Port Hedland Outer Harbour Development

SPOIL GROUND SELECTION STUDY

- WV03716-MV-RP-0039
- Revision 2
- 15 February 2011

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Limitation

The sole purpose of this report and the associated services performed by Sinclair Knight Merz ("SKM") is to document the spoil ground selection process undertaken for the Port Hedland Outer Harbour Development dredging program in accordance with the scope of services set out in the contract between SKM and the Client (BHP Billiton). That scope of services, as described in this report, was developed with the Client.

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Executive Summary

BHP Billiton Iron Ore proposes to dredge 54 Mm^3 of sediment offshore from Port Hedland as part of the proposed Port Hedland Outer Harbour Development. The preferred disposal option of dredge material is unconfined sea disposal. This report explains the rationale behind site selection of the spoil ground and is intended to act as a supporting document to the Outer Harbour Development Sea Dumping Permit Application to the Department of Environment, Water, Heritage and the Arts.

Numerous offshore spoil ground options have been considered and investigated in marine environmental studies undertaken since December 2007. Three proposed spoil grounds have been selected from nine options based on environmental, engineering and financial criteria.

Land disposal of dredge material has been considered but is not a preferred option due to the logistical and economical challenges of transporting this volume of material to land. There is also a lack of space in the vicinity of Port Hedland Inner Harbour for reclamation or land disposal of this quantity of material. The existing offshore spoil grounds H, I and J are not viable options as they are required for future disposal from Port Hedland Inner Harbour maintenance and capital dredging. There is insufficient capacity for all of the Outer Harbour Development dredge spoil within the existing spoil grounds.

The three preferred spoil ground options and one contingency option satisfy key environmental and engineering criteria, including:

- absence of modelled sensitive ridgeline habitats that may support benthic primary producers;
- absence of benthic habitat within the proposed spoil ground footprints;
- absence of contaminants of concern within the dredge spoil material that may be mobilised during disposal;
- sufficient water depth to reduce the potential for re-suspension of medium to coarse spoil material under normal sea state conditions;
- avoidance of areas required for current or future shipping activities;
- adequate holding capacity for the dredge volume; and
- optimal locations for dredge hopper (sailing cost and time considerations).

This report describes and illustrates the selection process resulting in the proposed final three spoil grounds, summarised in **Table 1**. As the final options satisfied environmental and engineering criteria listed in **Section 2** of this document, it is proposed that they are suitable locations for unconfined sea disposal of material from the Outer Harbour Development dredging program.

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- **Table 1 Summary of spoil grounds and primary reasons for acceptance or rejection**

	Spoil Grounds													
	January 2008					February 2008								
	A	B	C	D	E	1	2	3	4	5	6	7	8	9
Reason for rejection														
Insufficient capacity	✗	✗	✗	✗	✗	✗	✗*						✗	
Insufficient water depth	✗	✗	✗	✗	✗									
Proximity to benthic habitat									✗	✗	✗			
Proximity to infrastructure														
Used by another project						✗								
Acceptable for use as a spoil ground	✗	✗	✗	✗	✗	✗	✗		✗	✗	✗		✗	
Reason for success														
Sufficient capacity								✓				✓		✓
Sufficient water depth								✓				✓		✓
Sufficient distance from benthic habitat								✓				✓		✓
Acceptable for use as a spoil ground								✓				✓		✓

*Sufficient capacity to act as a contingency spoil ground

Contents

Figures

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Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
A	08/07/09	PF Morrison	R Burgess	13/07/09	Draft for Client Review
B	10/09/2009	PF Morrison	R Burgess	11/09/09	Final Draft for Client Review
0	22/09/2009	PF Morrison	R Burgess	22/09/2009	Final
1	25/11/2009	R Burgess	R Burgess	25/11/2009	Incorporates changes to approved spoil grounds associated with the RGP6 project.

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1. Background

1.1. Project Overview

BHP Billiton Iron Ore currently exports iron ore from port facilities in Port Hedland, Western Australia. The current port operations consist of processing, stockpiling and shiploading facilities at Nelson Point and Finucane Island (referred to as the Inner Harbour), located on opposite sides of the Port Hedland Harbour. The operations currently have an approved capacity of 155 million tonnes per annum (Mtpa).

BHP Billiton Iron Ore is in a phase of significant growth and has been focused on growing the business via a phased approach to meet market demand. This has been, and continues to be, achieved by a series of Rapid Growth Projects which enable BHP Billiton Iron Ore's capacity to be increased incrementally.

BHP Billiton Iron Ore's expansion program will continue to grow with market demand for iron ore, which is expected to remain strong for some time as China continues its urbanisation phase. This growth will also have a flow-on effect to other steel producers in the Asian region and will underpin the current and proposed expansion activities.

To meet the expected global demand for iron ore, BHP Billiton Iron Ore is embarking on a development program to increase capacity through additional iron ore loading and berthing facilities called the Outer Harbour Development. It is anticipated that the development will be staged to achieve approximately 240 Mtpa of installed capacity.

The Outer Harbour Development will involve the construction and operation of landside and marine infrastructure for the handling and export of iron ore (**Figure 1**). The Outer Harbour Development will provide an export capacity of approximately 240 Mtpa of iron ore, with an estimated construction time of eight years. This will be established in four stages, with incremental expansions brought on line to reach the maximum capacity. Expansion stages will occur through four separate stages, each with a nominal capacity of up to 60 Mtpa. Regulatory approvals are being sought for the infrastructure required to deliver the total capacity of 240 Mtpa.

The Outer Harbour Development is the subject of a referral to the Western Australian Department of the Environment and Conservation (DEC) and the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (previously the Department of Environment, Water, Heritage and the Arts - DEWHA).

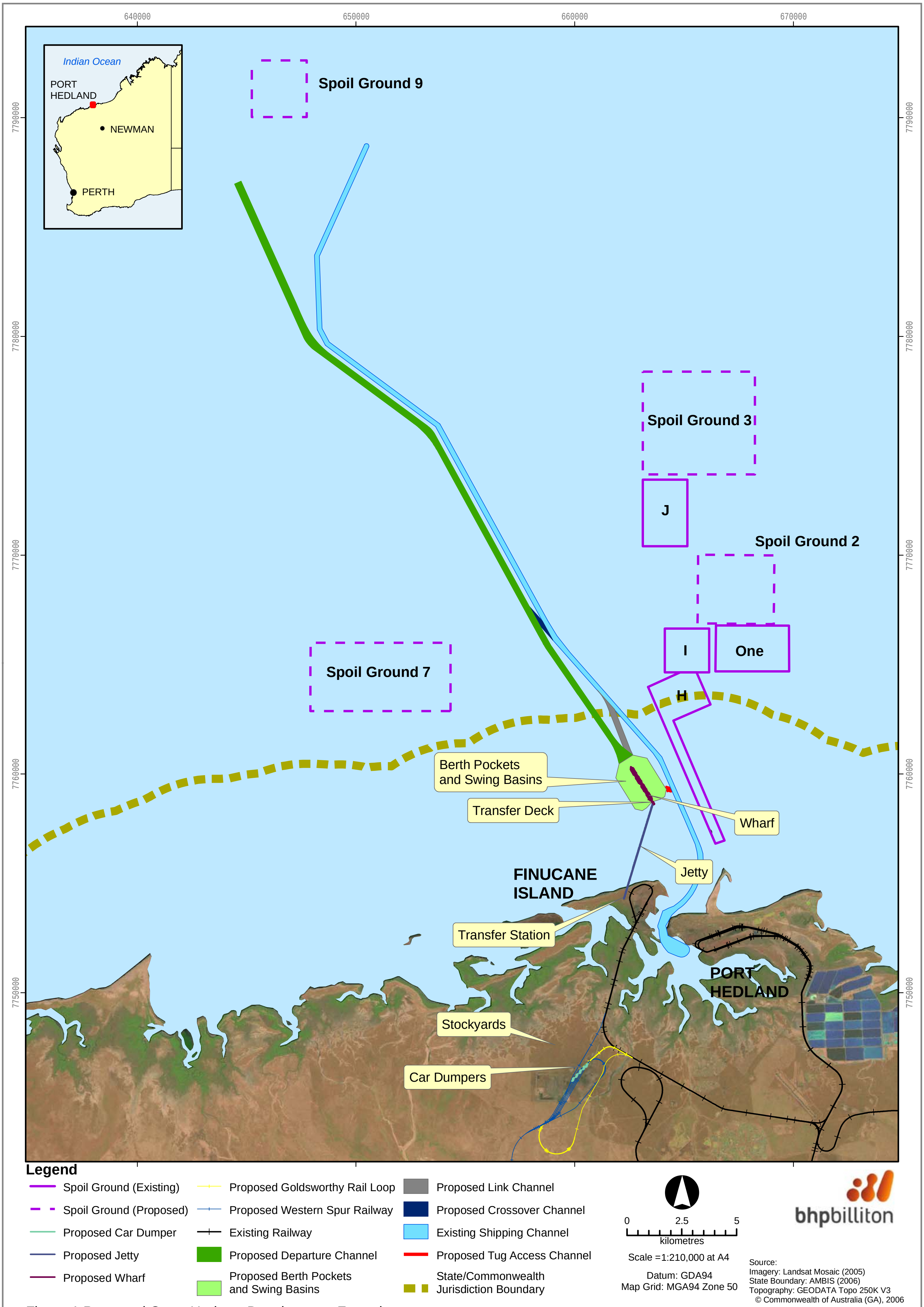

Figure 1 Proposed Outer Harbour Development Footprint

1.2. Marine Infrastructure

Key marine structures and activities will include:

- an abutment, jetty and wharf;
- mooring and associated mooring dolphins;
- transfer station and deck;
- associated transfer stations, ore conveyors and shiploaders;
- dredging for berth pockets, basins and channels; and
- aids to navigation.

The marine infrastructure for the new offshore loading facility will be constructed immediately north of Finucane Island. The new jetty and wharf will extend nominally 4 km offshore in a northerly direction, adjacent to the existing inner harbour shipping channel (**Figure 1**). The new iron ore loading facility will be capable of berthing and loading vessels between 180,000 and 250,000 deadweight tonnes (DWT) in size, with a design provision for 320,000 DWT vessels to berth and load in the future.

