Outer Harbour Development

Implementation of Best Practicable Approach to Dredging Program

Rev 0

October 2011

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1 INTRODUCTION

1.1 BACKGROUND

BHP Billiton Iron Ore plans to develop the proposed Outer Harbour Development ('the Project') in Port Hedland, Western Australia. The development will be located adjacent to BHP Billiton Iron Ore's current operations at Port Hedland. The development will require dredging and spoil disposal to provide access for vessels to the new wharf facilities.

Dredging operations will create new berth pockets, turning basins, departure 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 51 Mm^3 over a timeframe of approximately five years.

BHP Billiton Iron Ore is currently progressing the environmental approvals for the proposed development in accordance with the State Environmental Protection Act 1986 (EP Act) and the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

1.2 PURPOSE

BHP Billiton Iron Ore recognises that there is a risk of impacts occurring over a range of environmental factors as a result of the dredging program associated with the proposed Project. Environmental factors that may be impacted upon as a result of the dredging program include water quality, benthos (including benthic primary producers (BPP)) and marine fauna.

BHP Billiton Iron Ore has considered these risks during the design phase of the wider Project and the dredging program and specifically in the selection of the dredging contractor. Furthermore, BHP Billiton Iron ore is committed to managing these risks during construction and as such is developing a range of management plans which will outline the mitigation, management, monitoring and reporting requirements to be implemented.

Environmental Assessment Guideline No 3 – Protection of Benthic Primary Producer Habitat (EAG3) details the hierarchy of principles to be addressed by all proponents applying the EAG. It also notes that the Environmental Protection Authority (EPA) will apply these principles to its consideration of proposals that could cause damage/loss of benthic primary producer habitats. According to EAG3, the EPA expects that proponent's Environmental Impact Assessment documentation will demonstrate how principles 1 to 3 below in particular have been applied in advance of any assessments of cumulative benthic primary producer habitat loss.

The principles are:

1) All proponents should demonstrate consideration of options to avoid damage/loss of benthic primary producer habitats, by providing the rationale for selection of the preferred site and broad project design for example.
2) Where avoidance of benthic primary producer habitats is not possible, then design should aim to minimise damage/loss of benthic primary producer habitats (e.g. through iterative design and demonstrable application of Principle 3 below). Proponents will be required to justify that design in terms of operational needs and environmental constraints of the site.
3) Proponents will need to demonstrate 'best practicable' design, construction methods and environmental management aimed at minimising further damage/loss of benthic primary producer habitats through indirect impacts and minimising potential for recovery.
4) The EPA's judgement on environmental acceptability with respect to damage/loss of benthic primary producer habitats and the risk to ecological integrity will be based primarily on its consideration of the proponent's application of principles 1 to 3 and calculations of cumulative loss of each benthic primary producer habitat type within a defined local assessment unit (the most

'realistic' scenario), together with supporting ecological information, and expert advice, as required.

With regards to principle 1, considerations during the design phase and contractor selection processes reflect BHP Billiton Iron Ore's commitment to achieving the best practicable project with respect to broad design and location. Further details on how principle 1 has been applied are provided in **Section 2**.

With respect to principle 2, **Section 2** also provides background into the detailed design and design optimisation that BHP Billiton Iron Ore has undertaken.

With respect to principle 3, BHP Billiton Iron Ore has aimed to achieve the best practicable design and construction methodology by ensuring early input by the selected dredging contractor through a 'early contractor involvement' approach (**Section 3** and **Section 4**). During the implementation of the dredging program BHP Billiton Iron Ore will implement best practicable environmental management by utilising the best practicable technologies and implementing proactive and reactive management measures (**Section 5** and **Section 6**).

2 SITE SELECTION, ENGINEERING AND DESIGN

2.1 OVERVIEW

With most major construction projects, the greatest gains with respect to achieving the best practical environmental outcome can be realised during the concept, selection and definition (engineering and design) phases of the project.

BHP Billiton has undertaken a detailed concept study (including site selection process), selection phase study (including broad project design) and definition phase (including detailed design and engineering). Potential environmental impacts and the requirement to achieve a best practicable environmental outcome have been considered during each of these phases.

