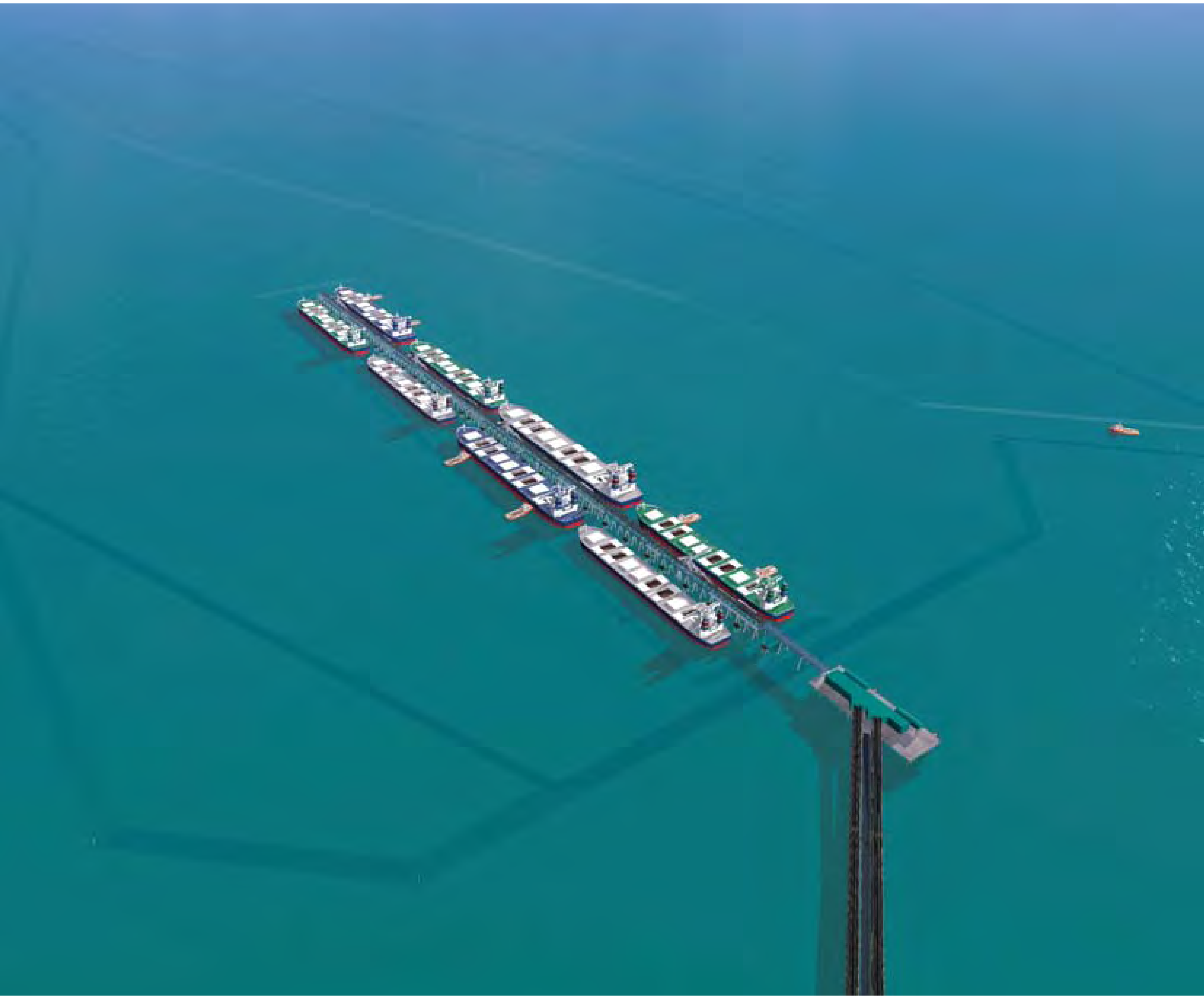
Appendix A3
Dredge and Spoil Disposal Management Plan



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List of Abbreviations

ADP	Asset Development Project
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment and Conservation Council
AQIS	Australian Quarantine Inspection Service
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AS/NZS	Australian Standard/New Zealand Standard
BPP	Benthic Primary Producers
BPPH	Benthic Primary Producer Habitat
CALM	Conservation and Land Management (now DEC)
CAMBA	China-Australia Migratory Bird Agreement
CD	Chart Datum
CEO	Chief Executive Officer
CITES	Convention on International Trade in Endangered Species
CMS	Convention on Migratory Species
CPCe	Coral Point Count with Excel Extensions
CSD	Cutter Suction Dredger
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEC	Department of Environment and Conservation
DEH	Department of Environment and Heritage (now DSEWPaC)
DEWHA	Department of Environment, Water, Heritage and Arts (now DSEWPaC)
DGPS	Digital Global Positioning Service
DoE	Department of Environment (now DEC)
DoF	Department of Fisheries
DSDMMP	Dredge Spoil Disposal Management and Monitoring Plan
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
DWT	Dead Weight Tonnes
EA	Environment Australia (now DSEWPaC)
EMP	Environmental Management Plan
EP (Act)	Environment Protection (Act)
EPA	Environmental Protection Authority (now OEPA)
EPBC (Act)	Environment Protection Biodiversity (Act)
EQO	Environmental Quality Objectives
FCC	Fouling Control Coating
HBI	Hot Briquetted Iron
HFO	Heavy Fuel Oil
HSEC	Health Safety Environment and Community
IMO	International Maritime Organisation
IMS	Invasive Marine Species
IMSMA	Invasive Marine Species Management Area
IUCN	International Union for Conservation of Nature
JAMBA	Japan-Australia Migratory Bird Agreement
JHA	Job Hazard Analysis
LAC	Light Attenuation Coefficient
LTDMMP	Long Term Dredge Material Management Plan
LiDAR	Light Detection and Ranging

Mm3	Million cubic metres
MPA	Marine Protected Areas
MPRSWG	Marine Parks and Reserves Selection Working Group
MSDS	Material Safety Data Sheet
Mtpa	Million Tonnes Per Annum
NIMPIS	National Introduced Marine Pest Identification System
NOAA	National Oceanographic and Atmospheric Administration (United States)
NODGDM	National Ocean Disposal Guidelines for Dredged Material (Australia)
NTU	Nephelometric Turbidity Units
OEPA	Office of the Environmental Protection Agency
OSCP	Oil Spill Contingency Plan
PAH	Polycyclic Aromatic Hydrocarbon
PER/EIS	Public Environmental Review/Environmental Impact Statement
PHPA	Port Hedland Port Authority
PM	Partial Mortality
PSD	Particle Size Distribution
QA/QC	Quality Assurance/Quality Control
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
ROV	Remotely Operated Vehicle
SAP	Sampling and Analysis Plan
SOPEP	Ship Board Oil Pollution Emergency Plan
SDP	Sea Dumping Permit
SKM	Sinclair Knight Merz
TSHD	Trailing Suction Hopper Dredger
TSS	Total Suspended Solids
TBT	Tributyltin
UCL	Upper Confidence Limit

1. INTRODUCTION

1.1 PROPOSED OUTER HARBOUR DEVELOPMENT

BHP Billiton Iron Ore plans to develop the proposed Outer Harbour Development in Port Hedland, Western Australia. The development will be located adjacent to BHP Billiton Iron Ore's current operations at Port Hedland (**Figure 1-1**), and includes: construction of stockyards within the vicinity of the decommissioned Hot Briquetted Iron (HBI) plant at Boodarie; an overland conveyor; and a jetty/wharf structure offshore from Finucane Island.

The construction of the development will require dredging to enable vessel access to the wharf and for loaded vessels to depart to deep water.

The extent of the proposed dredging areas is shown in **Figure 1-1**. Dredging operations will create new berth pockets, swing basins and departure basins, a departure link channel to the existing shipping channel, a departure channel, a cross-over link channel and tug access channel from the existing channel into the berth pockets. The proposed departure channel will be approximately 34 km in length and aligned approximately parallel to the existing Port Hedland shipping channel, deviating to the north-west from the existing channel at the outer end.

The total volume of material to be dredged is estimated to be approximately 54 Mm^3 over a timeframe of approximately five years.

1.2 PROPONENT

BHP Billiton Iron Ore is the Proponent for the proposed Outer Harbour Development at Port Hedland.

BHP Billiton Iron Ore is involved in sourcing, mining and processing iron ore to supply products to the global steel market. BHP Billiton Iron Ore currently has operations in Western Australia and Brazil. The Company's Australian iron ore assets are based in the Pilbara region of Western Australia and employ approximately 8,000 people across the region (BHP Billiton Iron Ore 2008).

Further information on the proponent can be sourced from the Company's website (www.bhpbilliton.com).

1.3 THIS DSDMMP

This draft Dredging and Spoil Disposal Management and Monitoring Plan (hereafter referred to as the DSDMMP) provides a framework for the environmental management of the construction dredging and disposal activities of the proposed Outer Harbour Development. The DSDMMP has been prepared with a performance-based management approach, structured to allow for the management of the potential environmental impacts associated with the construction dredging activities as proposed.

The Port Hedland Port Authority (PHPA) has prepared a Long Term Dredge Material Management Plan (LTDMMP) in support of an application for a long term permit for maintenance dredging, spanning seven years (GHD 2008). The LTDMMP includes management measures designed to mitigate potential impacts that may occur as a result of maintenance dredging operations within the Port. Where applicable the management measures described within this DSDMMP are consistent with the requirements of the LTDMMP.

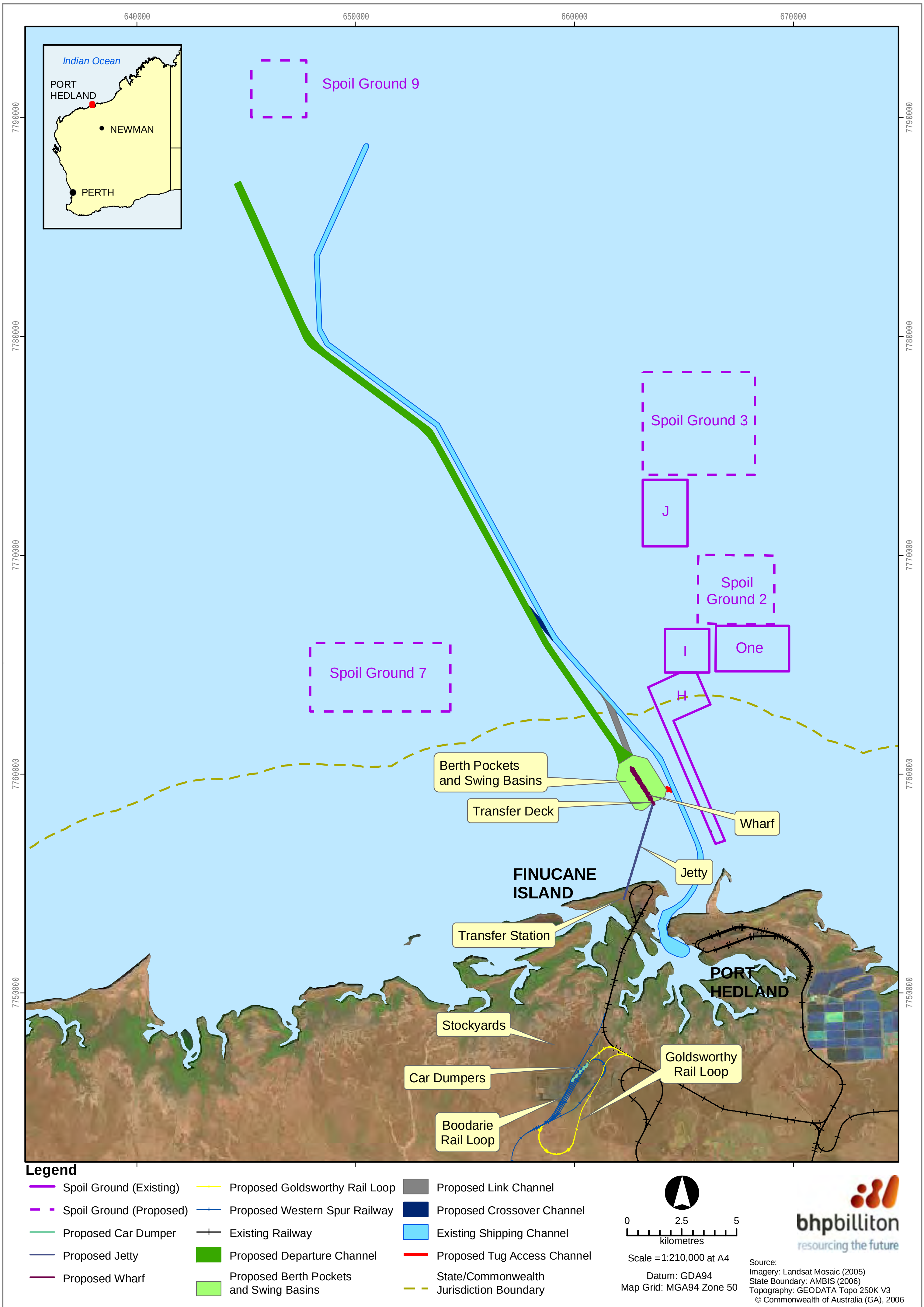


Figure 1-1 Existing Dredge Channel and Spoil Grounds and Proposed Outer Harbour Development