The construction of the Outer Harbour Development will require dredging to enable vessel access to the wharf. Dredging operations will create new berth pockets, swing basins and departure basins, a departure link channel to the existing shipping channel, a proposed departure channel and a cross-over link channel enabling safe passage for departing, laden vessels from the Inner Harbour shipping channel into the new departure channel.

Bathymetric and light detection and ranging (LIDAR) surveys were conducted to map the sea bed topography (**Figure 2**). These surveys indicated that the depth of the existing seabed within the project footprint varies from less than +1.4 m Chart Datum (CD) to deeper than -25 m CD (SKM 2008a; Tenix 2008). Dredging operations will commence at depths of approximately -5 m CD to create new berth pockets, swing basins, arrival and departure basins, a link channel to the existing inner harbour shipping channel and a new departure channel. This new departure channel will be approximately 34 km in length.

The required dredged depths will be approximately -22 m CD for the berth pockets, -23 m CD for the wharf area, -11 m CD for the swing basins and -16 m CD for the departure basins based on the requirements of a 250,000 DWT vessel. The basins, berth pockets and up to 3 km of the new departure channel will be located in State waters, with the remainder of the departure channel being in Commonwealth waters (**Figure 1** and **Figure 2**). The depths along the departure channel will range from -15.2 m CD to -16.7 m CD.

The total volume of dredged material is estimated to be approximately 54 Mm^3, including an allowance for over-dredging. There is a range of material types in the proposed dredging footprint, thus requiring the use of a trailing suction hopper dredger (TSHD) for softer material, while harder materials will first require cutting/crushing using a cutter suction dredger (CSD). Geotechnical studies completed to date have identified no areas in the dredging footprint that would require marine blasting operations for material extraction (FUGRO 2008).

It is envisaged that dredging will occur in a staged manner, as follows:

- **Stage 1** – dredging of berth pockets, eastern swing and departure basins and a link channel into the existing channel to provide two ore loading berths serviced with a single shiploader.
- **Stage 2** – dredging of the western swing and departure basins to provide two additional ore loading berths and an additional shiploader. This will also include dredging works for the new 34 km long departure channel.
- **Stage 3** – dredging for the extension of the wharf with additional berth pockets and the extension of the swing and departure basins to accommodate another four ore loading berths and two shiploaders.
- **Stage 4 –** there is no proposed dredging activities in Stage 4.

It is proposed that dredge material will be disposed of at sea in offshore spoil grounds located in Commonwealth waters.

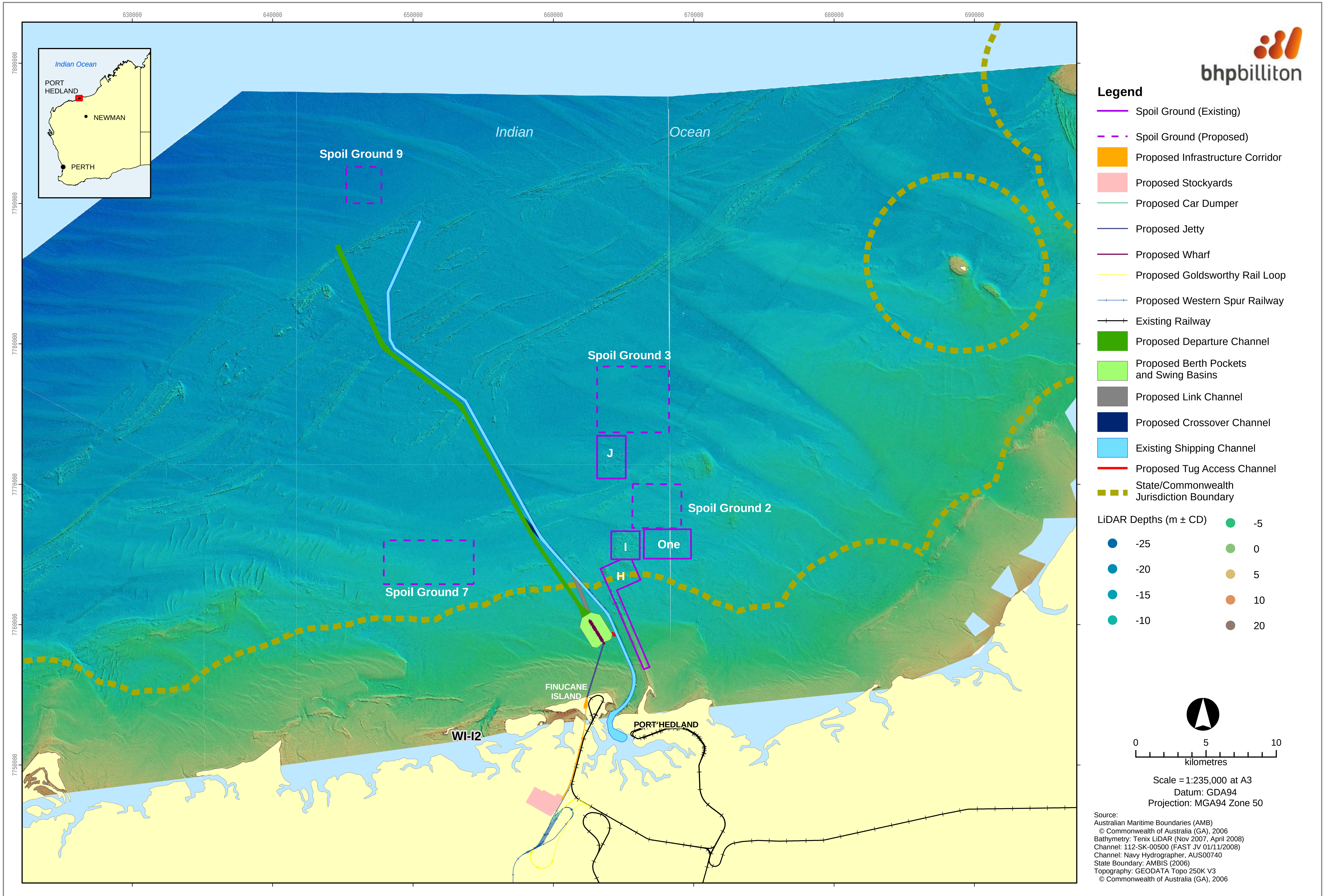

Figure 2 Sea Bed Topography of the Study Area from LIDAR Surveys

PRELIMINARY

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2. Introduction

2.1. Spoil Disposal Considerations

The disposal of dredge material from the Outer Harbour Development may have the potential to adversely impact the marine environment in numerous ways, including release of contaminants, smothering of benthic habitats and increased turbidity leading to reduction in light available to benthic primary producers. In an effort to minimise potential impacts, BHP Billiton Iron Ore has implemented studies recommended by DEWHA (now DSEWPaC) in the National Ocean Disposal Guidelines for Dredged Material (NODGDM) (EA 2002)[1].

These studies support the application for a Sea Dumping Permit to DSEWPaC and have been described in more detail in the Outer Harbour Development Sea Dumping Permit application (SKM 2009a). One such study required to support the Sea Dumping Permit application was the explanation of the processes followed to identify areas suitable for the disposal of dredge material. NODGDM (EA 2002) Section 4.2 describes environmental factors relating to the establishment of new spoil grounds that should be considered. This information can be summarised as follows:

General (NODGDM Section 4.2)

A range of alternative sites (including land disposal) should be proposed and considered, with sufficient data collected for each site to allow for informed decisions.

Physical and Chemical Characteristics (NODGDM Section 4.2.1)

Consideration of the following:

- water depths;
- tidal characteristics;
- currents;
- wind and wave characteristics;
- modelling of suspended solids/sedimentation/turbidity/light penetration;
- bathymetry of seabed;
- sediment grain size characteristics;
- sediment chemistry;

---

[1] The proposed Outer Harbour Development approvals for sea dumping were sought under the National Ocean Disposal Guidelines for Dredge Management (Environment Australia 2002). During this period, the NODGM have been revised and the environmental assessment process is now guided by the National Assessment Guidelines for Dredging (2009); however, the NODGDM will be referred to in this report.

- previous disposal operations; and
- visual recordings of seabed to capture site conditions.

Marine Communities (NODGDM Section 4.2.2)

Consideration of the following:

- investigate existing literature for descriptions of marine communities in the area;
- implement investigations and monitoring of sensitive habitats (e.g. hard corals);
- field investigations to determine pre-disposal infaunal invertebrate communities structures in the proposed spoil grounds; and
- determine potential impacts on fish communities.

In addition to environmental factors, engineering needs influence the suitability of spoil grounds. Consideration needs to be given to factors such as:

- holding capacity of spoil grounds;
- travelling distance from dredging locations and associated cost;
- existing operations and requirements in the region (e.g. shipping lanes and anchorages); and
- future operational requirements that may be impaired by spoil ground locations.

Section 3 of this report will discuss the history of spoil ground investigations and the reasons for rejecting or modifying potential spoil grounds as additional information was gathered.

2.2. Objectives

This report presents justification for the selection of locations for disposal of dredge material from the Outer Harbour Development. It will be submitted as a supporting document for the Sea Dumping Permit Application to demonstrate to DSEWPaC that BHP Billiton Iron Ore have thoroughly investigated options to minimise potential impacts to the marine environment.

The report explains the reasons for acceptance or rejection for each spoil ground option that has been considered, particularly in relation to the factors listed in Section 4 of NODGDM (EA 2002). The report describes and illustrates the history of the spoil ground selection process and how it was influenced by environmental investigations and modifications to engineering designs.

The report also provides a figure illustrating the locations of the three preferred spoil grounds and a list of coordinates of the spoil ground boundaries.

3. Spoil Ground Selection Process

Numerous spoil ground sizes and locations have been considered during the Outer Harbour Development scoping phase. Modifications to engineering designs and dredge footprints have necessitated investigation of locations previously considered unsuitable due to factors such as distance from dredging activities. Concurrently with the progression of engineering design, marine environmental investigations were identifying and delineating areas of sensitive benthic (seabed) habitat that would preclude disposal of spoil (SKM 2009b).