2.2 CONCEPT STUDY

To accommodate BHP Billiton Iron Ore's future growth plans, a concept study was undertaken to evaluate the potential options for increasing port capacity in the Pilbara region of Western Australia. In addition to considering further development at Port Hedland, several alternative coastal locations within 200 km of Port Hedland were identified as potential sites to establish a new port facility and its associated infrastructure. The studies considered the conceptual expansion of Port Hedland Harbour through the upgrading of the existing harbour and channel, as well as a number of variations around a new port facility directly adjacent to Port Hedland, using either a dedicated shipping channel, or the existing shipping channel.

Examples of the screening criteria applied to the identified port locations include:

- safety (e.g. material handling requirements and travel distance from BHP Billiton Iron Ore's existing operations);
- heritage (e.g. avoidance of indigenous and European heritage sites);
- environment and disturbance footprint (e.g. development of brownfield sites preferred to development of greenfield sites, build infrastructure adjacent to existing footprint);
- proximity to existing BHP Billiton Iron Ore operations and port infrastructure (e.g. maximising use of existing infrastructure such as accommodation and airports);
- synergies with existing BHP Billiton Iron Ore operations, to maximise throughput and optimise Inner Harbour operations;
- proximity to existing utilities such as power and water;
- proximity to existing communities and social infrastructure, including schools, hospitals, police and emergency services, airports;
- land tenure; and
- cost.

In addition to considering further development at Port Hedland, several coastal locations within 200 km of Port Hedland were identified as potential sites for the establishment of a new port facility and associated supporting infrastructure.

These locations and the associated assessment are shown in **Table 1.** The factors that have a potential environmental benefit or loss are highlighted in italics.

Table 1 Alternate Port Locations Options Assessment

Port Options	Infrastructure	Social and Environment
Cape Keraudren	150 km of new rail and road infrastructure. No infrastructure such as airport, accommodation or existing port to support construction and operational workforce and movement of construction materials and equipment.	*Not previously disturbed (marine/terrestrial environment).* Located adjacent to proposed marine park. Extreme tides. *Shallow water which would require a long dredged channel.*
Depuch Island	Over 120 km of new rail and road infrastructure. No infrastructure such as airport, accommodation or existing port to support construction and operational workforce and movement of construction materials and equipment. Probably requires combined use of islands and surrounding land to achieve suitable port arrangement. *Would require a long causeway to coastline (5 km)* *To achieve depths of -14m LAT (vessel access), requires 16 km dredged channel.*	*Not previously disturbed (marine/terrestrial environment).* Area is low lying and subject to inundation over much of the surrounding land within 7 km of the coast – requiring significant ground improvements. *Island offers naturally sheltered harbour basin.* Major heritage site – significant rock carvings.
Cape Thouin	Requires 70 km of new rail and road infrastructure. Close proximity to Port Hedland, leverage off Port Hedland infrastructure and mobilise materials and equipment via new road infrastructure. *Approaches to Cape Thouin are on river delta, of the Yule river.* Utilise Port Hedland airport to support construction and operational workforce, still requires accommodation village, offers little economic benefit to nearby towns.	*Not previously disturbed (marine/terrestrial environment).* Economic benefit to the town of Port Hedland during construction. *Low lying delta region, bounded by Yule and Turner River Mouths which is prone to flooding.* Would require major earthworks to escape flooding/surge. *Extensive mangroves in near vicinity*
Ronsard Island	Requires 100 km of new rail and road infrastructure. Close proximity to Port Hedland, leverage off Port Hedland infrastructure and mobilise materials and equipment via new road infrastructure. Utilise Port Hedland airport to support construction and operational workforce, requires accommodation village. Requires long causeway, approximately 5 km from train unloaded to stockyard and port. *To achieve depths of -14 m LAT, requires 17 km dredged channel, dredging of offshore bars.*	*Not previously disturbed (marine/terrestrial environment).* Economic benefit to the town of Port Hedland during construction. Pearl farm. *Mangroves recognised by EPA as very high conservation value in a regional context* *Whales come close to shore on southern migration, possible turtle nesting sites, dugong feeding and breeding area. Known location for large number and various species of migratory birds.* Likely to have various archaeological and anthropological /ethnographic survey sites of importance.
Port Hedland	Requires 30 km of new rail infrastructure. Existing road network will be used. Leverage off Port Hedland infrastructure including water supply, airport, and accommodation (construction and permanent). Offers a shorter delivery schedule, and opportunities to delay capital expenditure for later stages through use of existing infrastructure.	*Existing marine and terrestrial environment already perturbated, within operating port (exports more than 150 Mtpa, undergoes maintenance dredging, existing spoil grounds), proposed infrastructure adjacent to existing infrastructure.* Economic benefit to the town of Port Hedland during construction and operations. Development is included in the Port Hedland Port Authority's Ultimate Development Plan.