1.3.1 Objectives

The intent of the DSDMMP is that at a minimum, the environmental impacts arising from the proposed construction dredging and disposal activities will be managed at levels deemed acceptable by the requirements of the Conditions of the State Ministerial Statement, the Commonwealth Approval Decision and Sea Dumping Permit.

The DSDMMP presents the management measures including objectives, actions and associated key performance indicators (KPIs) that will be implemented throughout the dredging program. The DSDMMP also presents the proposed monitoring and inspection programs required to determine any environmental impacts arising from the construction activities, and allow for the effective and timely implementation of contingency measures if required.

1.3.2 Content

The construction dredging activities covered by this DSDMMP comprise:

- Stage 1: the dredging of berth pockets, eastern swing and departure basins, a tug access channel and a link channel to the existing channel to provide two loading berths;
- Stage 2: the dredging of the western swing and departure basins to provide two additional loading berths. This stage also includes the dredging works for the new 34 km departure channel and the cross link channel; and
- Stage 3: the dredging for the extension of the wharf with additional berth pockets and the swing and departure basins to accommodate another four loading berths.

Further detail on the proposed construction dredging activities is provided in **Section 3**.

Considering the proposed construction dredging and disposal activities outlined above, this DSDMMP:

- outlines the proposed dredging and spoil disposal program during construction;
- describes the over-arching strategy which forms the design basis of this management plan;
- describes the procedures that will be implemented to minimise and manage potential impacts on water quality and sensitive receptors;
- outlines the environmental monitoring and inspection programs that will be implemented;
- outlines the contingency measures that will be implemented in the event that specified threshold limits for environmental receptors and indicators are exceeded;
- identifies and temporally defines the key ecological windows during which particular environmental receptors may be vulnerable to dredging pressures;
- describes the measures that will be implemented to manage environmental issues relating to marine quarantine, the use and handling of hydrocarbons, waste management, noise and vibration impacts, and vessel operations and directs the reader to supporting documents for management actions; and
- outlines how the environmental management strategies will be implemented including definition of clear and accountable roles and responsibilities, coordination and communication, auditing and reporting requirements.

The DSDMMP incorporates the requirements of the State Minister for the Environment (Ministerial Statement No.XXX, dated XXX 2011 (**Appendix x**)) and the Commonwealth Minister for Sustainability, Environment, Water, Population and the Community (Approval decision EPBC 1999/xx dated XXX 2011 and sea Dumping Permit No. SD2009/xx, dated XXX 2011) (**Appendix x**).

Table 1.1, Table 1.2 and Table 1.3 outline the sections within the DSDMMP where each of these requirements is addressed.

Table 1.1 Cross reference of the DSDMMP with Ministerial Statement No. Xxx

Condition and Commitments under Ministerial Statement No.		DSDMMP Section

Table 1.2 Cross Reference of the DSDMMP with the Commonwealth Approval Decision (EPBC 20xx/xx

Condition and Commitments under Commonwealth Approval Decision (EPBC 20xx/xx)		DSDMMP Section

Table 1.3 Cross Reference of the DSDMMP with Sea Dumping Permit No SD20xx/xx

Condition and Commitments under Sea Dumping Permit (No. SD20xx/xx)		DSDMMP Section

The aim of the DSDMMP is to ensure the Limits of Environmental Impacts specified in Ministerial Statement No. XXX, Condition X, are not exceeded due to the impacts of the dredging and spoil disposal activities associated with the development.....

This DSDMMP is required under Condition x of Ministerial Statement No. Xxxx which states:

Prior to commencement of any dredging or spoil disposal activities associated with the facilities listed in Condition X, the Proponent shall prepare and submit a Dredge and Spoil Disposal Management and Monitoring Plan to the Minister that ...

This DSDMMP also satisfies the requirement of Condition X, of the EPBC Act which states:

Prior to the commencement of construction, a Dredge Spoil Disposal Management and Monitoring Plan.......

This DSDMMP also satisfies the requirements under Condition X of Sea Dumping Permit SD2009/X which states:

BHP Billiton Iron Ore must manage the environmental impacts of the activity through dredging and spoil disposal management and monitoring measures in the Dredge and Spoil Disposal Management and Monitoring Plan as specified in....

1.3.3 Approval, Revision and Distribution

This DSDMMP is a draft and has been prepared as part of the Public Environmental Review/ Environmental Impact Statement (PER/EIS) approvals process. On completion of the environmental approvals process, this draft DSDMMP will be finalised to incorporate the requirements of the:

- relevant Ministerial Statement to be issued by the State Minister for the Environment;
- relevant approval decision to be issued by the Commonwealth Minister for the Environment; and
- relevant Sea Dumping Permit to be issued by the Commonwealth Department for Sustainability, Environment, Water, Population and Communities (DSEWPaC).

Upon approval by the State Minister for the Environment and the Commonwealth Minister for Sustainability, Environment, Water, Population and the Community, the finalised DSDMMP will be made publically available and will be ready for implementation.

In the event that a substantial change to the proposed dredging and spoil disposal scope or methods occurs, the DSDMMP will be reviewed and revised as considered necessary by the State and Commonwealth Ministers, and assessing Authorities. Any review and revision of the DSDMMP will be provided to the Ministers and assessing Authorities, as directed.

1.4 LEGISLATIVE REQUIREMENTS

All proposed construction dredging and spoil disposal activities will be undertaken in compliance with the relevant international, Commonwealth and State legislative requirements.

1.4.1 International Conventions and Agreements

International agreements applicable to this DSDMMP may include, but are not limited to:

- The 1996 London Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (ratified by Australia in 2000);
- The International convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) (International Maritime Organisation);
- The International Convention for the Control and Management of Ships' Ballast Water and Sediments (International Maritime Organisation (IMO);
- United Nations Convention of the Law of the Sea;
- ANZECC Code of Practice for Antifouling and In-water Cleaning and Maintenance;
- The Convention on the Conservation of Migratory Species of Wild Animals (Secretariat of the Convention for the Conservation of Migratory Species of Wild Animals 1979);
- Japan-Australia Migratory Bird Agreement (JAMBA), 1974;
- China-Australia Migratory Bird Agreement (CAMBA), 1986; and
- Republic of Korea-Australia Bird Agreement (ROKAMBA), 2002.

1.4.2 Commonwealth Legislation

Applicable Commonwealth legislation includes, but is not limited to, the following Acts, Regulations (and relevant amendments):

- Australian Quarantine Regulations 2000;
- *Dangerous Substances Act 2004;*
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- *Environment Protection (Sea Dumping) Act 1981;*
- *Fisheries Act 1952;*
- *Marine Act 1982;*
- *National Environment Protection Council Act 1994;*
- *National Environmental Protection Measures (Implementation) Act 1998;*
- Navigable Waters Regulations 1958;
- Port and Harbour Regulations 1966*;*

- *Protection of the Seas (Prevention of Pollution from Ships) Acts 1983;*
- *Quarantine Act 1908;*
- *Seas and Submerged Lands Act 1973;* and
- *Soil and Land Conservation Act 1945.*

1.4.3 State Legislation

Applicable Western Australian legislation includes, but is not limited to, the following Acts (and relevant amendments):

- *Biosecurity and Agriculture Management Act 2007;*
- *Coastal Management and Protection Act 1995;*
- *Coastal Waters (State Powers) Act 1980;*
- *Conservation and Land Management Act1984* (CALM Act);
- *Environmental Protection Act 1986* (EP Act);
- Environment Protection Regulations 1987;
- Environmental Protection (Controlled Waste) Regulations 2001;
- Environmental Protection (Noise) Regulations 1997;
- Environmental Protection (Unauthorised Discharges) Regulations 2004;
- *Fish Resources Management Act 1994;*
- Fish Resources Management Regulations 1995;
- *Marine and Harbours Act 1981;*
- *National Environmental Protection Council (Western Australia Act 1996);*
- *Petroleum (Submerged Lands) Act 1982;*
- *Pollution of Waters by Oil and Noxious Substances Act 1987;*
- *Port Authorities Act 1999;*
- *Port Authorities (Consequential Provisions) Bill 1998*;
- *Shipping and Pilotage Act 1967;*
- Western Australian Port Authorities Regulations 2001;
- *Wildlife Conservation Act 1950* ; and
- Wildlife Conservation Regulations 1970.

1.4.4 Standards

The following Australian Standards are relevant to various aspects of this DSDMMP:

- Australian Standard/New Zealand Standard (AS/NZS) ISO 14001:2004 Environmental Management Systems – Requirements with Guidance for Use (Standards Australia/Standards New Zealand 2004): specifies the requirements for an environmental management system to enable the development and implementation of a policy and objectives which take into account legal requirements and includes information about significant environmental aspects (Australian Standard/New Zealand Standard 2004);

- AS/NZS 4360:2004 Risk Management (Standards Australia/Standards New Zealand 2004a): provides a generic guide for managing risk and specifies the elements of risk management systems (Australian Standard/New Zealand Standard 2004a);
- HB 203:2006. Environmental Risk Management – Principles and Process (Standards Australia/Standards New Zealand 2006): based on the generic risk management process developed in AS/NZS 4360:2004, but explains the principles and process of environmental risk management, and provides guidance on implementation; and
- AS 1940:2004.The Storage and Handling of Flammable and Combustible Liquids Standards Australia. (Standards Australia 2004).

1.4.5 Guidelines and Strategies

The Commonwealth and Western Australian Governments have written a number of strategy and guidance documents to advise proponents on the development of environmental management and monitoring programs.

Commonwealth strategies and guidance documents directly applicable to marine communities vulnerable to dredging and spoil disposal activities include, but are not limited to:

- the previous National Ocean Disposal Guidelines for Dredging Management (2002) and the current National Assessment Guidelines for Dredging (Commonwealth of Australia 2009)[1];
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000);
- National Strategy for Ecologically Sustainable Development (Commonwealth Government of Australia 1992);
- National Water Quality Management Strategy (Commonwealth Government of Australia 1992a);
- Intergovernmental Agreement on the Environment (Commonwealth Government of Australia 1992b);
- National Strategy for Conservation of Australia's Biological Diversity (Commonwealth Government of Australia 1996); and
- Intergovernmental Agreement on a National System for the Prevention and Management of Marine Pest Incursions, April 2005.