The selection of potential spoil grounds since project conception to their current and final configuration is detailed in chronological order below. The selection process considers the suitability of each spoil ground option against the main engineering and environmental issues, and is supported by figures and references to supporting studies.

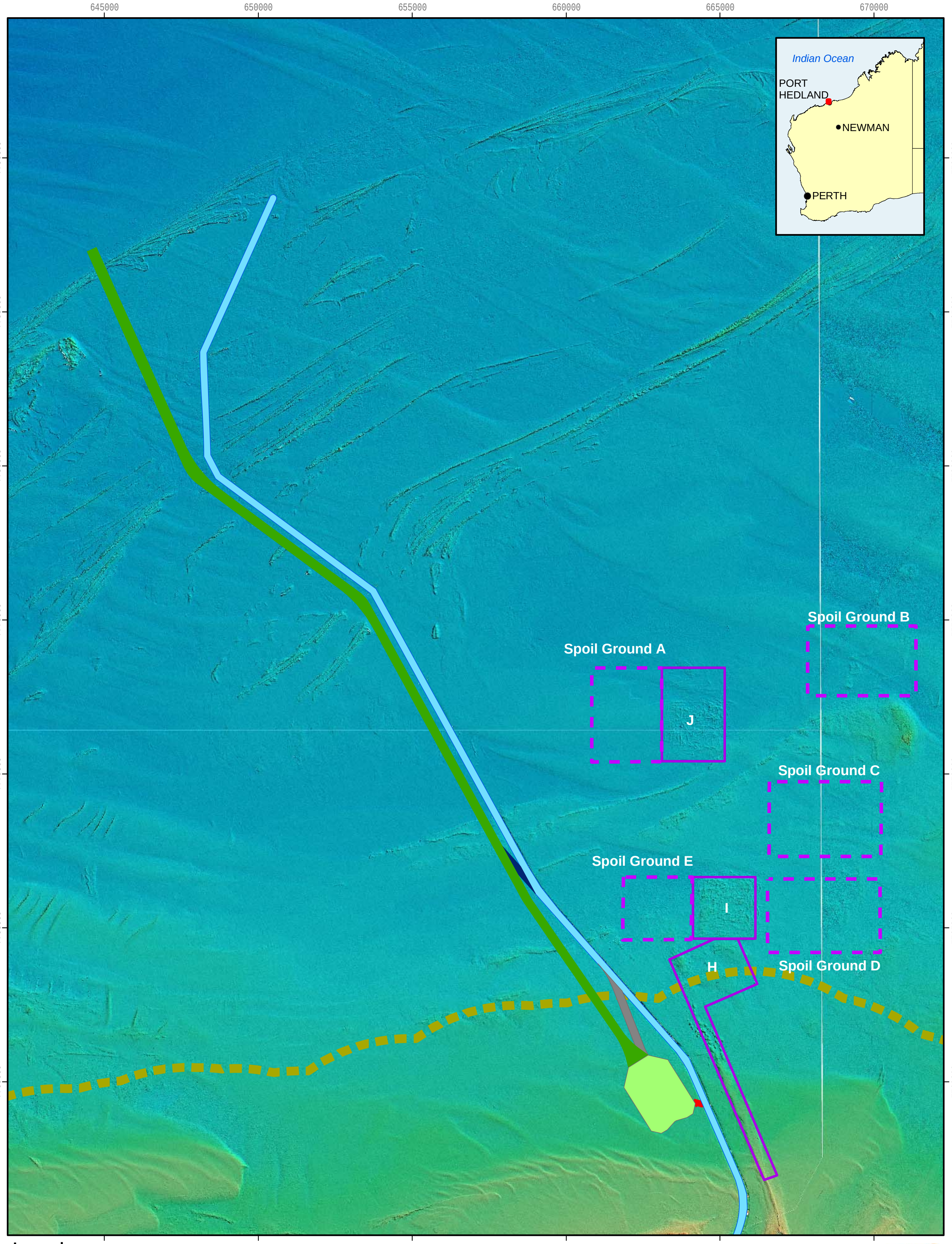
The existing spoil grounds H, I and J (**Figure 2**) were not considered as options due to future usage requirements by Port Hedland Port Authority (PHPA) and a lack of capacity for the total volume of Outer Harbour Development dredge material.

3.1. Preliminary Investigations

During the early phases of the Outer Harbour Development design process, the wharf head (and bulk of dredging) was located 6 km offshore, connected by a jetty to Finucane Island.

In December 2007, the alignment and location of the dredge footprint was considerably different to the current design. When the preliminary alignment was designed in 2007, bathymetric information available was limited to Australian Hydrographic Service (AHS) hydrographic charts. Preliminary investigations found significant areas of bare sand; however, spoil ground site selection was not undertaken at this stage.

In January 2008 five potential spoil grounds named A to E were proposed, based on AHS hydrographic charts and also on further seabed habitat investigations by divers (see **Figure 3**). Divers collected sediment samples from five locations within each of these potential spoil grounds, recording habitat and sediment/topographic relief observations when back on the vessel. All potential spoil grounds were later rejected based on insufficient capacity, inappropriate depth (too shallow) and an inappropriate distance to shore (resuspension of material is more likely in shallow water, where turbidity may be increased).



Legend

- Spoil Ground (Existing)
- Spoil Grounds (Proposed)
- Proposed Tug Access Channel
- State/Commonwealth Jurisdiction Boundary
- Proposed Departure Channel
- Proposed Berth Pockets and Swing Basins
- Proposed Link Channel
- Proposed Crossover Channel
- Existing Shipping Channel

0 1 2 3 4
kilometres

Scale =1:160,000 at A4

Datum: GDA94
Projection: MGA94 Zone 50

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Source:
Bathymetry: Final Lidar Imagery (08/05/2008)
Topography: Geoscience Australia, GEODATA Topo 250K V3 (Copyright Commonwealth of Australia, 2006)

Figure 3 Location of Potential Spoil Grounds A through E on LIDAR Background, January 2008

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3.2. Subsequent Investigations

A workshop involving maritime engineers and marine scientists convened in February 2008 identified exclusion areas which were unsuitable for spoil disposal in relation to the re-aligned dredge footprint (parallel to the existing PHPA departure channel) (**Table 2**). Criteria included water depth, existing and planned shipping requirements such as anchorages and approach channels, areas known or likely to contain sensitive benthic habitat and sailing distance from dredging activities. When these exclusion areas were overlaid on a hydrographic chart, all five options from January 2008 were rejected and nine new potential spoil areas were identified and plotted (**Figure 4**).

Nine potential spoil ground options relating to the Outer Harbour Development named 1 to 9 are those that are assessed further within this document. All other options are not considered further. These spoil grounds were selected based on the following criteria:

- water depths of greater than 10 m;
- no water stratification;
- areas outside significant influence of tides (distance from shore);
- low surface and bottom currents;
- small non-cyclonic wind and wave conditions; and
- no temperature gradients.

These areas were also selected due to their distance from any topographic relief (that may contain benthic primary producers) and their distance from the dredge footprint. These areas were later tested to compare chemical characteristics and particle size distribution (PSD) in order to find sites that were chemically and physically similar to the material being dredged.

- **Table 2 Assessment of potential spoil grounds against key selection criteria**

✓ = acceptable; ✗ = unacceptable	Potential Spoil Grounds								
Factor	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Engineering Factors:									
Sufficient spoil ground capacity [1]	✗	✗**	✓	✓	✓	✓	✓	✗	✓
Acceptable distance from dredging [2]	✓	✓	✓	✗	✗	✗	✓	✗	✓
Vessel Safety	✓	✓	✓	✓	✓	✓	✓	✓	✓
Absence of existing uses [3]	✓	✓	✓	✓	✓	✓	✓	✓	✓
Free of potential future use constraints [4]	✓	✓	✓	✓	✗	✓	✓	✓	✓
Spoil ground stability	✓	✓	✓	✓	✓	✓	✓	✓	✓
Environmental Factors – Water Column Physical:									
Water depth [5]	✓	✓	✓	✓	✓	✓	✓	✓	✓
Water stratification [6]	✓	✓	✓	✓	✓	✓	✓	✓	✓

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✓ = acceptable; ✗ = unacceptable	Potential Spoil Grounds								
Factor	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Tidal characteristics [7]	✗	✗	✓	✓	✓	✓	✓	✓	✓
Surface and bottom currents [8]	✓	✓	✓	✓	✓	✓	✓	✓	✓
Non-cyclonic wind and wave characteristics [9]	✓	✓	✓	✓	✓	✓	✓	✓	✓
Absence of temperature stratification[10]	✓	✓	✓	✓	✓	✓	✓	✓	✓
Environmental Factors – Sea Bed Physical:									
Topographic features flat featureless	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sediment chemistry and PSD similar to dredge area [11]	✓	✓	✓	—	—	—	✓	✓	✓
Environmental Factors – Sea Bed Biological:									
Proximity to significant ridgeline habitat [12]	✓	✓	✓	✓	—	✓	✓	—	✓
Benthic fauna – soft substrate [13]	*	*	*	*	*	*	*	*	*
Benthic fauna – reefs	*	*	*	*	*	*	*	*	*
Demersal fish communities [14]	✓	✓	✓	✓	✓	✓	✓	✓	✓