Finucane Island was selected as the preferred port location over Ronsard Island as its proximity to an existing working port and major regional centre; as well as the disturbed nature of the existing environment; presents clear advantages with respect to engineering, construction cost, logistics, environmental impact and socio-economic factors. Reasons that Finucane Island was selected as the preferred port location include:

- there is a more detailed understanding of the existing terrestrial and marine environment and a longer record of baseline conditions due to the existing operations in Port Hedland, including recent studies undertaken to support BHP Billiton Iron ore's recent growth projects in the inner harbour;
- the development would occur in a location that has already been disturbed (current iron ore operations, and export operations – Dampier Salt), and undergone prior perturbations (e.g. existing Port Hedland Port Authority (PHPA) dredged channel, and three spoil ground offshore) as compared to the relatively undisturbed environment of Ronsard Island;
- there is a smaller environmental footprint (synergies with existing infrastructure including utilities such as water, power and sewerage, at Port Hedland) in addition there are existing facilities (load-out facility, power station at Boodarie) owned by BHP Billiton Iron Ore which could be utilised for the proposed development;
- there are opportunities to locate the proposed development in previously disturbed areas or adjacent to these, such as the infrastructure corridor from Boodarie to Finucane Island;
- there is existing community and social infrastructure to support the construction and operational workforce, including schools, hospitals and doctors, police and emergency services, airport, local council, hotels, shops, service stations, and community groups and support;
- safety issues associated with commuting of staff and equipment from Port Hedland to a location such as Ronsard Island on a daily basis (fatigue management is a major safety focus for BHP Billiton Iron Ore);
- alignment with the State plans to grow Port Hedland as a city, rather than create small fragmented communities. Potential constraints due to land use issues are a key consideration of the detailed design of the Outer Harbour Development;
- synergies with the existing BHP Billiton Iron Ore operations - expansion of existing facilities is preferable over establishing a new remote facility and duplication of support services (including management, maintenance, logistics, security, tugs, towage and fuel); and
- there would be reduced capital costs and shorter construction and development schedules due to leverage off existing port facilities for construction activities e.g. importing of construction materials, and use of other facilities such as an airport to mobilise the workforce, and accommodation to house the workforce.

In locating the proposed development at Port Hedland, BHP Billiton Iron Ore optimises the current operations, and provides opportunity to maximise the Inner Harbour capacity. Finucane Island was also preferred in relation to land use considerations as compared to other locations, due to the interfaces with existing infrastructure (e.g. airport, port – shipping facilities, roads, water supply and accommodation) and planned urban uses within the Port Hedland area, specifically within Port Hedland Port Authority's Ultimate Development Plan.

2.3 SELECTION PHASE STUDY

2.3.1 Overview

Subsequent to the selection of Finucane Island as the port location, several design alternatives were evaluated during the selection-phase. This section presents the basis for adopting the selected options and for rejecting the alternatives. A summary of the selection-phase options is provided in **Table 2**.

Table 2 Selection Phase Studies Options Evaluation Assessment Outcome

Project Component	Options Investigated (Selected option in bold type)
Jetty/Wharf	**Jetty length 4 km (54Mm^3 dredging)** Jetty length 6 km (35Mm^3 dredging) Jetty length 10 km
Departure Channel	**Dredge new channel to mirror existing Port Hedland shipping channel** Dredge new channel heading north-west of proposed jetty/wharf Dredge new channel following a north-westerly alignment immediately to the east of above option, before heading in a northerly direction Dredge new channel following the same alignment as above, before the channel heads off in a westerly direction Expand existing channel
Dredge Spoil Disposal	**Offshore** Onshore Combination of offshore and onshore
Infrastructure Corridor	**Construction of a solid causeway with culverts** Construction of a full length solid causeway
Rail Location	**North-Western Alignment (Western Spur Railway)** Central-Western Alignment South-Western Alignment Central Alignment Eastern Alignment
Stockyards	**Boodarie** Finucane Island

Of these project components, the length of jetty, the alignment of the departure channel and the spoil disposal method would influence the level of environmental impacts potentially resulting from the dredging program.