Western Australian State strategies and guidance documents directly applicable to marine communities vulnerable to dredging and spoil disposal activities include, but are not limited to:

- State Water Quality Management Strategy (Document No. 6) (Government of Western Australia 2004);
- WA EPA Environmental Assessment Guideline No. 7: Marine Dredging Proposals (EPA 2010);
- WA EPA Environmental Assessment Guideline No. 3 – Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment (EPA 2009); and
- WA EPA Guidance Statement No. 1 – Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (EPA 2001).

The *Pilbara Coastal Water Quality Consultation Outcomes – Environmental Values and Environmental Quality Objectives* (DoE 2006) specifies Environmental Values (EV) and Environmental Quality Objectives (EQO) that guide the management of coastal water quality in the Pilbara region (**Table 1.4**). These EVs and EQOs will be an important consideration when managing the operation of

[1] The National Assessment Guidelines for Dredging (2009) are the current guidelines. The previous guidelines were the National Ocean Disposal Guidelines for Dredging Management (2002) and it is this earlier version of the guidelines under which the Sea Dumping Permit Application for the proposed Outer Harbour Development was lodged.

the proposed Outer Harbour Development facilities, to ensure maintenance of ecosystem function and social values in Pilbara Coastal Waters.

Table 1.4 Environmental Values and Environmental Quality Objectives of the Port Hedland Area

Environmental Values	Environmental Quality Objectives
Ecosystem Health (ecological value)	Maintain ecosystem integrity 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.
Recreational and Aesthetics (social use value)	Water quality is safe for recreational activities in/on the water (e.g. swimming, boating). Aesthetic values of the marine environment are protected.
Cultural and Spiritual (social use value)	Cultural and spiritual values of the marine environment are protected.
Fishing and Aquaculture (social use value)	Seafood (caught or grown) is of a quality safe for eating. Water quality is suitable for aquaculture purposes.
Industrial Water Supply (social use value)	Water quality is suitable for industrial supply purposes.

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

During the construction of the proposed Outer Harbour Development, dredging activities will alter water quality. In provision of environmental approval of the proposed construction dredging and disposal activities it is recognised that temporary disturbances of water quality conditions will result, and that therefore the values and objectives of the Pilbara Coastal Water Quality Consultation Outcomes will be temporarily comprised. Once construction activities have been completed however a return to ambient marine water quality conditions is expected. In addition, the extent of impacts to marine water quality can be greatly reduced through management measures applied to construction dredging and disposal activities, which is the focus of this DSDMMP.

1.5 STAKEHOLDER CONSULTATION

The stakeholder engagement undertaken for the proposed Outer Harbour Development and BHP Billiton Iron Ore's Pilbara expansion projects is detailed in **Section 4** of the PER/EIS.

BHP Billiton Iron Ore developed an Engagement and Communication Plan (BHPBIO 2008) for Pilbara communities and includes a process to facilitate existing communication and engagement processes with other stakeholder groups such as State and Commonwealth environmental management agencies and indigenous communities. The process allows for concerns and issues to be addressed wherever possible during the project design process, facilitating an informed assessment of the potential and perceived impacts.

The results collected to date of consultation undertaken as part of the Engagement and Communication Plan have been considered in the development of this DSDMMP.

2 STRUCTURE OF THIS DSDMMP

2.1 OUTLINE

An outline of the DSDMMP is as follows:

- **Section 3** provides an overview of the activities to which this plan is applicable;
- **Section 4** provides an overview of the existing marine environment and the key studies that have been completed in gaining an understanding of the region;
- **Section 5** details the results of the sediment plume modelling and representation of the marine environmental impact predictions as recommended by draft EAG No. 7 (EPA 2010);
- **Section 6** details the environmental project management structure that will be implemented;
- **Section 7** details the management strategies that are proposed to manage the works; and
- **Section 8** details the reporting requirements for the project.

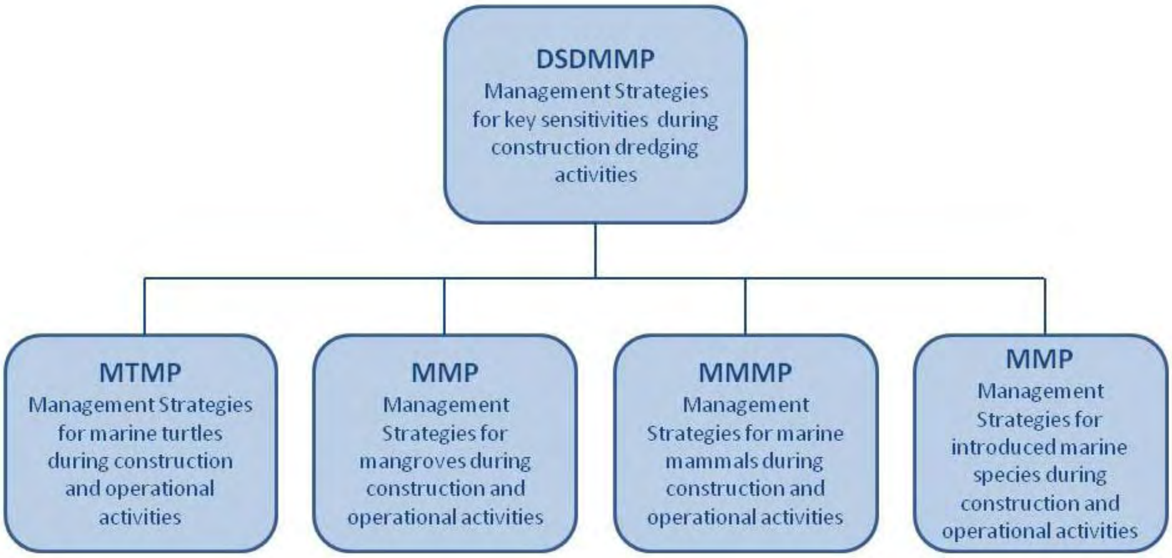
2.2 OTHER RELEVANT MANAGEMENT PLANS

This DSDMMP focuses on the management of key environmental sensitivities that may be impacted during construction dredging and spoil disposal activities. Key environmental sensitivities are also identifiable during operational activities. In this instance, supporting management plans to the DSDMMP have been developed that provide management strategies for both construction and operational activities for the environmental factor concerned.

The supporting management plans to this DSDMMP include (**Figure 2-1**):

- Marine Turtle Management Plan (MTMP) (**Appendix B1** of the PER/EIS);
- Mangrove Management Plan (MMP) (**Appendix B2** of the PER/EIS);
- Marine Mammal Management Plan (MMMP) (**Appendix B4** of the PER/EIS); and
- Introduced Marine Species Management Plan (IMSMP) (**Appendix B5** of the PER/EIS).

Figure 2-1 Relationship between the DSDMMP and Supporting Management Plans



3 DREDGING AND DISPOSAL ACTIVITIES

This section describes the marine components, as well as the supporting structures and systems of the proposed Outer Harbour Development. An overview of the location, layout and footprint is shown in **Figure 1-1**.

3.1 CONSTRUCTION AND INFRASTRUCTURE

The proposed Outer Harbour Development involves the construction and operation of landside and marine infrastructure for the handling and export of iron ore. The key components of the marine infrastructure comprise (**Table 3.1**):

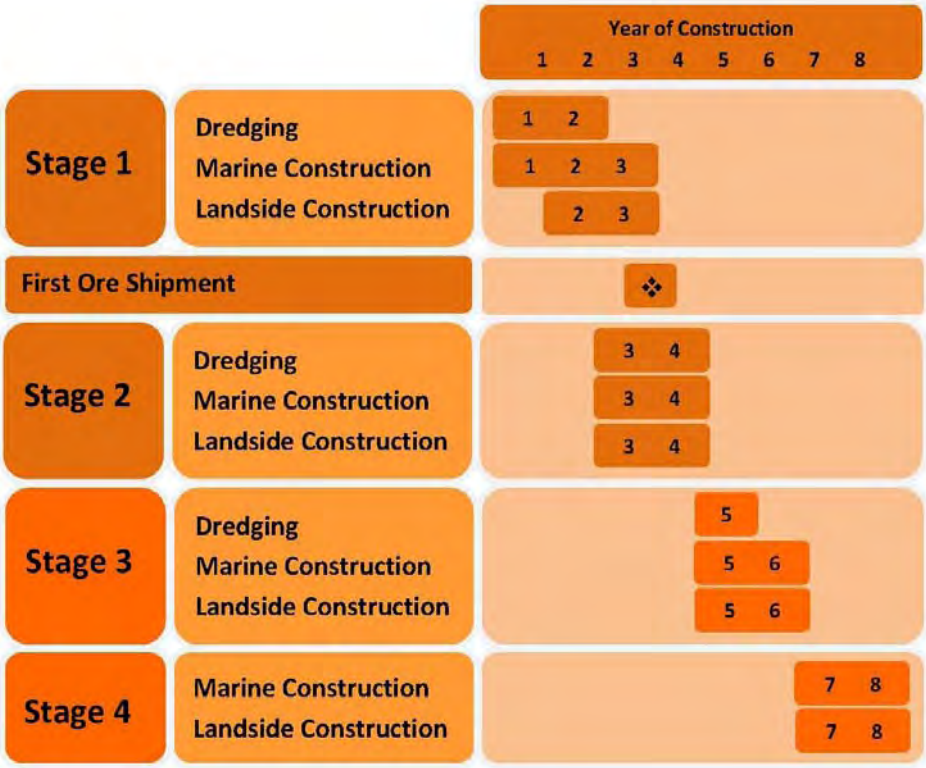
- an access jetty structure (approximately 4 km), including abutment works;
- a transfer deck located at the end of the jetty and connected to the wharf structure;
- a wharf structure (approximately 2 km);
- berthing and mooring dolphins;
- ship access gangways and conveyor cross-overs and cross-unders;
- aids to navigation;
- a ship arrestor barrier structure; and
- berth pockets, departure basins, swing basins, link channels, new departure channel and tug access channel.

Table 3.1 Summary of Marine Infrastructure Characteristics

Element	Description
General	
Proponent	BHP Billiton Iron Ore Pty Ltd.
Project Location	Port Hedland, Western Australia.
Proposal Description	Staged development of rail, iron ore handling, stockpiling and shiploading facilities at Port Hedland. Infrastructure includes a jetty, wharf and shipping channel offshore of Finucane Island with onshore infrastructure including ore transport (rail) and ore handling infrastructure (car dumpers, stockyards and conveyor system) and associated supporting infrastructure.
Construction Period	Staged Construction, each stage nominally 2-3 years
Marine Infrastructure	
Export Capacity	Marine Infrastructure nominal capacity of approximately 240 Mtpa
Wharf	Approximately 2 kilometres (km) in length. Eight berths and four shiploaders.
Jetty	Approximately 4 km in length.
Shipping Channel	Approximately 34 km in length (first 2 km located in State waters and remaining 32 km located in Commonwealth waters).
Dredge Material	Volume: Approximately 54 million cubic metres (Mm^3). Disposal: Four offshore spoil grounds located in Commonwealth waters.

Construction of the proposed infrastructure is scheduled to take place in four stages. An indicative project schedule for landside and marine construction of all four construction stages is summarised in **Figure 3-1**. Dependent on the market conditions and corporate financial approval, the proposed total construction period would be approximately eight years.

Figure 3-1 Indicative Construction Schedule for the Marine Infrastructure of the Proposed Outer Harbour Development



3.2 DREDGING WORKS

The total volume of material to be dredged is estimated to be approximately 54 Mm^3 required for completion of Stages 1, 2 and 3. There is no dredging proposed for construction of Stage 4[2].

A range of sediment types are present within the proposed dredge footprint, requiring the use of different types of dredgers. A Trailing Suction Hopper Dredger (TSHD) will be utilised for unconsolidated materials while harder materials first require cutting and/or crushing using a Cutter Suction Dredger (CSD) before the subsequent removal of the crushed material from the sea floor by a TSHD. The dredge material that the CSD will dump on the seafloor is proposed to be concurrently removed by the TSHD; material may remain on the seafloor in the event that the TSHD has a mechanical failure.