1) Spoil grounds require sufficient capacity so that when dredged material was disposed there is still a 10 m clearance at low tide and no more than 2 m of mounding on the seafloor. Spoil grounds 1 and 2 have inadequate capacity for dredge volumes originating from vicinity of wharf head.
2) Since the majority of dredge material will be in the vicinity of the wharf head, potential spoil grounds 4, 5, 6 and 8 are unsuitable due to excessive travel time, cost and fuel usage. Spoil ground 3 is considered acceptable as it is well situated to receive material from the entire dredge footprint. Excessive distance was considered relative to locations of other spoil grounds, the closest of the options being preferred.
3) Does not interfere with current activities or infrastructure, such as mooring areas or current departure channel.
4) Potential future BHP Billiton Iron Ore entrance channel passes over part of potential spoil ground 5.
5) Water depth must be greater than 10 m when all dredge spoil has been disposed.
6) Stratification is not an ideal characteristic.
7) Significant tidal influence is not ideal and is determined by the distance from the shore.
8) Surface and bottom currents should not be sufficient to resuspend material. These can be determined by the PSD of the spoil ground sediment.
9) Wind and wave characteristics at all potential spoil grounds are considered to be similar at each of the potential spoil grounds.
10) Temperature stratification is not ideal.
11) PSD and chemistry were investigated in spoil grounds 1–3 and 7–9. All chemistry results were within acceptable levels outlined in NODGDM (EA 2002), with the exception of arsenic, which occurs naturally in the Port Hedland region. The PSD data for each of these spoil grounds was dominated by medium grain sand or larger (indicating reduced potential for re-suspension).
12) Sediment fate modelling undertaken to date for options 1–4, 6, 7, and 9 indicate that sedimentation would be unlikely to cause a significant impact on nearby sensitive habitats. Note that modelling is continually being refined.
13) The validity of further infauna studies will be examined in consultation with DSEWPaC for the proposed Outer Harbour Development.
14) No specific studies have been undertaken for each spoil ground, but a related desktop study (SKM 2009c) has identified target species such as snappers, emperors and cods are not dependent on these sand plains during their juvenile or adult stages. Based on LIDAR bathymetry and ground truthing, the spoil grounds do not appear to be located on seabed unique for the study area (and presumably the greater region). These are often transient species that move through open sandy areas and are not restricted to one area.

* Data not yet obtained. Field work has been scheduled.

** Sufficient capacity to act as a contingency spoil ground

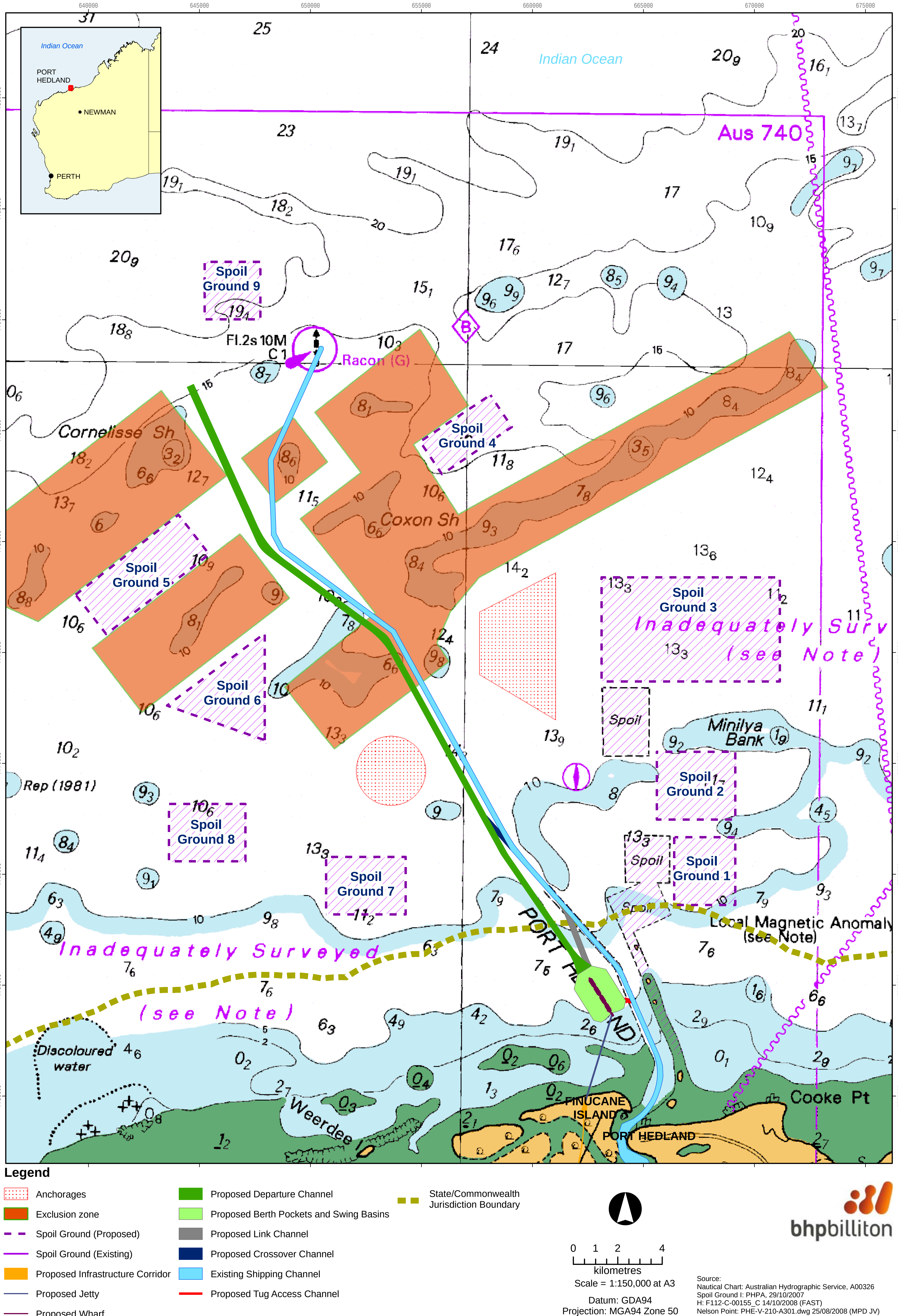


Figure 4 Exclusion Areas and Nine Proposed Spoil Grounds (1 - 9) in February 2008

3.3. May 2008 Investigations

Between February and May 2008, information received from the LIDAR surveys was compiled into a highly detailed bathymetric chart. This chart provided vastly improved detail of the seabed compared to the AHS hydrographic charts and highlighted numerous areas of elevated areas of seabed (and potential associated sensitive benthic communities) not previously identified. Environmental investigations conducted by divers and towed video, guided by the LIDAR bathymetry, identified areas of previously unknown sensitive benthic habitat (**Figure 5**).

Prior to receiving the LIDAR bathymetry, spoil grounds 4, 5 and 6 did not appear to be located near any areas of relief considered likely to support sensitive benthic habitat (based on observations by divers). However, the LIDAR bathymetry illustrated seabed relief that was not well defined on existing hydrographic charts, and spoil grounds 4, 5 and 6 were in close proximity to the more accurately defined features (**Figure 6**). Subsequent spot dives confirmed the presence of sensitive benthic habitat (such as reef areas containing hard corals, sponges and gorgonians. Consequently spoil grounds 4, 5 and 6 were rejected due to the risk of re-suspended spoil material settling on the adjacent habitat.

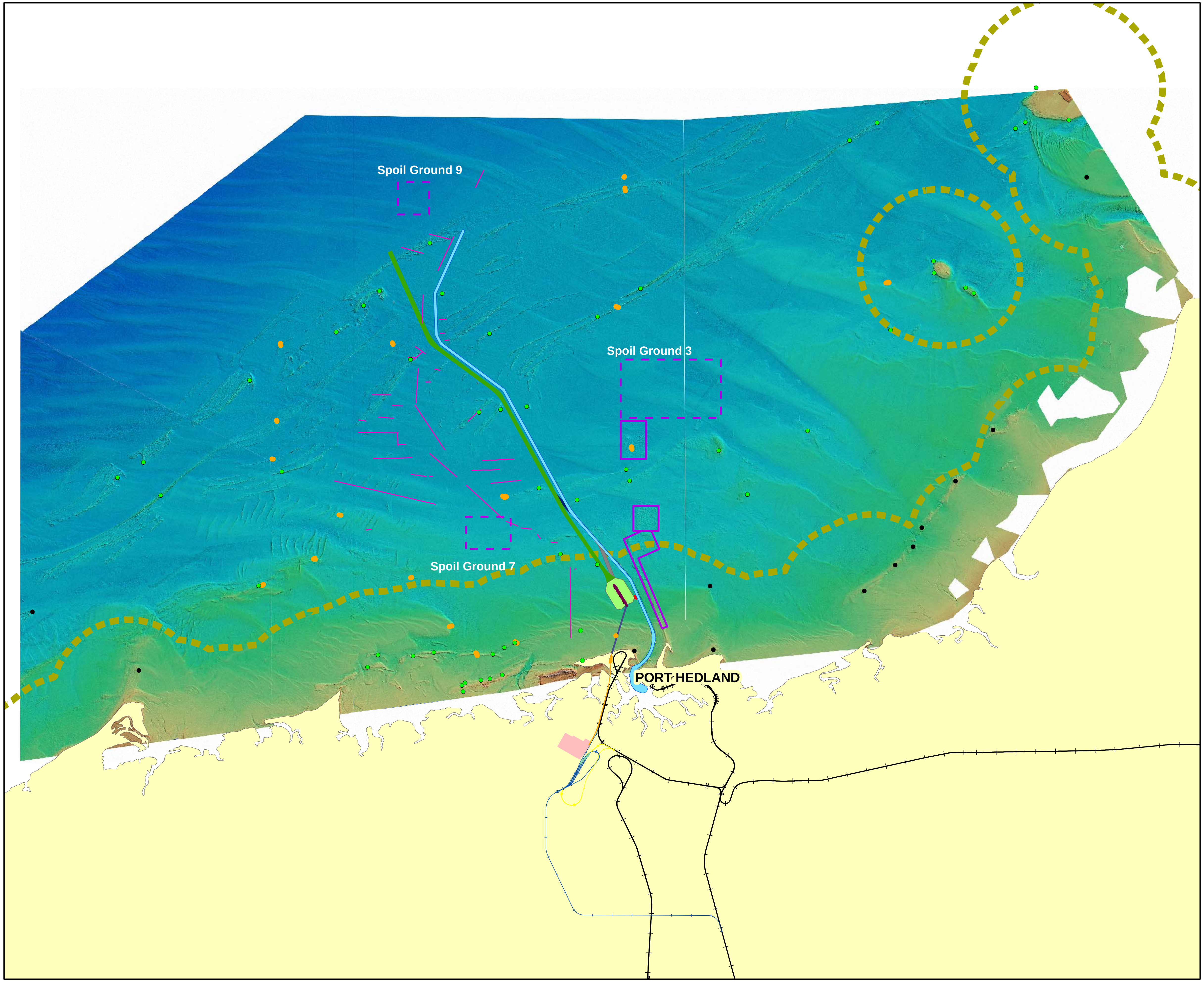
Engineering constraints also contributed to the rejection of spoil ground locations 4, 5 and 6. The majority of dredge material in the Outer Harbour Development originates from the wharf head, berths and basins and as spoil grounds 4, 5 and 6 are located approximately midway along the approximately 34 km channel, they would have incurred excessive transportation cost and time if used as dredge spoil disposal sites. Spoil ground 5 was also deemed to be unsuitable as it overlays a potential shipping approach channel under consideration at the time.