2.3.2 Jetty/Wharf Configuration

Following the decision to locate the port facilities off the north of Finucane Island, the position of the wharf and the preferred shipping channel alignment were identified. This work was undertaken primarily using sea state and tidal current data measured over a seven year period offshore of Port Hedland Harbour and on recently collected bathymetry data. Detailed marine engineering studies and modelling including geotechnical drilling, sea state, tidal current, wind analysis and coastal processes have input into the design, wharf orientation and location.

Wharf positions were identified, in association with each of the proposed channel alignment options. The proposed wharf locations varied from 6 to 10 km offshore for the preliminary options analysis.

The wharf location immediately adjacent to the existing Port Hedland channel was adopted, with a maximum base case jetty length of 6 km. During design optimisation, an additional option for a jetty length of 4 km was identified. The evaluation of this jetty option was driven by minimising the area of disturbance, and to balance jetty/wharf costs and dredging costs.

Sea state modelling and final marine engineering studies resulted in minor modifications to the preferred wharf location and orientation, which further reduced dredging volumes and optimised operability (this data was modelled and verified with a scale model designed and operated to provide the optimum location for the wharf facility to maximise berthing capabilities in all weather and sea-state conditions).

The bathymetry of the area is such that unless the jetty is significantly extended, minimal reductions in dredging volumes can be achieved. Water depth varies up to approximately 12 m in the area within 25 km of shore.

Criteria for Assessing Options
The options were evaluated against a number of broad criteria including:

- maritime safety, in particular conflict with existing port operations;
- potential marine environment impacts;
- volume of material to be dredged;
- channel and alignment costs;
- minimise the aggregate of capital expenditure and operating expenditure commensurate with the dredging volumes;
- maintenance and operability costs of both the jetty/wharf and dredged channel;
- technical issues associated with operating a large facility over water, especially the longer conveyors (no precedent for 6 km long conveyors over water transferring up to 60 Mtpa of ore); and
- synergies with the existing shipping channel.

Selected Option
When compared with the longer jetty/wharf options, the 4 km option reduces the:

- project infrastructure footprint and associated marine environmental impacts;
- tug operating costs due its relative proximity to the inner harbour;
- light spill and sky glow (shorter jetty, wharf oriented to the north-west away from turtle nesting beaches) therefore reducing potential impacts to turtles; and
- overall operating and maintenance costs.

2.3.3 Wharf Location and Shipping Channel Alignment

The shipping channel has been designed in accordance with PIANC (the World association for waterborne transport infrastructure) guidelines for Navigation channels. These guidelines provide minimum specifications for safe underkeel (channel depth) and bank clearances (channel widths).

Four facility location and shipping channel options were developed and evaluated during the Selection Phase:

Option 1 – comprises a 6 km jetty, wharf and shipping channel all aligned in a north-westerly direction from Finucane Island.

Option 2 – the wharf is located to the east of Option 1, and along with the jetty is aligned in a north-westerly direction. The shipping channel runs parallel to Option 1 then turns northwards to run adjacent to and parallel with the existing channel.

Option 3 – the wharf and jetty are identical to Option 2. The shipping channel follows deeper water available generally in a west-north-westerly direction.

Option 4 – the wharf is located adjacent to the existing shipping channel. The new shipping channel runs adjacent and parallel with the existing channel before deviating to the north-west.

Option 5 – the wharf is located adjacent to the existing shipping channel. The existing shipping channel is widened and used.

Criteria for Assessing Options

The options were evaluated against a number of broad criteria including:

- PIANC guidelines;
- maritime safety, in particular conflict with existing operations;
- Port Hedland Port Authority Requirements;
- optimising shipping channel capacity;
- potential marine environment impacts;
- dredging volume;
- channel length; and
- synergies with the existing shipping channel.

Selected Option

Option 4 was selected as the preferred wharf location and channel alignment for the following reasons:

- this option has the lowest dredging volumes of all the options listed;
- it is located where deeper water is available closer inshore, allowing for cost optimisation by shortening the access jetty, and reducing the dredging volumes;
- it reduces environmental impact due to the location of the channel immediately alongside a 'pre-disturbed area' and reduced dredging volumes by locating in the deeper water therefore reducing turbidity impacts;
- it presents an opportunity to link into the existing Port Hedland shipping channel increasing efficiency by utilising residual existing shipping channel capacity;
- it has the potential to mitigate the risk of channel blockage in the event of a ship grounding;
- it presents the safest option with respect to the effects of winds and current on shipping operations;
- its proximity to the inner harbour reduces the tug operating costs; and
- it provides contingency for continued port operations if a shipping incident occurs.