Offshore geotechnical investigations are ongoing to further characterise the material to be dredged, confirm dredging techniques and optimise engineering design. Based on the information collected to date, including the recent geotechnical program, there is no requirement for marine blasting operations for material extraction.

Typically, dredging will start with a TSHD removing the top layers of unconsolidated materials. Once a sufficiently large area has been cleared down to the hard layer, a CSD will then be deployed to crush the material and deposit it back onto the seabed immediately behind the cutter head using its submerged ladder pump, for subsequent removal by a TSHD. The sequence of cutting and crushing per layer in a certain area and subsequent removal by a TSHD will be repeated until the design depth is reached. In areas where the surface is of harder material, the CSD will be required as the first pass to cut and crush material before the TSHD is deployed.

[2] Refer to **Section 2** of the PER/EIS for further detail on the Project Description of the proposed Outer Harbour Development.

In the shallow areas irrespective of the sediment types it may be necessary to first create sufficient water depth for the TSHD by using the CSD. In this case the dredged materials will be stockpiled into deeper water within the dredge footprint away from the CSD using a floating pipeline and a spreader barge discharging at near seabed level, from where it will subsequently be removed by the TSHD.

Dredging operations will be conducted on a 24 hours per day, 7 days per week basis. Careful planning of the dredging program is required for tidal influences in the shallow areas of the wharf and berth area. The specific areas to be dredged in Stages 1 to 3 are depicted in Figure 3-2. The approximate duration of the dredging and respective estimated volumes of dredged material are summarised in **Table 3.2**.

Table 3.2 Summary of Estimated Dredging Volumes for each Construction Stage

Stage	Approximate Dredging Period (Months)	Approximate Volume Dredged (Mm^3)
Stage 1	24	22
Stage 2	25	25
Stage 3	7	7
Total	56	54

The dredging volumes are approximate only, and will be further refined during detailed design. The dredging duration includes down times for maintenance and weather related interruptions.

3.3 OFFSHORE SPOIL DISPOSAL

The suitability of a number of potential offshore spoil ground locations has been investigated and there are four preferred locations, designated as Spoil Grounds 2, 3, 7 and 9 (**Figure 3-2**). These spoil areas are of sufficient size to accommodate the entire volume of dredged materials. All of these offshore spoil grounds are located in Commonwealth waters in depths of greater than 10 m Chart Datum (CD) and are located clear of existing and proposed channels and anchorages (**Table 3.3**).

Table 3.3 Location of the Proposed Offshore Spoil Grounds

Spoil Ground	Depth (m CD)	Corner	Latitude[1]	Longitude[1]	Easting[2]	Northing[2]
2	-10	NW	S 20°11.3'	E 118°37.1'	669101	7766853
		NE	S 20°11.3'	E 118°35.1'	665617	7766887
		SE	S 20°09.6'	E 118°35.1'	665647	7770023
		SW	S 20°09.6'	E 118°37.1'	669132	7769990
3	-13	NW	S 20°05.080'	E 118°33.601'	663114	7778387
		NE	S 20°05.054'	E 118°36.542'	668240	7778386
		SE	S 20°07.598'	E 118°36.568'	668240	7773692
		SW	S 20°07.625'	E 118°33.626'	663114	7773692
7	-12	NW	S 20°11.867'	E 118°24.941'	647914	7766000
		NE	S 20°11.837'	E 118°28.620'	654321	7766000
		SE	S 20°13.530'	E 118°28.634'	654318	7762877
		SW	S 20°13.560'	E 118°24.954'	647910	7762877
9	-20	NW	S 19°57.456'	E 118°23.276'	645234	7792610
		NE	S 19°57.445'	E 118°24.713'	647742	7792610
		SE	S 19°58.849'	E 118°24.726'	647742	7790020
		SW	S 19°58.860'	E 118°23.288'	645234	7790020

[1]Datum GDA94, [2]Projection MGA94 Zone 50

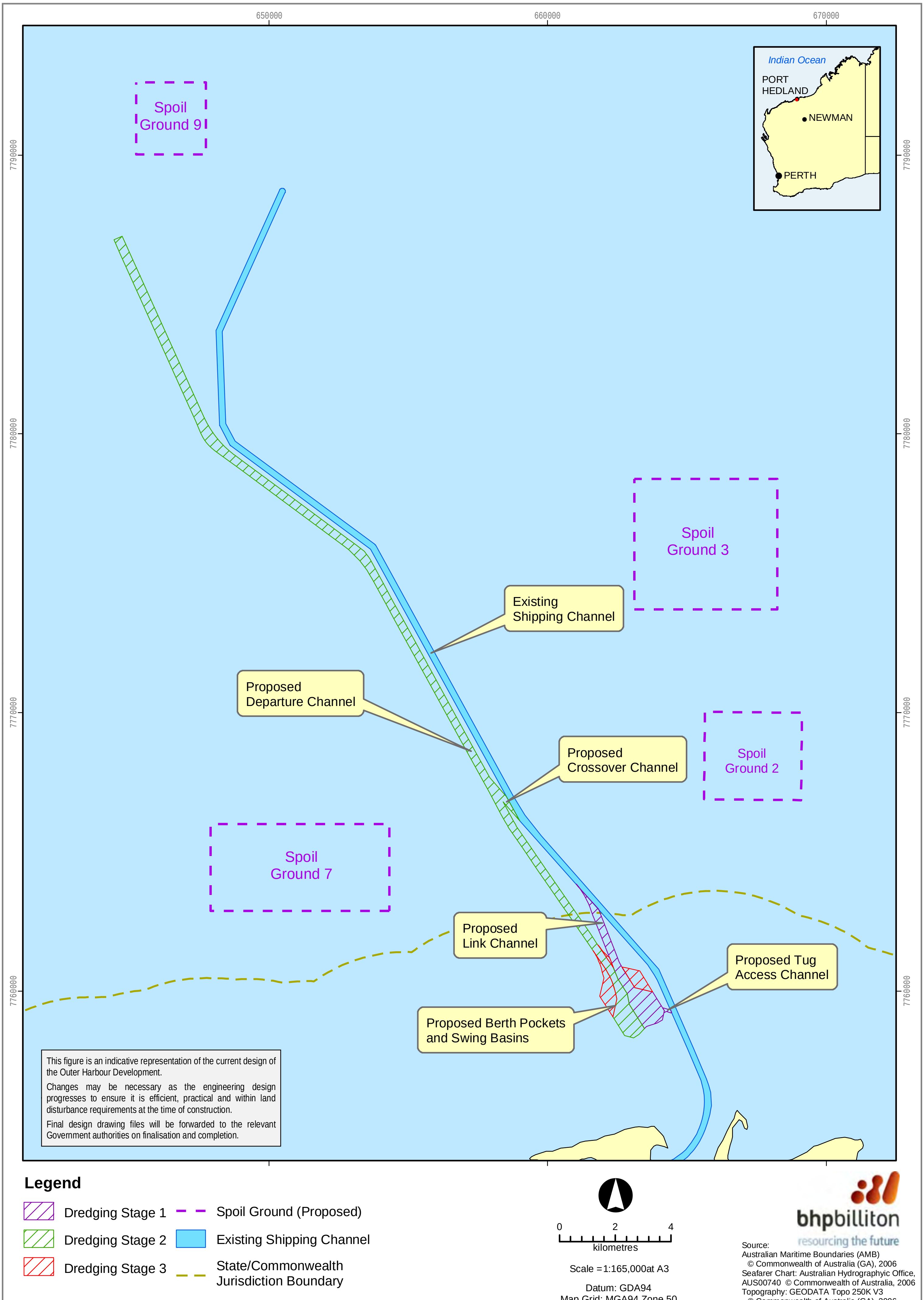


Figure 3-2 Dredging Locations During Each Stage of the Outer Harbour Development

4 EXISTING ENVIRONMENT AND RELEVANT STUDIES

Characterisation of the existing marine environment offshore of Port Hedland and an assessment of the potential impacts of the proposed Outer Harbour Development were undertaken as part of the environmental impact assessment process. The characterisation was based on existing knowledge of the area, desk top studies and analyses, and a number of detailed studies.

The results of the following studies undertaken during the development of the PER/EIS are of particular importance to the environmental management of the construction dredging and spoil disposal activities and summaries are included in this DSDMMP:

- baseline water quality monitoring (**Section 4.3.3**);
- marine sediment quality investigations (**Section 4.3.4**); and
- BPPH surveys and analyses (**Section 4.4.1**).

In addition, a study investigating the marine impacts due to the sediment plume was undertaken incorporating water quality thresholds used to interpret plume modelling outputs. An overview of the impact assessment is provided in **Section 5**, and the full reports for the marine BPPH impacts and water quality thresholds are in **Appendix A10** and **Appendix A2** of the PER/EIS, respectively.

Further details of the existing marine environment and the results of the impact assessment can be found in **Sections 6** and **10** of the PER/EIS, respectively.

4.1 KEY ENVIRONMENTAL SENSITIVITIES

The key environmental sensitivities that could potentially be impacted upon by the proposed construction dredging and dredge spoil disposal activities include:

- soft and hard substrate subtidal habitats and the primary producers supported thereon;
- coastal intertidal habitats; and
- a number of conservation significant species including marine turtles, humpback whales and dugongs.

4.2 MARINE PARKS AND RESERVES

There are no marine parks or reserves in the vicinity of the proposed Outer Harbour Development. The proposed Dampier Archipelago Marine Park is the closest marine park. The proposed park is situated 225 km west of Port Hedland, and lies well outside the predicted area of influence from the proposed construction dredging and disposal activities.

The footprint of the proposed Outer Harbour Development does not contain any World Heritage Properties, National Heritage Properties or Ramsar Wetlands of International Significance.

4.3 EXISTING PHYSICAL ENVIRONMENT

4.3.1 Coastal Geomorphology and Processes

The Port Hedland area is a limestone barrier coast. The combination of offshore limestone ridges and the large tidal range produces protected embayments, sandy substrates with mangroves, mud flats, wide salt flats and a number of islands and associated reefs. Regional scale coastal processes and tropical arid climatic conditions interact to produce these diverse coastal landforms (Semeniuk 1993; Environ 2004).

Swell waves and locally generated waves produce coastal landforms such as beaches (including Mundabullangana Beach, Cemetery Beach, Pretty Pool and Cooke Point) and cause sea-front erosion. Prevailing onshore winds (west to north-westerly) develop coastal dunes. Episodic cyclones and storm surge can cause flash flooding of inshore creeks, and erosion and dispersion of coastal sediment, in particular, creek erosion of mud deposits and fluvial and shoreline accretion (Gilmour et al. 2006).

Coastal landforms in the project area include a sandy beach and low limestone cliff near the location of the proposed jetty abutment on the north side of Finucane Island with lines of sand dunes above the beach and a low rocky limestone platform extending seaward from the intertidal zone. To the south of Finucane Island the landform is one of silty tidal channels fringed with mangroves, mud flats, salt flats and sandy plains.

4.3.2 Metocean Conditions

The coastal oceanographic system of the region is dominated by the large semi-diurnal tidal regime in the embayments and tidal channels, while elsewhere the nearshore coastal environment is wave dominated.

The highest astronomical tide (HAT) is 7.5 m, with a mean spring tidal range of 5.5 m (ANTT 2008). A summary of the tidal plane information is provided in **Table 4.1**. These large tides drive oscillating currents of around 1 m/s (2 knots) which can increase in the entrances to the numerous tidal creeks along the coastline. The direction of tidal currents is typically aligned north-west to south-east across the local bathymetric contours (APASA 2009).