Summary of May 2008 Investigations

Spoil grounds under consideration: 1 through to 9.

Spoil grounds rejected: 4, 5 and 6 due to close proximity to benthic habitats (**Figure 6**).

Still under consideration: spoil grounds 1, 2, 3, 7, 8, 9.



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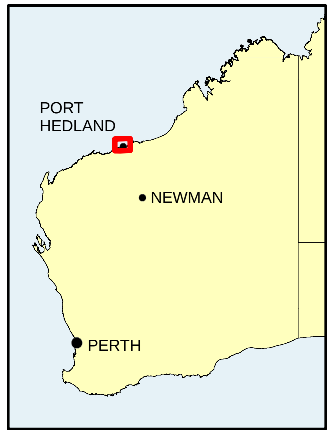
Legend

- Towed Video Site
- Spot Dive
- Video Transect Sites
- Towed Video Transects
- Spoil Ground (Existing)
- Spoil Ground (Proposed)
- Proposed Infrastructure Corridor
- Proposed Stockyards
- Proposed Car Dumper
- Proposed Jetty
- Proposed Wharf
- Proposed Goldsworthy Rail Loop
- Proposed Western Spur Railway
- Existing Railway
- Proposed Departure Channel
- Proposed Berth Pockets and Swing Basins
- Proposed Link Channel
- Proposed Crossover Channel
- Existing Shipping Channel
- Proposed Tug Access Channel
- State/Commonwealth Jurisdiction Boundary



0 2 4 6 8
kilometres

Scale = 1:300,000 at A3
Datum: GDA94
Projection: MGA94 Zone 50

Source:
Sampling: SKM (Various 2007 - 2008)
Bathymetry: Final lidar data (Nov 2007)
State boundary: AMBIS (2006)
Topography: Geoscience Australia, GEODATA Topo 250K V3
(Copyright Commonwealth of Australia, 2006)

Figure 5 Location of Spot Dives and Towed Video Transects on LIDAR Background, May 2008

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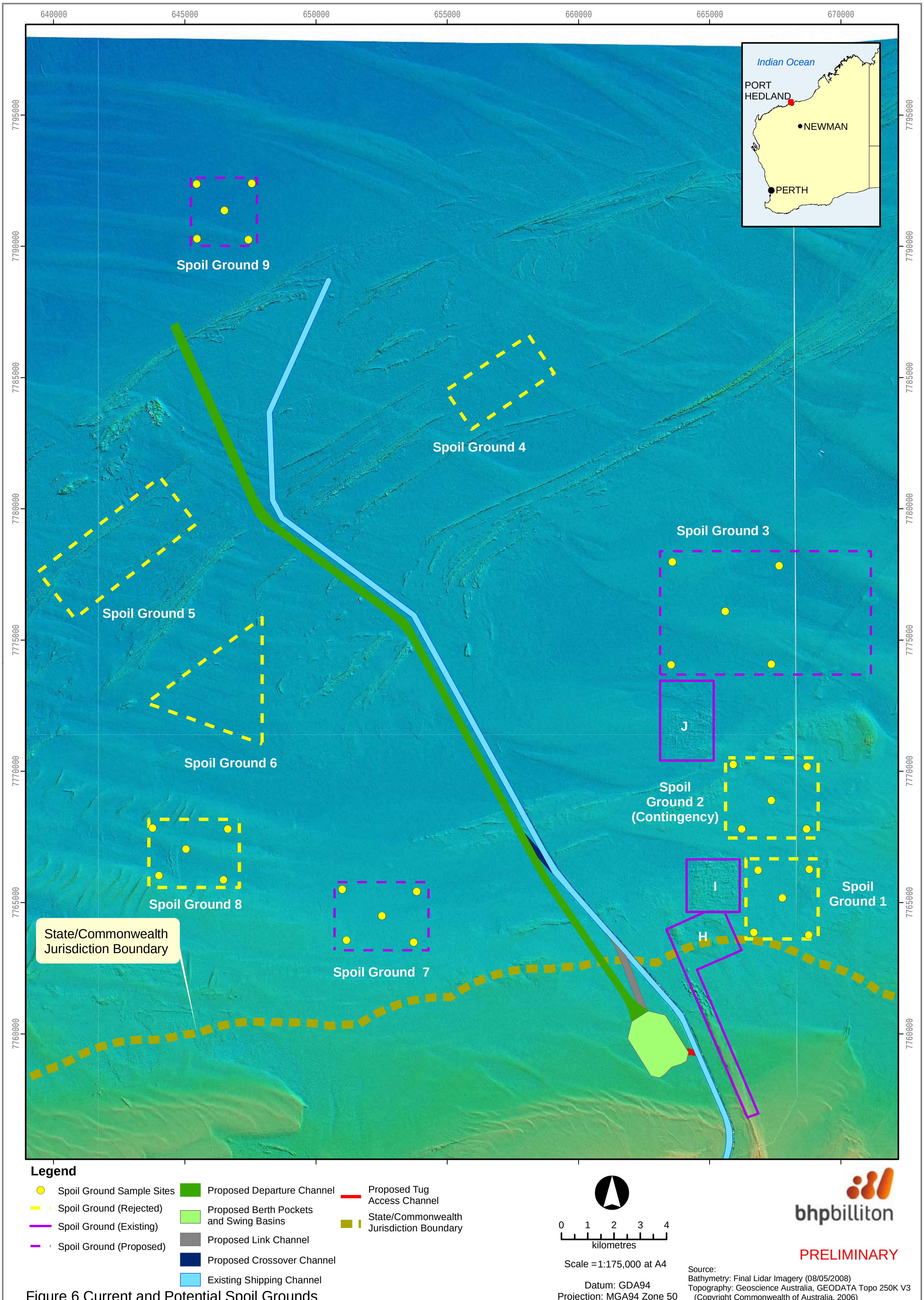

Figure 6 Current and Potential Spoil Grounds 1 – 9 (Proposed and Rejected) on LIDAR Background, May 2008

3.4. September 2008 Investigations

In mid to late May 2008, divers undertook sediment sampling at the six remaining potential spoil grounds. Samples and observations were collected from five sites within each of potential spoil grounds 1, 2, 7, 8 and 9. Eight sites were sampled from spoil ground 3 due to its larger size relative to other spoil grounds. Physical and chemical analyses of sediment samples demonstrated that all potential spoil grounds were suitable as receiving environments, and observations by divers at each of the sites detected little or no sensitive benthic biota (SKM 2008a; 2009b).

Between May and September 2008, optimisation studies (refinement of engineering design, cost benefit analysis and re-calculation of dredge volumes) resulted in shortening the jetty length from 6 km to 4 km and a revised dredge volume of 54 Mm^3. For this reason, spoil ground 7 was increased in size and additional sites were sampled for sediments (**Figure 7**). The modification to spoil ground 7 was explained in detail in the Supplemental SAP, submitted to DEWHA (now DSEWPaC) in December 2008 (SKM 2008b).

Engineering calculations determined that potential spoil grounds 1 and 8 were economically and logistically unsuitable for the proposed Outer Harbour Development due to a combination of unsafe vessel operations, longer sailing distance from the dredging activities and inadequate capacity to hold the dredge spoil. Spoil ground 7 was expanded in size to the extent that spoil ground 8 was no longer required. Spoil Ground 2, although originally deemed unsuitable for the proposed works due to inadequate capacity to hold the dredge spoil, is being considered as a contingency spoil ground. At that time there were no environmental reasons for rejecting any of these areas.

Summary of Investigations (September 2008)

Spoil grounds under consideration: 1, 2, 3, 7, 8 and 9.

Spoil grounds rejected: 1 and 8.

Spoil Ground 1 was subsequently identified as a Spoil Ground for use by the RGP6 project. It was approved for use by RGP6 in November 2009 (**Figure 7**).