The deviation of the proposed alignment of the departure channel from the existing channel was selected over aligning it more closely with the existing channel for the following reasons:

- it is the most direct and safest route for outbound ships – the present departure channel is not aligned with the dominant wind/sea-state conditions, making navigation at its exit more difficult as the vessels have to turn into the weather;
- it minimises the dredging volume required as it follows the deepest route;
- the northerly orientation of the channel, with less turns in the channel reduces navigation risk; and
- it minimises the impact on the outer reefs and avoids the most sensitive marine areas.

2.3.4 Spoil Disposal Method

In parallel with the preliminary engineering design process, a number of desktop and field-based marine environmental investigations were undertaken to guide the selection of a preferred dredging strategy and dredged material management, including potential onshore and offshore disposal sites.

The options of no dredging, offshore, onshore and a combination of offshore and onshore dredge spoil disposal were considered for the proposed Outer Harbour Development.

No Dredging

No dredging would have been an option if BHP Billiton Iron Ore opted to use the existing shipping channel. Channel throughput modelling indicates that the existing shipping channel has little or no capacity to support the Outer Harbour Development – the continued expansion of the inner harbour is using all available capacity of the existing channel to ship commodities. The requirement to dredge could also have been eliminated if a significantly longer jetty (up to 25 km) was constructed. However, this would have prohibitive cost and operational implications.

Offshore

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

Nine preliminary offshore spoil ground locations were identified using available bathymetric data. The key criteria used to identify and evaluate potential locations for the offshore disposal of dredge spoil included the:

- proximity to dredging area (ideally located within 15 km of dredging source);
- suitability of water depth for bottom dumping, and deep enough for large vessels at low tide;
- proximity to existing spoil grounds;
- ability to avoid existing and proposed shipping and anchorage areas;
- spoil ground stability; and
- environmental impacts, such as proximity to limestone ridges, coral systems and other sensitive marine habitats.

The location and sizes of the offshore spoil grounds were subsequently refined using the results of an airborne light detection and ranging (LiDAR) survey which provided detailed bathymetry, coupled with field-based marine environmental investigations. The field-based environmental investigations included:

- conducting towed video transects along the proposed dredge footprint and potential spoil grounds;
- seabed habitat investigations conducted by divers; and
- collection and analysis of samples from the preliminary spoil grounds as part of early investigations.
- This approach served to minimise potential environmental impacts associated with the proposed offshore disposal of dredge spoil, including:
- exclusion of potential spoil grounds located on or in close proximity to limestone ridges and coral systems; and
- expansion of potential spoil ground located where ground conditions were deemed to be favourable (i.e. no sensitive marine habitats were identified).

The final selection of the preferred offshore spoil grounds was strongly influenced by proximity to the dredging footprint, the baseline habitat investigations and sampling results. The spoil grounds were sited in areas that are not known to support any benthic primary producer habitats of significance. The final selection process identified three preferred locations to support this project, designated as Spoil Grounds 2, 7 and 9. All of these offshore spoil grounds are located in Commonwealth water and are clear of existing and proposed channels and anchorages. Spoil Ground 7 is the preferred location, whilst the smaller spoil grounds 2 and 9 have been identified as potential alternate spoil grounds to be utilised to reduce potential environmental impacts associated with the dredging program.

Onshore

In addition to offshore dredge spoil disposal, the feasibility of disposing all or a portion of the spoil onshore has been investigated. To bring material onshore the Trailer Suction Hopper Dredger would have to enter the Inner Harbour at Finucane Island and pump onshore to a containment area, which would act as a settlement pond. The material would then have to be trucked for use. This approach is limited by the distances the material has to be pumped, the ability to access the Inner Harbour and the availability of a suitable location to construct a containment area.