Table 4.1 Tidal Planes at Port Hedland

Tidal Plane	Elevation Above Datum (m)
Highest Astronomical Tide (HAT)	7.5
Mean High Water Springs (MHWS)	6.7
Mean High Water Neaps (MHWN)	4.6
Mean Sea Level (MSL)	3.9
Mean Low Water Neaps (MLWN)	3.3
Mean Low Water Springs (MLWS)	1.2
Lowest Astronomical Tide (LAT)	0.0

Source: ANTT (2008)

Wind is the secondary forcing mechanism for local currents, and typically drives persistent, residual flows along the coastline. A slight dominance in the strength and persistence of west to north-westerly winds during the spring and summer months (wet season) typically results in a long term drift towards the east and north east, following the coastline. Weaker and less persistent current reversals occur during times of northerly and easterly winds during autumn (transitional period) and winter (dry season) (APASA 2009).

For most of the year there is a relatively calm wave regime, with typically less than 1 m background swell. Between December and May (wet season), the Pilbara region is subjected to sporadic, intense storms and an average of three to four cyclones occur each season (CSIRO 2008). Cyclones have affected Port Hedland on average about once every two years, with seven severe (Category 3 or greater) cyclones recorded since 1910 (BOM 2008). One of the most significant cyclones to have affected Port Hedland was Cyclone Joan which crossed the coast 50 km west of Port Hedland in December 1975 and achieved wind gusts of up to 208 km/h (BoM 2009b).

Under cyclonic conditions, strong currents and possibly extreme waves may act to resuspend settled material, with subsequent dispersion over a larger region. In addition, land flooding (storm surge) that often results under low pressure conditions can lead to a large scale sediment plume resulting in nearshore waters from onshore runoff (APASA 2009).

4.3.3 Marine Water Quality

The existing water quality conditions for Port Hedland were monitored for twelve months (1 June 2008 to 4 June 2009) at six water quality monitoring locations (**Figure 4-1)**. At each location, water column turbidity, light and temperature were recorded, while gross sedimentation rates and the characteristics of sediment within traps and on the seabed (particle size distribution (PSD), organic content) were also assessed. The data were collected as part of an ongoing baseline study for the proposed Outer Harbour Development (SKM 2009d).

The location of each of the six water quality monitoring sites was assigned based on *a priori* knowledge including existing information, preliminary plume modelling results, BPPH pilot field studies and observations (**Table 4.2**).

Table 4.2 Water Quality and Coral Health Monitoring Sites

Site	Site code	Approx. distance from mainland (km)	Approx. mid-tidal water depth (m)	Susceptibility to sediment resuspension	Latitude	Longitude
Weerdee Island	WIS	3	4.6	High	20° 17.414' S	118° 28.893' E
Cape Thouin	CTH	10	7.9	Medium	20° 14.995' S	118° 17.194' E
Minilya Bank	MIB	16	10.2	Medium	20° 09.002' S	118° 38.157' E
Little Turtle Island	LTI	19	10.2	Medium	20° 01.081' S	118° 47.991' E
Coxon Shoal	COX	28	13.5	Low	20° 03.998' S	118° 27.485' E
Cornelisse Shoal	COR	33	12.5	Low	20° 02.040' S	118° 22.560' E

Datum is GDA94.

Results for the water quality monitoring program (**Table 4.3**) indicate that:

- nearshore waters were characterised by variable turbidity and high sedimentation rates, and highly variable light climate and temperature; and
- further offshore, water quality conditions exhibited fewer extremes in the variables monitored, but still experienced occasional high levels of sedimentation and turbidity, low light and variable temperatures.

Table 4.3 Median Values of Water Quality Parameters Measured at Baseline Monitoring Sites from June 2008 – June 2009.

Site	Turbidity (NTU)		Light (µmoles/m^2/day)		Temperature (ºC)		Sedimentation* (mg/cm^2/day)	
	Wet#	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Weerdee Island	1.0	1.4	4.9	8.0	30.2	22.5	322.7	93.4
Cape Thouin	1.1	0.7	5.7	7.6	30.5	22.3	129.5	11.5
Minilya Bank	1.5	0.9	2.5	4.2	30.2	22.7	37.8	9.0
Little Turtle Island	1.9	1.8	1.8	2.6	30.3	22.9	30.9	19.4
Coxon Shoal	0.7	0.4	2.3	5.1	29.6	23.9	27.9	6.4
Cornelisse Shoal	0.8	0.5	3.7	6.4	30.3	23.9	18.0	7.4

Wet season is from December 1 – May 30; dry season is June 1 – November 30.
*The mean value is reported due to low replication during each sampling event.

In general, the majority of light, turbidity, water temperature and sedimentation data were weather dependent and showed a strong seasonal transition from the dry to the wet seasons. The tidal regime appeared to be an influential factor determining variations in the light climate, turbidity and water temperature at all sites on a fortnightly basis.

On a seasonal basis, these water quality variables appeared to be influenced by climate (air temperature), storms and cyclone events. Sedimentation rates at all sites increased during the wet season.

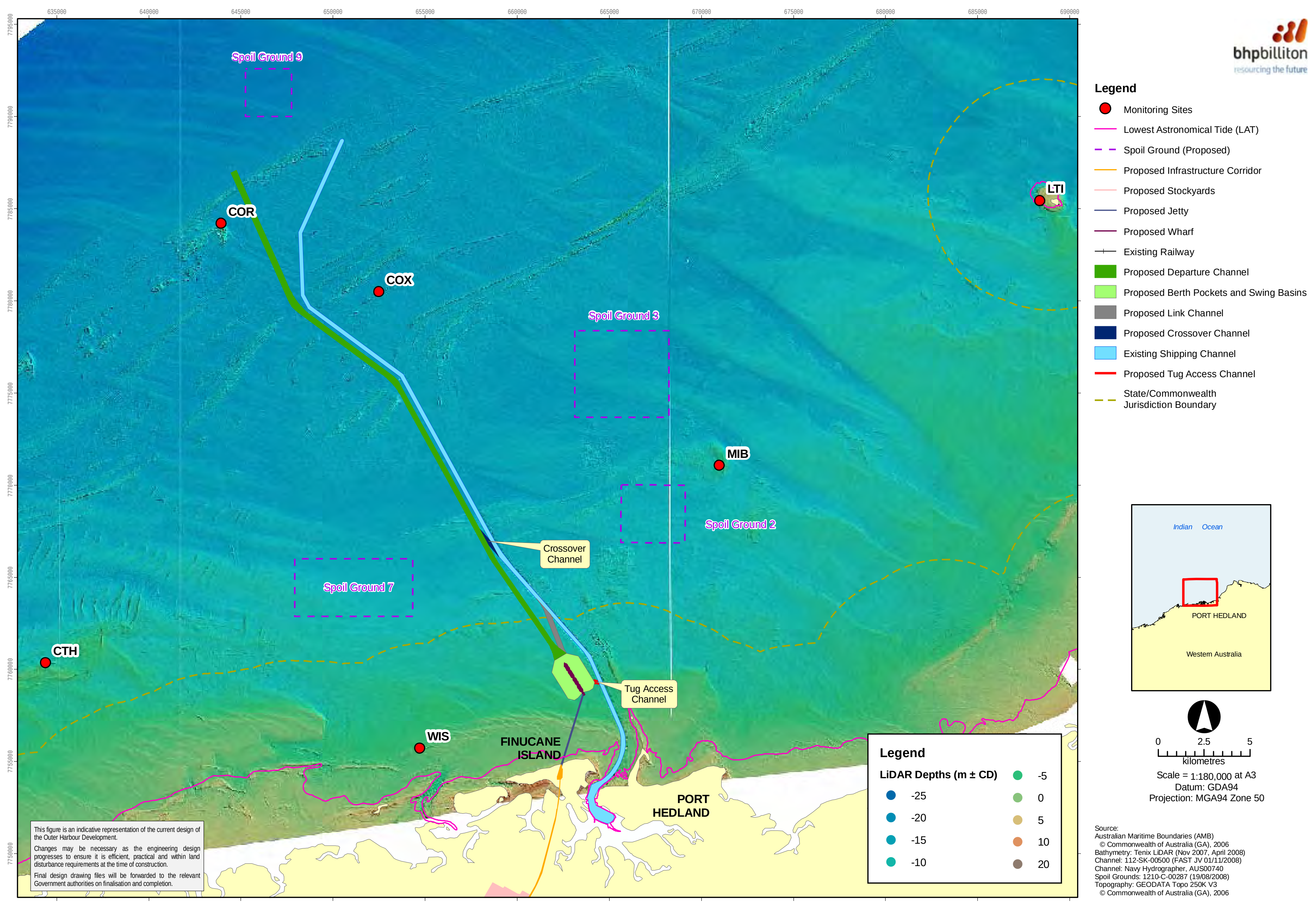


Figure 4-1 Water Quality and Coral Health Baseline Monitoring Sites

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4.3.4 Marine Sediments

4.3.4.1 Sediment Quality

There has been no previous spoil disposal within the proposed dredge footprint and the lack of nearby sources of contaminants makes it unlikely that the sediments are contaminated from anthropogenic sources.

Analyses of the sediments within the proposed Outer Harbour footprint, including within the proposed dredge footprint and the potential spoil grounds (SKM 2009e), showed that:

- arsenic (95% upper confidence limit (UCL)) was above the NODGDM (EA 2002) screening level (20 mg/kg) in surficial material in all areas investigated, and in borehole samples to a depth of 4 m;
- nickel (95% UCL) exceeded the NODGDM (EA 2002) maximum level (52 mg/kg) to a depth of 19 m in borehole samples, but not in surficial material;
- tributyltin (TBT) (95% UCL) did not exceed the NODGDM (EA 2002) screening level (5 µg Sn/kg) in any samples collected;
- elutriate testing on borehole material demonstrated that none of the contaminants of potential concern were bioavailable at levels that would exceed ANZECC/ARMCANZ (2000) water quality trigger levels for 99% species protection;
- ecotoxicity testing on borehole material demonstrated that none of the metal contaminants with values exceeding NODGDM (EA 2002) screening levels were toxic; and
- the proposed spoil grounds were deemed suitable receiving environments for spoil based on remoteness from sensitive benthic habitats, water depth and material holding capacity.

Material within the proposed dredge footprint is therefore considered to be clean of contaminants and suitable for unconfined sea disposal. Although arsenic, chromium and nickel have been measured at elevated concentrations in the sediments, these are believed to be naturally occurring (DEC 2006) and were also found in the background material (pilot study) of the area and in boreholes of undisturbed base material, and are therefore not considered to be contaminants of anthropogenic origin.

4.3.4.2 Particle Size Distribution

Borehole samples to dredge depth

Throughout the dredge footprint, particle size distribution (PSD) was measured from samples collected in boreholes to the anticipated dredge depth material from the borehole samples has been classified into soil units based on the criteria presented in **Table 4.4** and can be summarised as follows:

- Unit 2a ranges from medium sand to medium gravel;
- Unit 2b is classified as a clayey sand and has a clay contact of greater than 15%;
- Units 4b and 4c are primarily coarse-grained, containing a high proportion of fines (ranging from 5–45%); and
- Units 6a and 6b are variable silty/clayey sands, with a relatively large proportion of clay.

Table 4.5 provides an approximation of the percentage of each soil unit in the areas of the dredge footprint, which may be refined with further geotechnical investigations. **Appendix A** presents figures showing the PSD of material from each of these soil units.