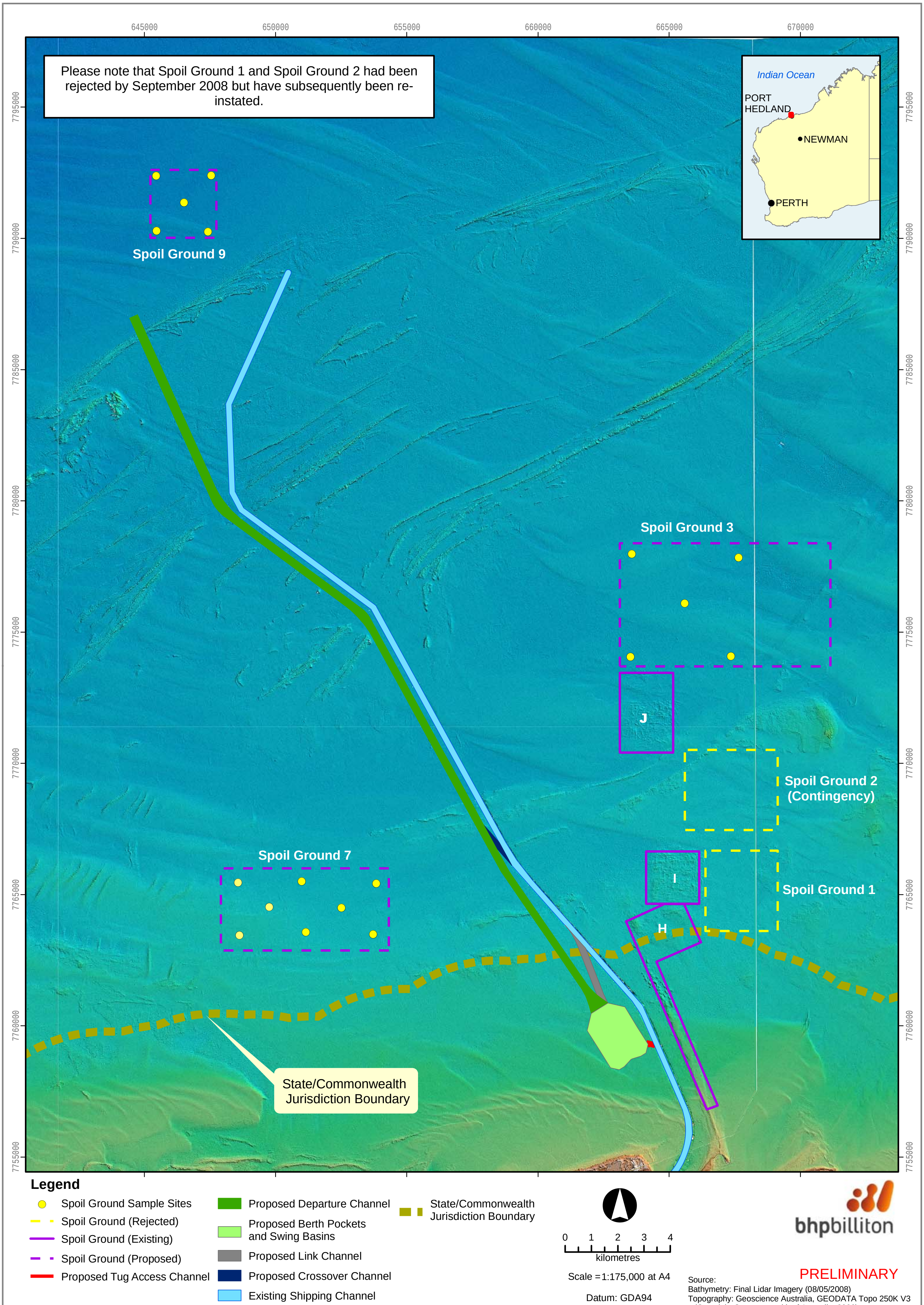

Figure 7 Spoil Ground Options with Expanded Spoil Ground 7, September 2008

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3.5. Sediment Analysis

For suitable spoil grounds to be selected, sediment chemistry and PSD needed to be compared between the dredge footprint and potential spoil grounds. All parameters measured were under the screening levels (according to the NODGDM (EA 2002)) at both the dredge footprint and all potential spoil grounds, with the exception of arsenic (**Table 3** and **Table 4**). Arsenic has been demonstrated to be naturally occurring in the Port Hedland region. Further detail is provided in the Sampling and Analysis Implementation Report (SKM 2009c).

Similarly, the PSD was similar between the dredge footprint and the potential spoil grounds and were characterised by medium grain sand or larger (**Figure 8**, **Figure 9**). However, the spoil grounds did have a larger component of sand than the dredge footprint. Also, the sediment analysed for PSD from the dredge footprint was surficial sediments only, whereas, when consolidated material is dredged is will likely consist of coarser material.

- **Table 3 Sediment analysis of potential spoil grounds 1, 2, 3, 7, 8, 9**

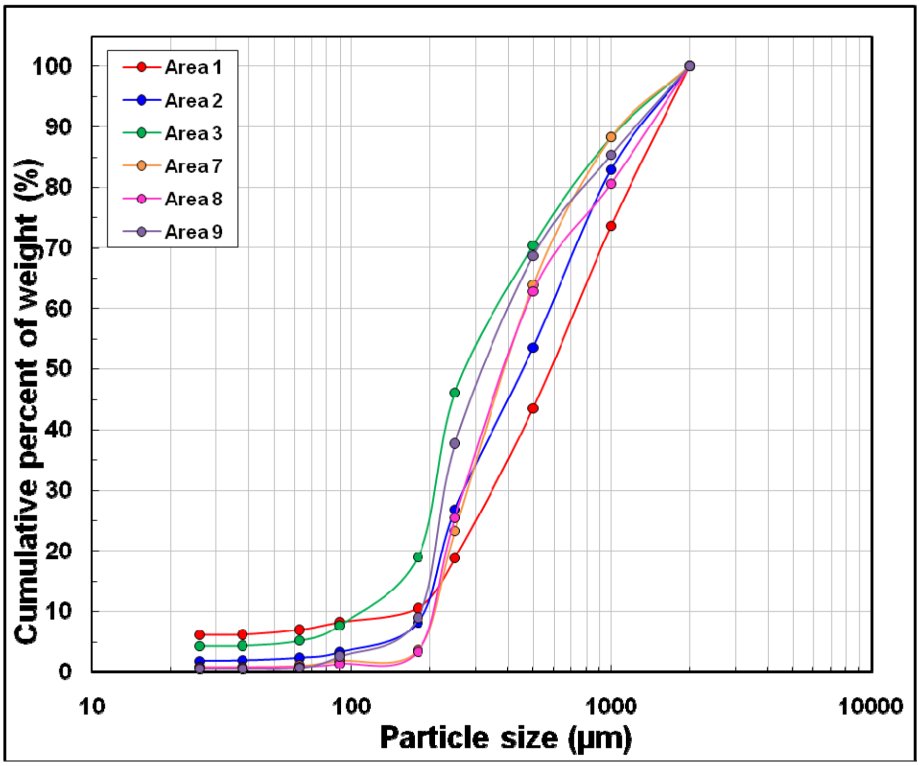
Parameter	Units	Guidelines [a]		Potential Spoil Ground Areas					
		Screening	Maximum	Area 1	Area 2	Area 3	Area 7	Area 8	Area 9
Antimony	mg/kg	2	25	0.3	0.4	0.3	1.6	0.7	0.32
Arsenic	mg/kg	20	70	**42.9**	**40.8**	**43.1**	**70.1**	**50.1**	**27.6**
Cadmium	mg/kg	1.5	10	0.05	0.1	0.17	0.19	0.16	0.1
Chromium	mg/kg	80	370	20.5	23.6	24.8	45.7	39.2	25.2
Cobalt	mg/kg	–	–	6.4	6.5	7.5	8.9	6.8	3.9
Copper	mg/kg	65	270	4.5	4.7	10.0	5.4	4.8	2.8
Lead	mg/kg	50	220	4.0	4.1	4.9	6.8	5.0	3.2
Manganese	mg/kg	–	–	369.5	599.7	1296.3	634.4	651.3	514.4
Mercury	mg/kg	0.15	1	0.005	0.005	0.005	0.11	0.06	0.03
Nickel	mg/kg	21	52	6.9	9.1	10.1	9.2	8.0	4.2
Silver	mg/kg	1	3.7	0.05	0.05	0.07	0.15	0.05	0.05
Zinc	mg/kg	200	410	13.7	13.9	14.9	8.9	7.7	6.2

a National Ocean Disposal Guidelines for Dredge Material (EA 2002).
Note: Bold values exceed screening levels indicating elevated naturally occurring levels

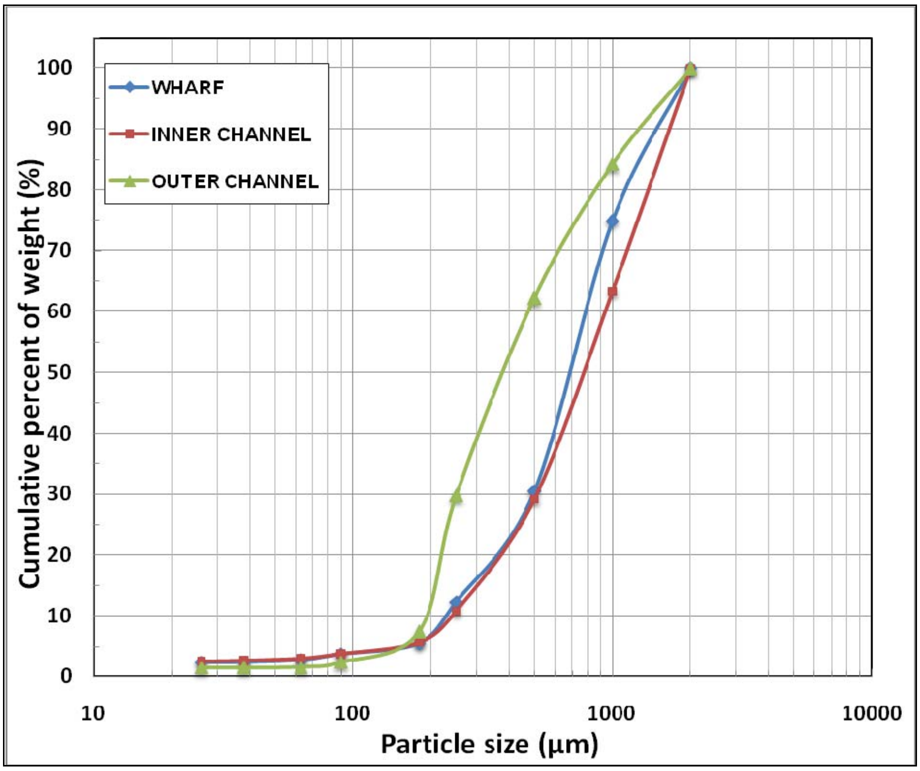
■ **Table 4 Sediment analysis of dredge footprint**

Parameter	Units	Guidelines [a]		Proposed SAP Dredge Footprint		
		Screening	Maximum	Wharf Area (1-10)	Inner Channel (11 – 31)	Outer Channel (32 – 50)
Antimony	mg/kg	2	25	0.3	0.3	0.3
Arsenic	mg/kg	20	70	**42.7**	**41.7**	**22.2**
Cadmium	mg/kg	1.5	10	0.1	0.1	0.1
Chromium	mg/kg	80	370	18.1	17.6	16.4
Cobalt	mg/kg	–	–	6.4	5.9	4.0
Copper	mg/kg	65	270	4.1	3.3	3.2
Lead	mg/kg	50	220	5.0	4.6	3.2
Manganese	mg/kg	–	–	249.3	649.0	494.5
Mercury	mg/kg	0.15	1	0.005	0.005	0.005
Nickel	mg/kg	21	52	7.0	8.3	6.2
Silver	mg/kg	1	3.7	0.1	0.1	0.1
Zinc	mg/kg	200	410	7.8	8.1	5.8

a National Ocean Disposal Guidelines for Dredge Material (EA 2002).
Note: Bold values exceed screening levels.