Onshore disposal of dredged material has been considered, with the following major constraints identified:

- the potential impact to turbidity and water quality through the rehandling of dredged material and the discharge from onshore reclamation areas;
- the logistical, economic and environmental challenges of pumping such a large volume of material between 4 and 34 km from the dredged areas to land;
- land use for reclamation offshore of Finucane Island is constrained due to activities potentially increasing dust and noise levels at Port Hedland;
- the limited proportion of dredged material which would be suitable as land fill material (approximately4 Mm^3 of the total volume is classified as calcareous sands and gravels which would be suitable as engineering fill);
- the ability of BHP Billiton Iron Ore to access and gain tenure over an appropriate land area (which is significantly larger than the current facilities for onshore disposal of inner harbour dredge spoil);
- additional large vessel movements into the Inner Harbour, whereby the material can be pumped onshore, causing increased marine traffic within the already constrained harbour, potentially resulting in restricted public access;
- the lack of a suitable berth and mooring facility for dredger and barge access to enable pumping of transported dredged material to land; and
- the lack of space in the vicinity of the Inner Harbour for reclamation or land disposal of this quantity of material.

Previous Port Hedland projects have been able to bring material onshore due to the close proximity of the dredging footprint to the reclamation areas, and the availability of reclamation areas identified by Port Hedland Port Authority in its Ultimate Development Plan. The South West Creek Development project is bringing material onshore and disposing of it in areas identified by the plan, at this stage no other areas have been identified.

A key element in determining if the onshore disposal of the dredged material is feasible is the availability of opportunities to beneficially reuse the material onshore. Any such opportunity would be required to provide sufficient benefit to offset the environmental, logistical and economical constraints identified above. No such opportunities have currently been identified.

Criteria for Assessing Options
The options were evaluated against a number of broad criteria including:

- potential environmental and social impacts;
- timelines for obtaining land tenure and approvals;
- operability;
- relative cost; and
- sustainability.

Selected Option
The option of offshore disposal of dredge spoil material when compared to options of onshore disposal was selected as the preferred option due to the following reasons:

- it reduces impact on public amenity and public health – onshore reclamation areas are a source of airborne dust as they dry out and require ongoing dust suppression;
- it requires less rehandling of material – due to the large pumping distances (greater than 4-6 km offshore, and 8 km to Boodarie), the material would have to be re-handled and pumped in a staged manner onshore and then to Boodarie to be used;
- it reduces the overall ecological project footprint – a large bunded area would be required to store this material onshore, available areas within proximity of the dredging footprint would result in impacts to mangroves or identified heritage sites;
- it is a lower cost option when compared to onshore disposal, which will require containment facilities to be constructed, pipelines built, rehandling of the material, onshore pump station, and a booster pump station; and
- it minimises potential impacts to water quality which would result from discharge from the material management areas.

Engineering studies have determined that onshore disposal of dredge material will not be viable and therefore will not be undertaken as part of the Outer Harbour Development.

2.4 DEFINITION PHASE STUDY

Further design and construction method optimisation have occurred during the definition phase of the project. Examples of this optimisation include:

- extensive geotechnical investigations to provide detailed information for the channel design and alignment. This results in a reduction in the dredging volumes and execution time, the elimination of the need for drilling and blasting activities, and the best environmentally manageable outcome;
- on-going optimisation of the facility's design, such as the removal of the link channel. This decision, in particular, resulted in a significant reduction in the required dredging volumes (>4 Mm^3);
- a comprehensive spoil ground section process undertaken to establish the most appropriate site for the spoil grounds, based on a number of key criteria including environmental factors; and
- optimisation of berths, departure basis, swing basin and the departure channel design depths has resulted in a further decrease in the total volume of material to be dredged.

3 CONTRACTOR SELECTION

3.1 EARLY ENGAGEMENT OF THE DREDGING CONTRACTOR

The early engagement of a world class marine engineering and dredging contractor has and continues to be critical to the achievement of a best environmental dredging program. This early engagement, which occurred during the design phase of the project, has enabled BHP Billiton Iron Ore to access dredging, civil, marine engineering and environmental management specialists that have contributed to the design process of the proposed marine infrastructure, the development of the dredging methodology, and the progression of the environmental approvals.

Importantly, the dredging contractor has provided significant input into the sediment plume modelling process, which has resulted in an increase in the robustness and accuracy of the results and the subsequent impact assessment conclusions. This is especially important as the result of the modelling leads directly to the development of appropriate management measures and marine monitoring programs.

The dredging contractor has continued to be instrumental during the development of the Dredging and Spoil Disposal Management Plan (DSDMP).