Table 4.4 Soil Unit Classification and Description of Material in the Proposed Dredge Footprint

Soil Unit	Unit Name	Generalised Material Description	Major Material Types
2a	Sand dunes, beach and stream deposits	Silica or calcareous sand	Sand (99%) Gravel (1%)
2b	Sand dunes, beach and stream deposits	Gravelly or clayey sand / mixed sand, gravel and clay	Sand (56%) Gravel (23%) Clay (15%) Sandstone (3%) Coral (3%)
4a	Lithified bach material	Siliceous calcarenite / calcareous sandstone	Sandstone (49%) Siliceous Calcarenite/ Coral (43%) Sand (6%) Clay (1%) Gravel (1%)
4b	Lithified bach material	Siliceous calcarenite / calcareous sandstone	Siliceous Calcarenite/ Calcarenite/ Coral (35%) Sandstone /Siltstone (37%) Sand (8%) Clay/Silt (1%) Gravel (1%)
4c	Unlithified bach material	Calcareous clayey and/or calcareous sand / sandstone	Sand (43%) Clay (20%) Gravel (17%) Sandstone (13%) Siliceous Calcarenite (7%)
6a	Upper red beds	Clayey and/or calcareous sand / sandstone	Sandstone (43%) Sand (41%) Clay/ Silt (13%) Siliceous Calcarenite/ Calcarenite (1%) Claystone/ Siltstone/ Mudstone/ Silcrete/ Breccia (1%) Gravel (1%)
6b	Lower red beds	Sandstone	Sandstone (93%) Sand (5%) Siliceous Calcarenite (2%) Claystone/ Siltstone/ Silcrete/ breccia (<1%) Sand (<1%) Clay (1%)

Table 4.5 Estimated Percentage of Material Types to be Dredged in each Area of the Proposed Dredge Footprint

Basin Area	2a	2b	4a	4b	4c	6a	6b
Berth pocket / wharf area	5.4	4.6	0.0	0.0	2.7	66.8	17.5
Departure channel	8.5	12.7	0.0	0.0	4.1	71.8	2.8
Swing basin	21.1	25.1	0.0	5.2	14.3	34.3	0.0
Link channel	6.5	12.3	13.4	33.6	11.3	20.0	2.9
New channel	23.0	10.6	66.4	0.0	0.0	0.0	0.0

Surficial samples

Sediment cores were collected in the dredge footprint and three spoil grounds to a depth of 0.5 metres. Less than 10% of surficial sediment material from the proposed dredge footprint was fine sand (<250 µm) or smaller (**Table 4.6**).

Sediment grain size has a strong correlation with contaminant binding potential, particularly for metals and sediment particles less than 2 µm in size (DEC 2006). The PSD results illustrated in **Table 4.6** and **Figure 4-2** indicate a low potential for contaminant binding with surficial material from the proposed dredge footprint. Sediment size also relates to the potential for suspension and resuspension of particles in the water column — larger particles are less likely to remain in suspension than smaller particles (and result in reduced potential plume impact).

Figure 4-2 Mean PSD of Surficial Sediments Collected from Sites in Three Sections of the Proposed Dredge Footprint

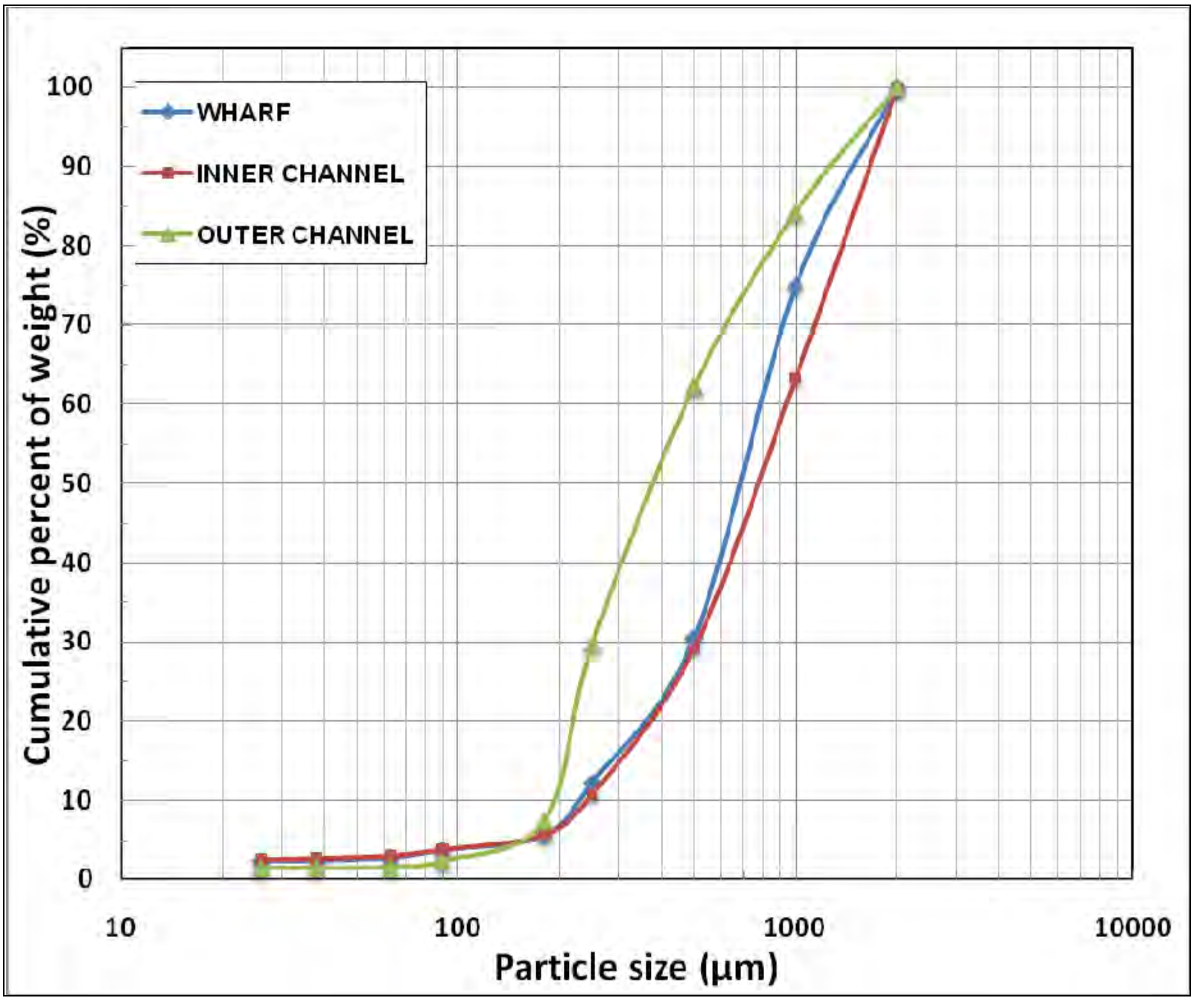
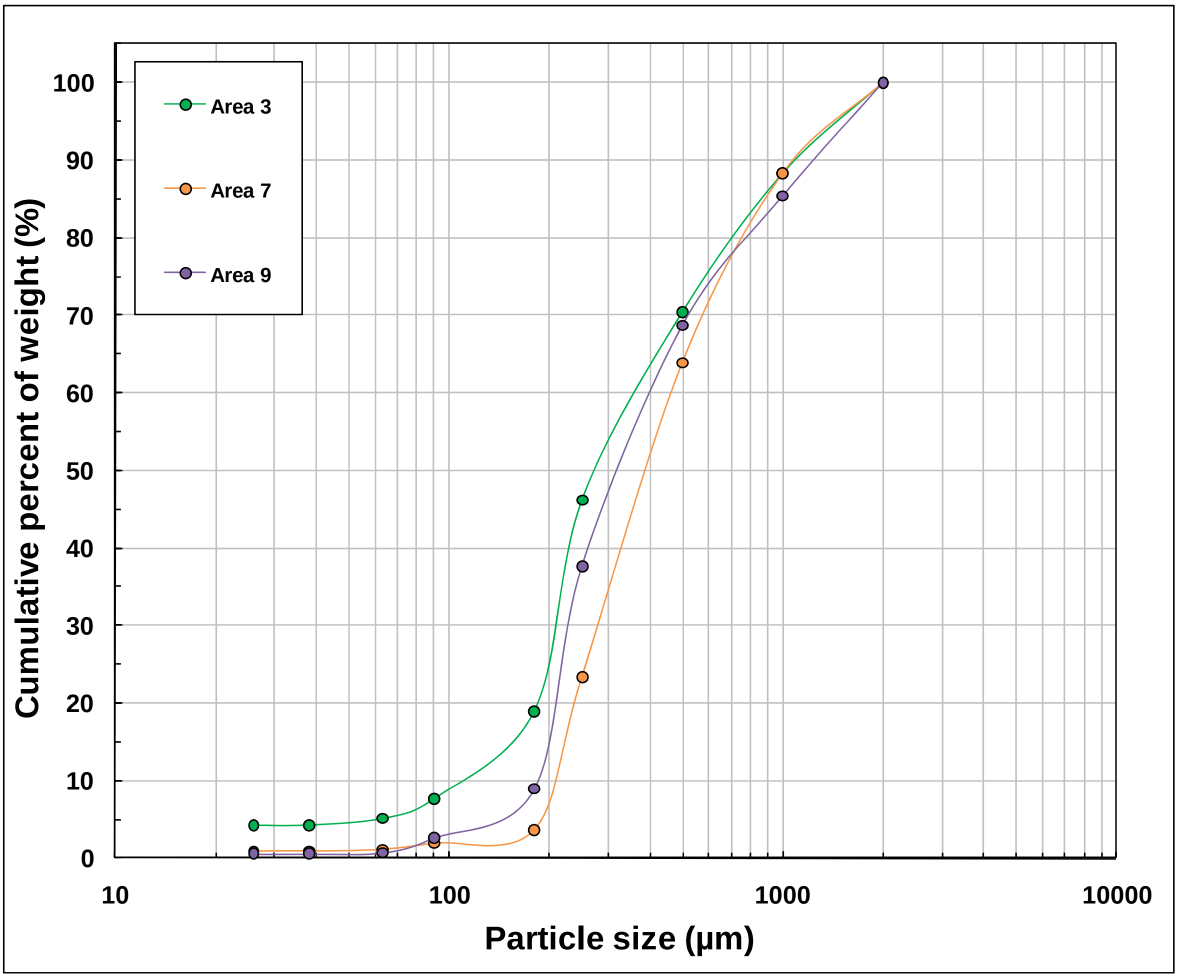


Table 4.6 Mean Percentage of Sediment by Grain Size Class of Surficial Sediments in the Proposed Dredge Footprint

Classification	Grain Size (µm)	Proposed Footprint Area		
		Wharf	Inner Channel[3]	Outer Channel
Very fine gravel	> 2000	25.11±8.27	36.64±16.21	27.32±15.29
Very coarse sand	1000–2000	44.45±13.47	34.16±10.19	32.29±14.97
Coarse sand	500–1000	18.14±11.16	18.38±9.54	21.79±12.19
Medium sand	250–500	6.77±6.71	5.17±3.00	10.19±9.29
Fine sand	180–250	1.81±1.43	1.88±1.15	2.69±2.63
Very fine to fine sand	90–180	0.96±0.61	0.77±0.51	0.80±0.53
Very fine sand	63–90	0.35±0.25	0.35±0.18	0.28±0.19
Coarse silt	38–63	0.07±0.07	0.14±0.45	0.09±0.31
Medium silt	< 38	2.34±0.88	2.51±1.72	2.15±1.50

Surficial PSD in the three proposed spoil grounds are presented in **Figure 4-3** and represent the mean value of all sites within each spoil ground. For this figure, there were five sites in Spoil Grounds 7 and 9 and eight sites in Spoil Ground 3. Particles less than 180 µm accounted for less than or equivalent to 10% by weight of the means within each spoil area.

Figure 4-3 Mean PSD of Surficial Sediments Collected from Sites in the Proposed Spoil Grounds



[3] Approximately the first half of the proposed departure channel, described in SKM (2009e).

4.4 EXISTING BIOLOGICAL ENVIRONMENT

4.4.1 Benthic Primary Producer Habitat

Marine benthic habitats are those that occur on the seabed, and include sandy habitats and hard substrata such as limestone or coral reefs. Benthic habitats extend from the high water mark of the intertidal zone, through to all areas of the subtidal zone (SKM 2009j). The benthic habitat categories found in the propose Outer Harbour Development area, relevant to the DSDMMP include:

- Coastal intertidal habitats; and
- Subtidal habitats.