■ **Figure 8 Particle size distribution of sediments at the potential spoil grounds**



- **Figure 9 Particle size distribution of sediments within the dredge footprint**

Based on the results of the sediment chemistry and PSD analyses, all potential spoil grounds were deemed to have comparable sediment characteristics to that of the dredge footprint and were acceptable for use as spoil grounds from that perspective.

3.6. June 2009: Final Spoil Ground Locations

Between September 2008 and June 2009, detailed marine habitat mapping was undertaken using inputs from LIDAR bathymetry and ground truthing environmental investigations (SKM 2009b). The habitat map indicated that an area in the eastern section of proposed spoil ground 3 was likely to contain sensitive benthic primary producers such as hard corals. The presence of hard corals in this area was confirmed during ongoing marine investigations. Consequently, marine scientists recommended that spoil ground 3 be reduced in size, thereby avoiding direct impacts on the predicted sensitive habitat (**Figure 10**).

When the dredge spoil is disposed, the area affected by sedimentation will be greatest within the boundaries of the spoil ground, which will receive a maximum sediment load of 2 m. This sediment will smother any benthic primary producer or infauna within this area and also change the PSD of the spoil ground. Immediately outside the spoil ground will be a buffer zone, where sedimentation will occur to a lesser degree. Biota in this buffer zone will not be smothered, but the PSD of the area may be altered. Areas outside the buffer zone may experience some sedimentation but the PSD will not be significantly changed.

Modelling was undertaken to predict sedimentation resulting from disposal in spoil ground options 1, 2, 3, 4, 6, 7 and 9 (APASA 2009). The modelling indicated that sedimentation resulting from disposal would not adversely impact on ridgeline habitat. The modelled sediment deposition on any ridgeline habitat was considered unlikely to impact on primary producer organisms, even when combined with the existing natural sedimentation load. A 30 day time series model of sediment thickness at a location approximately 2 km from spoil ground 3 was developed and is provided in **Appendix A**. Modelling indicated that during this period, the maximum sedimentation depth was 0.35 mm, and was regularly removed by tidal shear stress. It is expected that deposited sedimentation would be shifted by natural water movement to the troughs in the seafloor rather than build up on ridges.

It is expected that the disposed dredge spoil will smother any infaunal communities and will likely permanently change the sediment composition within the spoil ground boundary. Baseline infauna surveys are proposed to describe the infauna community structure and habitat composition, so that any changes can be recorded during an infauna monitoring program to be run during and after dredge spoil disposal. Surveys would comprise a detailed field investigation implemented prior to the commencement spoil disposal. Samples of sediment will be taken within and around the spoil grounds to look at abundance and diversity of infauna at and around the spoil ground locations as well as PSD and total organic content. PSD and total organic content are important factors in infauna habitats and the dredged material is likely to be different, and is likely to contain very coarse larger fragments. See SKM (2009a) for more information. The inputs for the time series model are provided in **Appendix A**.

The final sizes and locations of spoil grounds 2, 3, 7 and 9 are overlaid on LIDAR bathymetry in **Figure 11**. Coordinates of the spoil ground perimeters are provided in **Table 5**, below.

- **Table 5 Corner coordinates of spoil grounds 2, 3, 7 and 9**

Spoil Ground	Corner	Latitude	Longitude	Easting	Northing
Spoil Ground 2	NW	S 20°05.080'	E 118°58.500'	6654647	7770023
	NE	S 20°05.080'	E 118°58.500'	665617	7766886
	SE	S 20°05.080'	E 118°61.830'	669101	7766853
	SW	S 20°05.080'	E 118°61.830'	669131	7769989
Spoil Ground 3	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
Spoil Ground 7	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
Spoil Ground 9	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

Datum GDA94, Projection MGA94 Zone 50K

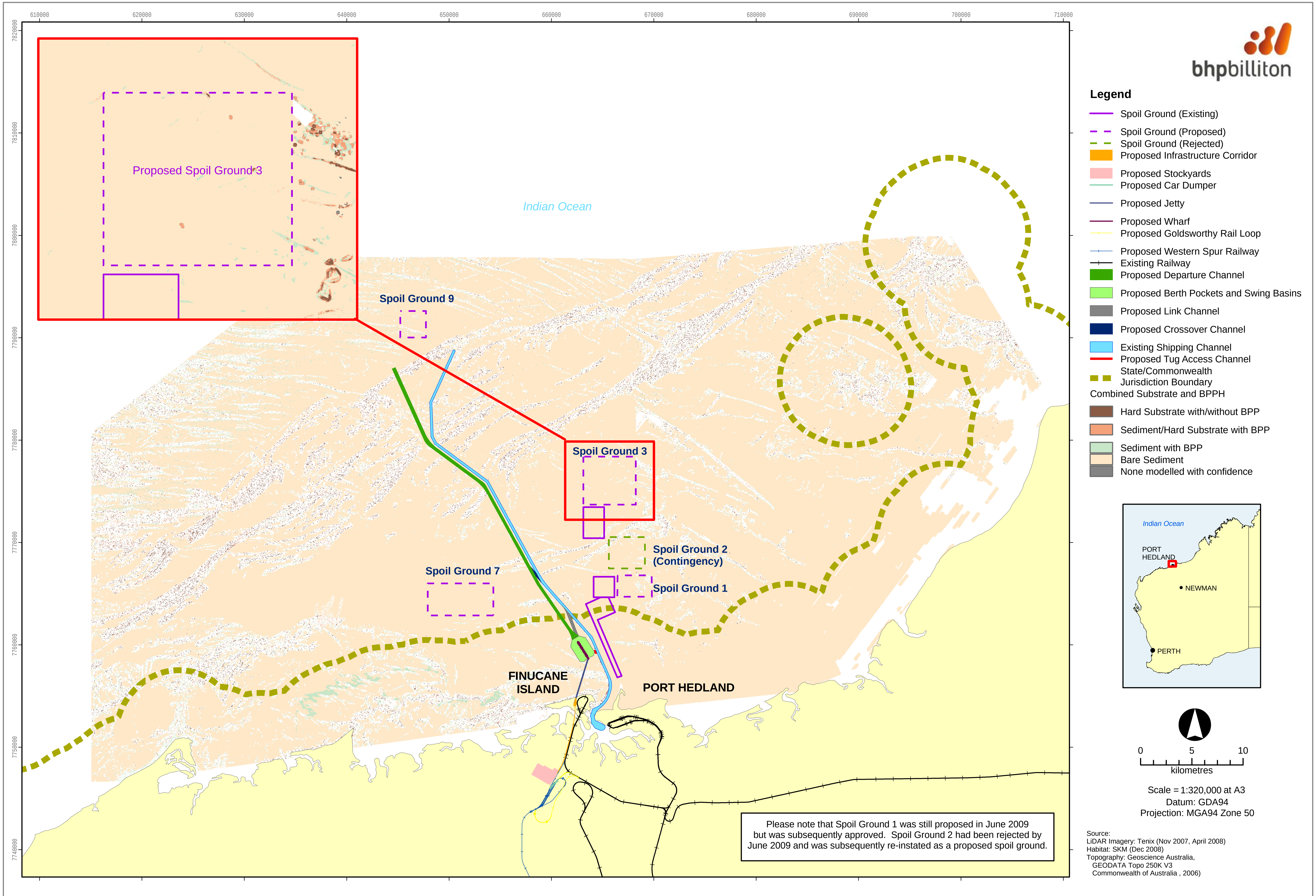


Figure 10 Habitat Map Illustrating the Reduction in Spoil Ground 3 to Exclude Sensitive Habitat, June 2009