3.2 SELECTED DREDGING CONTRACTOR

The world's leading dredging firms are continually undertaking research and development into increasing the efficiency, accuracy and environmental performance of their dredging equipment. This has resulted in the dual benefit of increased profitability of projects and improved environmental performance and outcomes. For example, increasing the accuracy of dredging equipment can reduce capital costs and environmental impacts through the reduction of the amount of dredging undertaken. For these reasons the selection of a world leading dredging contractor has been and will continue to be a critical component in achieving best environmental practice and an acceptable environmental outcome.

BHP Billiton Iron Ore placed significant weight on environmental performance during the contractor selection for the Project. Subsequently, Dredging International (Australia) Pty Ltd (DI) was selected to undertake the design and engineering for the dredging and spoil disposal activities for the Project. DI is part of one the largest dredging and marine engineering firms in the world, and commits significant investment into the development and implementation of environmentally sensitive dredging methods and technologies. DI operates a large modern fleet of dredging equipment which has been designed and built with environmental performance in mind. DI has operated in Australia since 1972 (under the name 'Dredeco' until 01 August 2010).

4 DREDGING METHOD

The selected proposed dredging method will involve two large Trailing Suction Hopper Dredgers (TSHD); one shallow draft TSHD and a large Cutter Suction Dredger (CSD).

Material that cannot be accessed by the shallow drafted TSHD or is too hard to be directly dredged by the TSHD will be initially dredged by the CSD. This material will then be placed back on to the seabed, either directly behind the dredge ladder pump on the CSD or via a pipeline and spreader pontoon. The material will then be 'rehandled' by the TSHD for disposal at the spoil grounds. This method of dredging the shallow areas or the harder substrate is considered to be the most efficient and environmentally acceptable. For both of these work methods, the discharge point of the slurry will be kept as deep as reasonable/ practicable possible below the water surface to minimise the dispersion of the turbidity plume.

Alternative work methods such as loading material into barges via the CSD would cause significant turbidity generation, as well as increased timeframes, thereby resulting in an increase in the spatial and temporal scale of the plume. Similarly, the use of a Backhoe Dredge to load the material into barges is not considered technically feasible due to the exposed nature of the area, the likely sea-state conditions and the extremely longer dredging timeframe that would result.

Material that can be dredged directly by the TSHDs will be dredged and directly disposed of at the offshore spoil grounds. One main spoil disposal ground has been identified (Spoil Ground 7). Two alternate spoil grounds will also be available. Spoil Ground 9 will be used to dispose of material dredged in the outer portions of the new departure channel. Both Spoil Grounds 2 and 9 will be available as spoil grounds to be utilised in the event that unacceptable environmental impacts associated with spoil disposal at Spoil Ground 7 are observed. This balance of spoil grounds to manage potential impacts is seen as the best environmental practice for spoil management.

Specific benefits of the proposed methodology with respect to environmental performance include:

- The utilisation of a shallow draft TSHD for dredging shallower areas will minimise the generation of propeller wash thus minimise sediment re-suspension.
- The utilisation of a shallow draft TSHD for dredging shallower areas will reduce the need for CSD in shallow areas with rehandling thus minimising the spatial and temporal extent of the sediment plume.
- The utilisation of large TSHDs will limit the amount of material that will be required to be pre-treated by the CSD and rehandled. This is because larger TSHD are able to dredge materials of higher strength. This will limit double handling and the resultant turbidity generation from such activities.
- The utilisation of two large TSHDs will optimise the duration of the work thus limiting the temporal extent of potential impacts.
- The use of one of the world's largest CSD is expected to reduce the overall project timeframe due to its greater sea state capabilities and the fact that it can easily dredge all materials know to be present. Consequently no marine drilling and blasting is foreseen to be required.
- The use of highly accurate RTK position system will assist in minimising the volume of material dredged and will facilitate effective management of spoil disposal.
- The use of modern dredgers and equipment will result in a reduction in atmospheric emissions (i.e. greenhouse gases and noise).

5 EQUIPMENT AND TECHNOLOGY

World leading dredging firms operate modern dredging fleets that are considered to provide the most advance methods of dredging, the best solution with respect to dredging accuracy and leading technology with respect to environmental performance.

An important consideration with respect to the equipment and environmental performance is the proper maintenance and calibration of the equipment prior to and during dredging operations. BHP Billiton Iron Ore will require the dredging contractor to properly maintain and calibrate its equipment.