Table 4.7 Summary of Benthic Habitat Coverage in the Study Area

Habitat Type	Total Area (ha)	State (ha)		Commonwealth (ha)
		Inside PHI LAU*	Outside PHI LAU*	
Coastal Intertidal				
Sediment	20,820	3,782	17,038	–
Mixed assemblage	1,364	498	866	–
Mangroves	116	–	116	–
Subtidal				
Hard substrate	365,453	898	7,230	35,531
Sediment			79,591	242,203
Hard coral	18,085.1	0.48	4,937	13,148
Macroalgae	16,025.9	162.1	3,083	12,781
Seagrass	86.0	–	86	–
Soft coral	3,400	0.33	733	2,667
Sponges	8,000	11.1	1,521	6,469
Sessile invertebrates	20,275	–	2,823	17,452

Coastal Intertidal Habitats

The coastal intertidal areas were assessed using aerial and satellite imagery which found that the coastal intertidal zone (defined as the area between LAT and the coastline, 22,269 ha in area) was dominated by tidal flats and soft bottom substrates (20,820 ha or 94% of the area). Hard substrates in the form of limestone ridges and intertidal platforms were also identified within the coastal intertidal area (1,364 ha or 6% of the area) (**Table 4.7**).

Subtidal Habitats

Baseline surveys of subtidal marine benthic habitats in the Port Hedland region were undertaken between December 2007 and May 2008 (SKM 2009g, **Appendix A14**). The area surveyed was extensive, covering approximately 3,650 km^2 (50 km to the east and west of Port Hedland Harbour and 40 km seaward) and included 343 survey locations.

Data derived from Light Detection and Ranging surveys (LiDAR), in combination with observations made by underwater video and diver investigations, were used to model, predict and validate the distribution of BPPH, other dominant habitats and BPP in areas that may potentially be impacted by the proposed development (**Figure 4-4**). Representative areas identified as BPPH were then surveyed in more detail to provide data on the composition and cover of various benthic communities.

Figure 4-4 Subtidal Habitat Map of Study Area.

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The results of the subtidal surveys show that benthic habitats offshore of Port Hedland comprise extensive plains of sand/silt, and limestone pavement and ridges (SKM 2009g; **Table 4.7**). The extensive plains surveyed are often bare of any large marine flora or fauna (such as coral and macroalgae), and mainly support smaller sediment dwelling invertebrates and very sparse sponge and soft coral assemblages. Many of the offshore limestone ridges run parallel to the coastline, and those areas of ridges surveyed support sparse hard corals, macroalgae, soft corals, gorgonians, sea whips and sponges.

Hard Corals

The distribution of hard corals within the proposed Outer Harbour Development study area was determined from the marine habitat survey at 52 sites (**Figure 4-5**). The field survey results show that percentage cover of hard corals on the hard substrate sites ranged from less than 3 to 27% (coral cover) and the majority of the substrate at all sites was the bare substrate component (sand, rubble and rock). The non-reef areas including the potential spoil grounds were primarily sandy sediment with no observed coral. The outer ridgeline systems generally have higher coral cover than the islands or the inner ridgeline or shoal system.

The species richness of coral taxa at all sites surveyed in the region was very low in comparison to other studies carried out in the Pilbara region and no corals considered endangered or unique to the region have been identified.

A total of 51 species of coral from 19 genera were identified from areas offshore from Port Hedland, which is considerably lower than the 120 coral species from 43 genera recorded in the Dampier Port and inner Mermaid Sound, Dampier (Blakeway & Radford 2005). The estimate for the offshore Port Hedland region is based on a smaller sampling effort when compared with the Mermaid Sound region. Although more species may be present offshore from Port Hedland, the number of coral genera recorded during field surveys is considered to be representative of the actual number of coral genera present in these coral communities.

Table 4.8 Hard Coral Cover as Recorded by Field Observations in the Benthic Environment around Port Hedland

Area		Proximity to Port Hedland entrance	Hard Coral Cover (%)	Bare Component (%)
Outer Ridgeline Systems	Outermost Ridgeline	37 km NW	4.9–27.1	>60
	Middle Ridgeline	31 km NW	5.8–21.8	>69
	Innermost Ridgeline	24 km NW	3.3–22.9	>67
Inner Ridge/Shoal Systems	Minilya Bank	19 km NE	3.6–19.6	>67
	Proposed Port Areas	4–6 km N	0.0–12.9	>79
	Weerdee Ridge	11 km W	0.2–21.6	11–75
	Cape Thouin Area	40 km W	7.6	>78
Islands	Weerdee Island	12 km W	<5	12–66
	North Turtle Island	58 km NE	0.2–18.9	>81
	Little Turtle Island	40 km NE	8.4–17.8	>69
Sand Plains	Eastern Shoreline	Inshore, from Port Hedland to Spit Point	0	100
	Potential Spoil Ground Locations[1]	Refer to **Figure 1-1**	0	100*
	Proposed Channel Footprint[2]	Refer to **Figure 1-1**	0	100**

Source: Summarised from SKM (2009k) (surveyed December 2007 to May 2008)

[1] a series of potential spoil ground locations investigated for the proposed Outer Harbour Development

[2] sites sampled at a proposed footprint which was subsequently realigned. Further investigations conducted within the current dredge footprint concluded the same results

* with the exception of sparse coverage of epifauna

**with the exception of the final section of the channel which intersects the outermost ridgeline (refer to table above for composition of hard coral and bare environment to overall benthic environment of the outermost ridgeline)

Figure 4-5 Hard Substrate that Supports Hard Corals (>5% cover)

Based on the generally low species richness and abundance of corals and the dominance of corals of the genus *Turbinaria*, coral communities that inhabit subtidal habitats in the Port Hedland region can be described as predominantly high turbidity (low light), high sedimentation adapted communities (SKM 2009r).

Macroalgae

Macroalgae occur on both hard and soft substrata and their abundance varies among different habitats and according to season.

Surveys of the three outermost limestone ridgelines undertaken for the proposed Outer Harbour Development recorded varying cover of macroalgae between 0 and 15% (mostly less than 5%) (SKM 2009g). At Weerdee Ridge, 11 km west of the Port Hedland Harbour entrance, macroalgal cover varied between 0 and 71% of the substrate. *Caulerpa* and *Halimeda* spp. were the most common algae at this site (SKM 2009g). At Little Turtle Island, macroalgal cover on subtidal pavement ranged from 0 to 15% (generally less than 5%). Subtidal pavement around North Turtle Island did not support any macroalgae (SKM 2009k).

Seagrasses

Seagrasses are not common in the Port Hedland area and those that do occur are ephemeral species such as *Halophila ovalis* that are present in low to medium densities. The greatest extent of seagrass observed during benthic habitat investigative studies was inshore of Weerdee Island where an approximate area of 86 ha contained sparse (25 to 50% coverage) patches of seagrass.

Sponges and Soft Corals

In the Port Hedland Harbour, sponges and soft corals are found along the outer and inner ridgeline systems and the island shoals. They commonly co-habit the ridgelines where hard corals are found. Unlike hard corals, soft corals and sponges also extend onto a narrow margin of the inter-ridge flats. The proposed spoil ground locations are predominantly bare with the exception of some sparsely distributed individuals of soft corals and sponges (**Table 4.9**) (SKM 2009k).

Table 4.9 Sponge and Soft Coral Cover in the Port Hedland Area

Area		Proximity to Port Hedland entrance	Sponges Cover (%)	Soft Coral Cover (%)	Bare Component (%)
Outer Ridgeline Systems	Outermost Ridgeline	37 km NW	2.9–11.6	0.0–3.1	>60
	Middle Ridgeline	31 km NW	3.6–9.6	0.2–1.8	>69
	Innermost Ridgeline	24 km NW	2.7–8.4	0.0–3.6	>67
Inner Ridge/Shoal Systems	Minilya Bank	19 km NE	6.4–9.8	0.0–6.0	>67
	Proposed Port Areas	4–6 km N	3.1–6.4	1.1–1.6	>79
	Weerdee Ridge	11 km W	1.8–12.2	0.0–7.1	11–75
	Cape Thouin Area	40 km W	7.8	1.1	>78
Islands	Weerdee Island	12 km W	minimal	minimal	12–66
	North Turtle Island	58 km NE	0.0–8.2	0.0–2.9	>81
	Little Turtle Island	40 km NE	2.9–9.6	<5	>69
Sand Plains	Eastern Shoreline	Inshore, from Port Hedland to Spit Point	0	0	100
	Potential Spoil Ground Locations[1]	Refer to **Figure 1-1**	minimal	minimal	100[3]
	Proposed Channel Footprint [2]	Refer to **Figure 1-1**	0	0	100[4]

Source: summarised from SKM (2009k) (surveyed December 2007 to February 2008)

[1] a series of potential spoil ground locations investigated for the proposed Outer Harbour Development

[2] sites sampled at a proposed footprint which was subsequently realigned. Further investigations conducted within the current dredge footprint concluded the same results

[3] with the exception of sparse coverage of epifauna

[4] with the exception of the final section of the channel which intersects the outermost ridgeline (refer to table above for composition of hard coral and bare environment to overall benthic environment of the outermost ridgeline)

Sessile Invertebrates

Unlike soft sediment areas, hard substrates such as reef areas and pavement provide permanent attachment points for sessile epifauna as well as perches and hiding places for mobile epifauna. The abundance and diversity of epifauna observed in these habitats markedly exceeds that found in the soft sediment areas where many of the mobile species are hidden beneath the sediment. The most conspicuous were the hydroids, feather stars (crinoids), sea cucumbers and ascidians. Many of the mobile epifaunal species are cryptic, such as rock lobster, crabs and gastropod molluscs, and were less commonly observed by divers during the survey.

Proposed Spoil Grounds

The proposed spoil grounds are located within non-ridgeline areas and have varying degrees of sand cover (20 to 50 cm or greater depth) overlying harder substrate. None of the locations had appreciable BPPH present (0.1 to 1.7% of area).

Epifauna observed in proposed spoil ground areas was very sparsely distributed and limited to small amounts of non-BPP biota such as sponges and sea whips attached to rubble, feather stars clinging to sea whips and hydroids attached to small rocks.

The footprint for the proposed departure channel is mainly bare sand substrate (96% of the area) with no appreciable cover of benthic organisms apart from the final section of the channel that transects the outermost limestone ridge to the east of Cornelisse Shoal (6.7% of the area).

4.4.2 Marine Fauna

Infauna

Infauna is animals that live within the sediments of aquatic environments. Typically, marine infauna is dominated by polychaete worms, molluscs and crustaceans. Conditions within the sediments, including the supply of water, oxygen and nutrients to the sediment and the stability of the system, affect the type and abundance of infauna in any particular environment (Little 2000).

A benthic infauna survey (SKM 2010) was conducted at Spoil Ground One in accordance with Section 4.4.2 of the NAGD (Commonwealth Australia 2009) to monitor change at the spoil ground and the containment of effects within the spoil ground boundary for BHP Billiton Iron Ore's Rapid Growth Project 6 (BHP Billiton Iron Ore 2009d). The purpose of this survey was to determine the baseline composition of the benthic infauna at Spoil Ground One and to confirm the appropriate number of replicates and adequate spatial distribution of sampling locations required for subsequent surveys.

Samples were taken from within and adjacent to Spoil Ground One. Sediment samples were collected at each location using a Van Veen grab and infauna within the samples remaining on a 1 mm sieve were identified to species level. A selection of samples were analysed for particle size distribution (PSD) and total organic content (TOC) to determine whether these abiotic parameters can be used to make predictions on infauna community change. PSD and TOC content will also be tested and their relationship to infauna composition re-examined, following the completion of the sea dumping program. This is recommended as the dredge spoil will be predominantly silty material and will likely change the sediment characteristics in and around the spoil ground after dredge spoil disposal.