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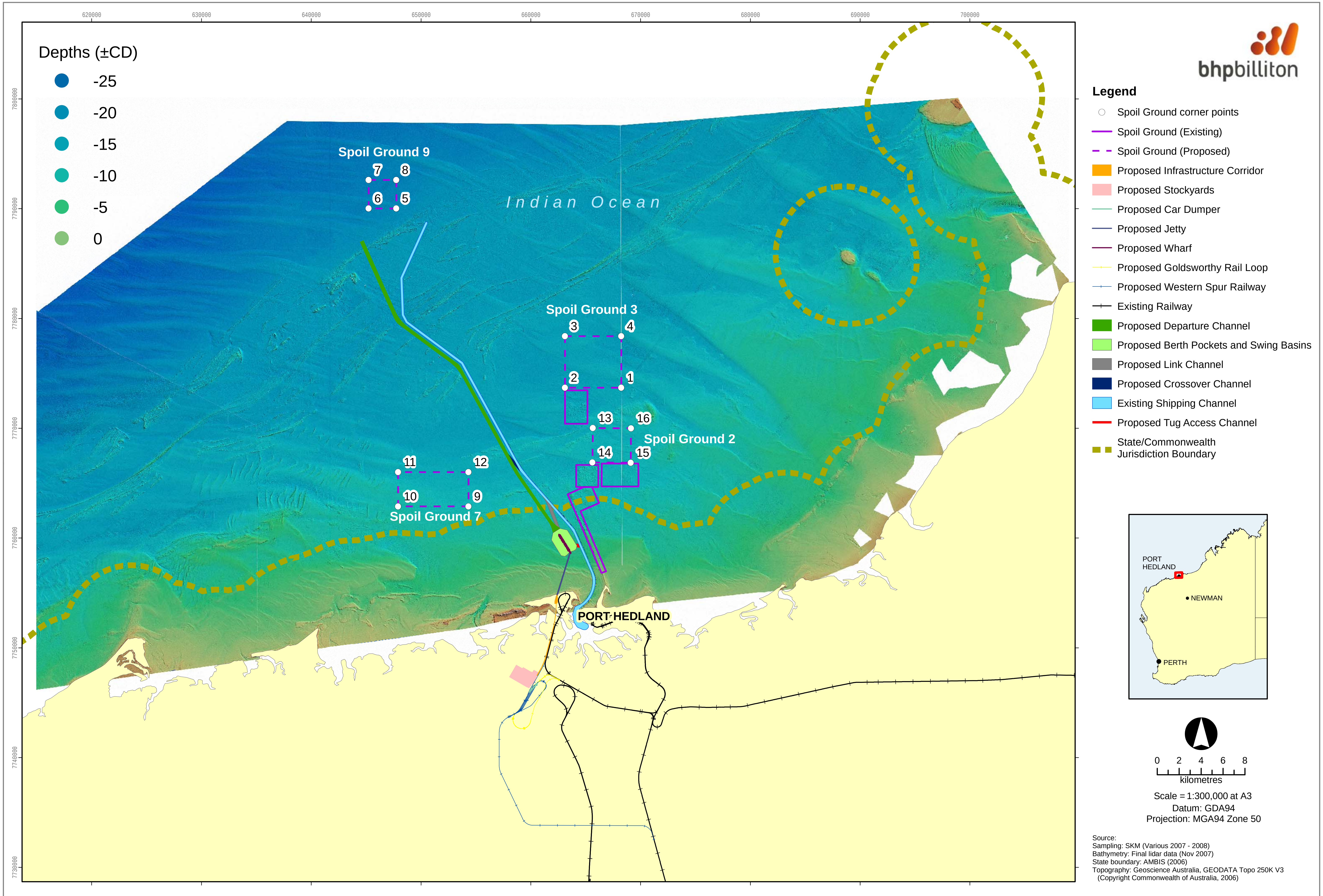

Figure 11 Final Layout of Spoil Grounds 2, 3, 7 and 9

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4. Suitability for Unconfined Ocean Disposal

Spoil grounds 3, 7 and 9 are considered to be suitable locations for unconfined sea disposal after meeting key environmental and engineering selection criteria listed in **Sections 2** and **3**. Dredge spoil will be distributed amongst all three spoil grounds depending on the location of the dredge to minimise steaming time; however, the majority will be placed into spoil grounds 3 and 7. Spoil ground 2 is being considered as a contingency to the 3 spoil grounds listed above should there be a need arise, it to meets key environmental and engineering selection criteria.

Within reason (e.g. excessive sailing distance), the selection process of the spoil grounds was driven by potential impacts on the marine environment. This concern is demonstrated by the numerous investigations undertaken to better understand the marine environment, in particular the delineation of sensitive benthic habitats and the natural water quality conditions to which they are exposed (SKM 2009d; SKM 2009e). The final spoil ground sizes and locations were designed so as to minimise the risk to these habitats, whilst remaining practical from engineering, cost (fuel usage and time) and safety perspectives.

Additionally, the chemical and physical properties of the material within the proposed dredge footprint and the proposed spoil grounds has been demonstrated to be clean as per NODGDM (EA 2002) criteria (SKM 2009c). This indicates that there is a minimal likelihood of contaminant release that could be potentially harmful to marine biota.

BHP Billiton Iron Ore believes that this report provides adequate evidence that the preferred spoil grounds have been selected only after thorough environmental, engineering and financial considerations.

5. References

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Appendix A Indicative Sedimentation from Spoil Ground 3

The panels below illustrate the thickness of sediment accumulated on a location approximately 2 km north of spoil ground 3 (marked with an X in **Figure 12**). The lower panel illustrates dredge disposal (red dots) and the resulting sedimentation dispersion prediction. The upper panel illustrates the build up of sediment over 30 days at the location. The sheer stress generated by tidal currents was predicted by the model to be sufficient to re-suspend the majority of finer material (APASA 2009). The material is able to settle during the turn of tide but is then re-suspended when the tide runs. This is most evident during the spring tidal cycle on the upper panel. The reduced sheer stress during the neap cycle allows sediment to maintain a layer of approximately 0.05 mm (or 50 µm), but this is quickly removed at the commencement of the spring tide. Both figures were based on the following assumptions:

- a 30 day period of spoil disposal;
- 100 separate releases of spoil material (red dots);
- each release contained 12, 750 m^3 of material (for a total of 1, 275, 000 m^3 of material);
- each release was over a duration of 2.5 hours; and
- release locations were randomised within the spoil grounds.

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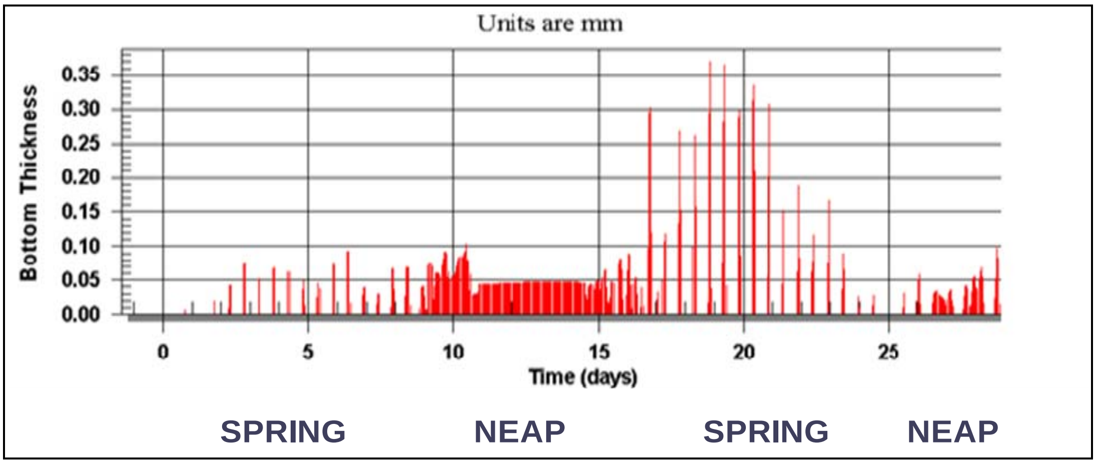

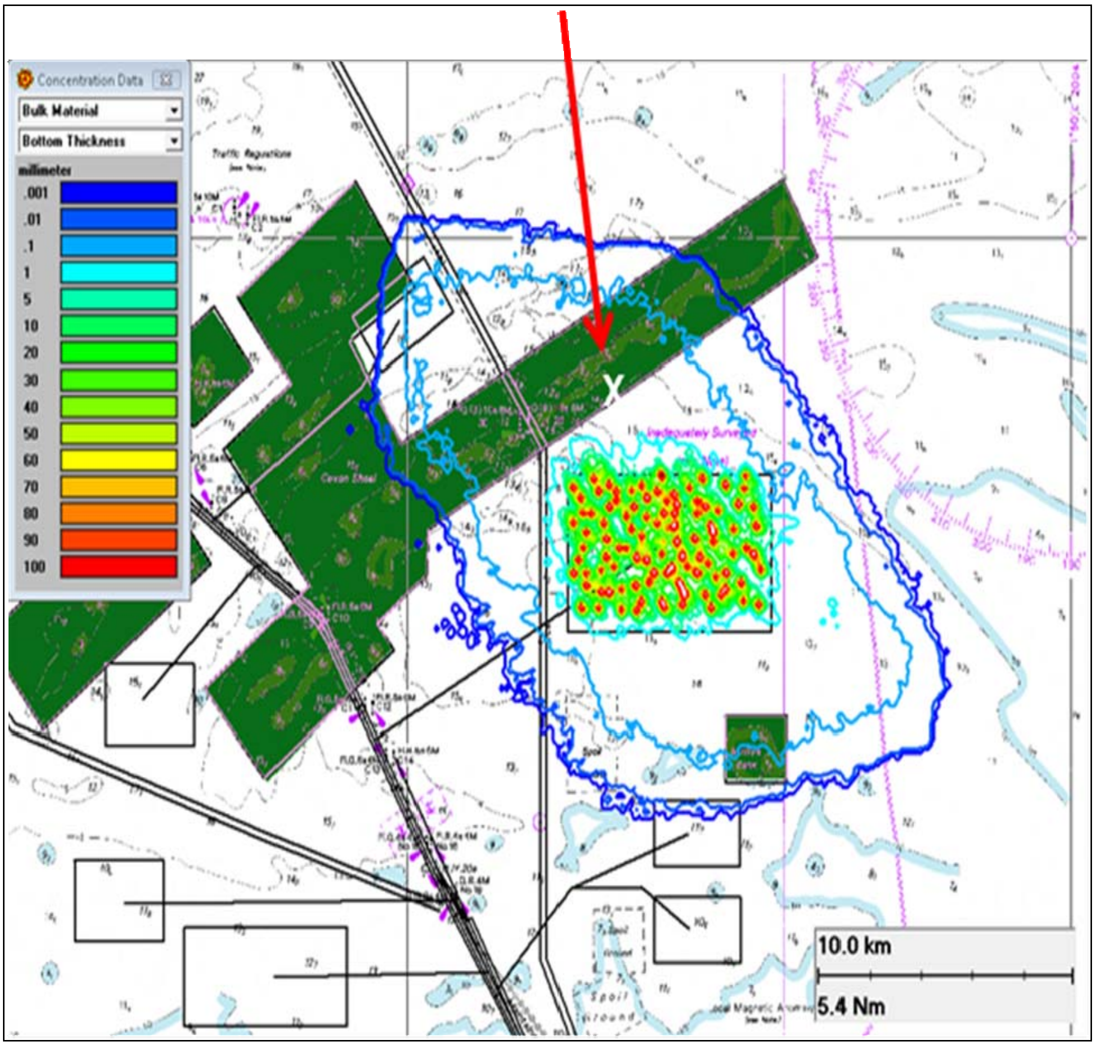

- **Figure 12 Sedimentation dispersion prediction of disposed dredge spoil at spoil ground 3**