The results of the baseline survey (SKM 2010) are summarised as follows:

- a total of 1,035 species were collected, comprised of 39,036 organisms;
- the most species rich phyla were Annelida (no. of species collected = 300), Crustacea (species = 266) and Mollusca (species = 224), while the most abundant phyla were Crustacea (15,457 individuals) and Annelida (14,964 individuals). The faunal groups were typical of lower latitude soft bottom benthic environments;
- Spoil Ground One and the adjacent eastern area had relatively similar species richness and abundances. Both areas had significantly greater species richness and abundance compared to the reference area;
- statistical analysis demonstrated that the abiotic parameters measured were variable across the sampling stations. Samples collected in the spoil ground area were relatively coarser compared

to the four locations furthest from Spoil Ground One, which was established as the reference area; and

- there was a decrease of the species richness and abundance from west to east.

Marine Turtles

The distribution of turtle species depends largely on their habitat requirements at different behavioural stages. Adult turtles occupy four main habitats corresponding to the four behavioural stages of foraging, mating, nesting and inter-nesting (Pendoley Environmental 2009a).

Table 4.10 Behavioural Stages of North-West Shelf Turtles and Respective Habitat

Life Stage		Green Turtle	Flatback Turtle	Hawksbill Turtle	Loggerhead Turtle
Post-hatchling		Oceanic nursery/pelagic.	Coastal waters.	Oceanic nursery/pelagic.	Oceanic nursery/pelagic.
Adult	Mating	Offshore from nesting habitat.	Currently unknown in the Pilbara.	Offshore from nesting habitat.	Currently unknown in Western Australia.
	Foraging	Neritic[1] habitats associated with seagrass/algal beds and mangrove habitat.	Currently unknown in the Pilbara.	Shallow reef, patch reef habitat.	Subtidal and intertidal coral and rocky reefs, seagrass meadows and deeper, soft-bottomed habitats of the continental shelf.
	Nesting	High energy, steeply sloped beaches. Deep well sorted medium grain size. Deep water approach.	Low-energy, narrow beaches. Moderate grain size. Low to moderate beach slope.	Shallow coarse sand and coral rubble associated with near shore coral reefs.	Sandy, wide, open beaches backed by low dunes and fronted by a flat sandy approach from the sea.
	Inter-nesting[2]	Shallow coastal waters within several km of the nesting beach.	Shallow near shore coastal waters within 5–10 km of nesting beach.	Shallow coastal waters within several km of the nesting beach.	Shallow coastal waters within several km of the nesting beach.

Source: Pendoley Environmental (2009c)

Timing and extent of the marine turtle breeding season, which includes mating, nesting and hatching, differs for individual species. Breeding seasons for the three species with most dependency on marine habitats in the Port Hedland region (Pendoley Environmental 2009c) are:

- Green Turtles: November to April with peak nesting in December to January;
- Flatback Turtles: November to March with peak nesting in December to January; and
- Hawksbill Turtles: August to April with peak nesting in October to November.

Research has addressed those aspects of marine turtle biology that: a) satisfy key monitoring areas for marine turtle populations as identified by the National Recovery Plan for Marine Turtles in Australia (2003) and the Marine Turtle Recovery Plan for Western Australia (2009); and b) provide relevant information regarding the potential interaction between marine turtles and the proposed Outer Harbour Development and appropriate management of those interactions.

An overview of the research activities undertaken in the proposed Outer Harbour Development area is provided in **Figure 4-6**, and a summary of observations made to date is provided below.

Nesting Habitat

[1] The neritic zone includes ocean waters from the low tide mark to a depth of about 200 m.
[2] The period between laying successive clutches of eggs within a breeding season

Marine turtle nesting populations are distributed widely across the Pilbara coastline and offshore Islands though large populations are concentrated in a few areas. Mundabullangana, located approximately 50 km west of Port Hedland, supports a regionally important Flatback Turtle rookery. This population is considered one of the largest nesting Flatback Turtle populations in the world (Pendoley Environmental 2009a) Eighty Mile Beach, approximately 278 km north-east of Port Hedland Harbour, is thought to support a similar size nesting population to Mundabullangana although this is not confirmed (Prince 1994). Surveys to confirm abundance at this rookery is scheduled for 2011/12 and 2012/13 reproductive seasons.

Small sandy beaches occur along the coastline between Mundabullangana and the mouth of the De Grey River (approximately 70 km north-east of Port Hedland Harbour) which may provide nesting habitat for marine turtles (Pendoley 2005). Aerial surveys of the coast to identify nesting habitat between Mundabullangana and the De Grey River (2008/09, 2009/10 and 2010/2011) found no nesting at a number of these beaches, including either Finucane or Weerdee Islands, despite both locations providing what may be suitable nesting habitat. If nesting does occur at these locations it is likely to be sparse. Observations at North Turtle Island recorded Flatback Turtle tracks and nests across the island (SKM 2009k; Pendoley Environmental 2009b). Nesting at Little Turtle Island has not been documented and is unlikely as most of the island is awash at high tide.

Flatback turtles also nest at Cemetery Beach, Paradise Beach, Pretty Pool, Cooke Point and Downes Island (Prince 1994; Pendoley Environmental 2009b). Cemetery Beach is the closest nesting beach to the proposed project area, located approximately 5 km east-south-east of the proposed jetty and wharf (**Figure 4-6**), and also has the highest nesting density of the beaches in the vicinity of the proposed project area. Subsequent surveys focused on this location. A mark-recapture program was conducted over two months at the peak of nesting for two consecutive reproductive seasons (2009/10 and 2010/2011) at Cemetery Beach. Data from the first year show annual number of nesting Flatback females at this site to be 188. Observations from this beach document a high level of public activity and low-level indigenous take of eggs. Predation by Varanid lizards also occurs (Pendoley Environmental 2010) There is some movement of nesting females between Mundabullangana and Cemetery Beach (*n*=5 individuals) (Pendoley Environmental 2010).

Surveys to assess reproductive output and primary sex ratio were conducted during the 20010/2011 season. Preliminary findings from programs conducted during 2010/2011 show hatch success to be 35% and emergence success 27%. Beach (sand) and clutch temperatures were also monitored.

Inter-nesting Habitat and Behaviour

Inter-nesting habitat has been delineated using data from satellite tracking units attached to sixteen post-nesting Flatback Turtles (**Figure 4-8** and **Figure 4-9**) at Cemetery Beach, over three consecutive nesting seasons (2008/2009 to 2010/2011) (Pendoley Environmental 2010).

These data show inter-nesting turtles occupying habitat up to approximately 60 km offshore from Cemetery Beach between laying successive clutches of eggs (Pendoley Environmental 2009b). In some cases, animals spent periods of time in the existing shipping channel. There was no movement recorded west of the Channel; all inter-nesting tracks logged were to the east of the shipping channel (**Figure 4-9**).

No locations were received that indicated animals spending any time in the proposed development area. Two per cent of received locations showed turtles spending time within existing spoil disposal grounds.

Flatback Turtles offshore from Cemetery Beach spent an average minimum of 31.5% of their time at the surface during inter-nesting, with a minimum of 68.5% of time spent diving (underwater). Seventy-five per cent of dives were less than 15 min. In 2009/2010, tracked Flatback Turtles spent an average of 34.4% of their dives resting on the seabed. For the remainder of the time they were mobile throughout the water column. They most frequently reside in water temperatures of 31°C (Pendoley Environmental 2010).

Migratory Pathways

Migratory pathways for animals tracked from Cemetery Beach in 2008/09 and 2009/10 are shown in **Figure 4-10** and **Figure 4-11**. Of a total of 13 tracks, nine travelled north from Cemetery Beach, stopping at locations from the mouth of the De Grey River to the Gulf of Carpentaria. This latter track is the longest known migration of a Flatback Turtle (Pendoley Environmental 2010). The remaining animals travelled south with three eventually occupying discrete areas located between the south-west of Barrow Island and to north of Serrurier Island. Migrating animals travelled along the coastline until reaching the northernmost tip of Western Australia where some animals continued north, away from the coastline, to become parallel with Australia's northernmost latitudes.

In-water Distribution and Abundance

Marine turtle density inshore of the 20 m isobath off Port Hedland was assessed during aerial surveys in summer 2008 and 2010 (mating, inter-nesting and foraging turtles) and winter 2009 (foraging turtles) (**Figure 4-12** to **Figure 4-14**). Density was calculated using a conversion factor extracted from Time-Depth-Recorder loggers attached to post-nesting turtles that measure the amount of time spent on the surface versus underwater. Marine turtle density in December 2008, April 2009 and January 2010 was 0.2, 0.8 and 2.5 turtles/km^2 respectively. The turtles were assumed to be mostly Green Turtles with smaller populations of Flatback, Hawksbill and Loggerhead Turtles.

Foraging Habitat

Data from satellite tracked animals show that all tracked post-nesting turtles do not return to one location to forage. Foraging habitat was highly varied with few animals selecting the same area. Some animals appeared to have multiple foraging grounds, moving between areas either of a similar latitude or stopping en route and then continuing north (**Figure 4-11**).

Aerial surveys documented foraging habitat at North Turtle Island and an area adjacent to the De Grey River mouth, approximately 70 km north-east of Port Hedland. Observations were not evenly distributed with density focused around the 20 m isobath in both summer (**Figure 4-12** and **Figure 4-13**) and winter (**Figure 4-14**).

Stable isotope analysis of gut samples collected during 2008/09 indicate Flatback Turtles are feeding on jellyfish and soft corals. Foraging groups of turtles may therefore be present where these food sources are identified. The same study indicated Green Turtles are foraging primarily on seagrasses and algae but they may also rely on higher order species for part of their diet.

Consistent with this, aerial and boat surveys observed Green Turtles on the intertidal platform on North Turtle Island, approximately 58 km from Port Hedland (Pendoley Environmental 2009a). The surrounding area is expected to be suitable foraging habitat as it is colonised by macroalgae and corals (SKM 2009k). Offshore ridges including Minilya Bank, and Coxon and Cornelisse Shoals support a variety of sessile organisms including corals, macroalgae, sponges, hydroids and molluscs (SKM 2009k). Based on stable isotope analysis, assessment of available food sources and known marine turtle distribution in other areas where these food sources are available, (Pendoley Environmental 2010), these offshore ridges is likely to support foraging turtles.

Juvenile turtles are often observed closer to the coastline, adjacent to the beaches and mangrove root systems (Pendoley Environmental 2009a). During sampling and turtle surveys, juvenile Flatback and Green Turtles have been observed in the tidal creeks of Port Hedland Inner Harbour (J. Crozier, SKM, 2009, pers. comm.; J.R. Hanley, SKM, 2009, pers. comm.; Pendoley Environmental 2009a; Biota 2004). It is likely that these turtles foraging on algae, mangroves and hard and soft corals found within area (SKM 2009k, 2009l). In addition, survey teams on Cemetery Beach frequently observe juvenile Green Turtles in the water immediately offshore from the beach (J. Oates, Pendoley Environmental 2009a, pers. comm.).

Following initial light source surveys by Bassett (2009), and in accordance with directives outlined by the EPA (2010) a comprehensive and biologically-relevant assessment of light effects was conducted to provide interpretation regarding perception of artificial light sources by marine turtles in the vicinity of Cemetery Beach (Pendoley Environmental 2010). These data once amalgamated with data that describe actual hatchling orientation in the period immediately following emergence from the clutch (Pendoley Environmental 2010), will identify the relationship between light sources and hatchling orientation on Cemetery Beach Values. Future hatchling behaviour will be modelled against these findings to allow identification of any dis- or mis-oriented hatchlings resulting from light generated by the proposed Outer Harbour Development.