Table 3 details the specific equipment and technology that will be available on each dredger and how this equipment and technology will improve the environmental performance of the project.

Table 3 Equipment / Technology to be utilised and predicted benefits

Equipment / Technology	Beneficial Effect	Environmental Benefit
Turbidity reducing valve.	Significantly reduces the amount of air that is entrained in the overflow waters on TSHDs.	Reduces the spatial and temporal extent of the sediment plume.
Highly accurate (cm accuracy) positioning systems (e.g. Differential GPS and RTK).	Provides accurate positioning information which reduces the occurrence of instances where dredging outside of the dredging area may occur. Effectively eliminates the risk of spoil disposal occurring outside of designated spoil grounds	Reduces the risk of direct environmental impacts occurring outside of the approved dredging footprint.
On-line visualisation of seabed, dredge position, drag head/cutter head position, vessel speed, design depths and tides.	Provides timely and accurate information to the dredge operators leading to an optimisation of the dredging program and a reduction in over-dredging. .	Reduces the duration of dredging which leads to a reduction in the temporal scale of potential impacts.
Online and instant measurement of production data include mixture velocity and density, hopper load and pressures.	Provides timely and accurate information to the dredge operators leading to an optimisation of the dredging program and a reduction in over-dredging. This is especially relevant with respect to optimising TSHD hopper overflow times.	Reduces the duration of dredging which leads to a reduction in the temporal scale of potential impacts.
Adjustable overflow pipes.	Allows for overflow pipes in the TSHD's hopper to be raised during sailing thus minimising the loss of sediments during transport to the spoil grounds.	Reduces the spatial and temporal extent of the sediment plume.
Use of rapid and highly accurate bathymetric survey	Provides timely and accurate seabed information to the dredge operators	Reduces the duration of dredging which leads to a

equipment	leading to an optimisation of the dredging program and a reduction in over-dredging.	reduction in the temporal scale of potential impacts.
Underwater pump on the CSD	Improves the operational efficiency of the CSD	Reduces the duration of dredging which leads to a reduction in the temporal scale of potential impacts.
Turtle excluding devices (tickler chains)	Fitted to the TSHD's, reduces the risk of entrainment of marine fauna in the dragheads of the TSHD.	Reduces the risk of injury or mortality of marine fauna.

6 MANAGEMENT MEASURES

Appropriate management measures will be applied throughout the dredging program to minimise the risk of unacceptable environmental impacts occurring. Some of these management measures will be applied throughout the program, whilst some will be applied in certain circumstances depending on site conditions and dredging requirements. Lastly, some responsive management measures will be applied only in the event that environmental monitoring activities indicate that an unacceptable environmental impact is occurring or is likely to occur without the application of further management measures. This proactive approach is considered to provide the best balance between effectively managing the environmental outcomes of the dredging program, while also maintaining the technical and commercial viability of the Project.

The management of the dredging will be in accordance with the Marine Facilities Construction Environmental Management Plan. This plan includes a number of sub-plans which detail management measure that will be applied to the dredging. The relevant management plans are:

- Dredging and Spoil Disposal Management Plan.
- Marine Fauna Management Plan.
- Invasive Marine Species Management Plan.

Table 4 presents some of the potential management measures that may be applied during the dredging program, as well as the situation that they may be applied and the predicted environmental benefit of the measures. It should be noted that the application of many of the management measures will increase the duration of the dredging activity, which could have an effect on sensitive receptors within the project area. The effort taken to apply a management measure should be balanced with the effectiveness of the measure to reduce the scale of effect.

Table 4 Potential Management Measures to be Implemented as Required and the Predicted Benefit

Management Measure	Situation where Management Measure will be applied	Environmental Benefit
Spoil will be strategically placed at the primary spoil ground so that coarse material is placed on the outside portions of the spoil ground while finer material will be placed on the inside portions.	Throughout spoil disposal at spoil ground 7 (subject to the total available capacity of the spoil ground).	The spoil ground will be more stable and less prone to re-suspension of fine sediments.
Daily planning and monitoring of spoil disposal operations so that a relatively even disposal pattern is achieved.	Throughout project.	Minimisation of high spots within spoil ground. Maximise the capacity of the spoil ground.
Loading graphs will be used to optimise overflow times.	Throughout project.	Reduction in the spatial and temporal extent of the sediment plume.
Adjust speed of operations (rate and/or mode of excavation) to reduce scale of plume in specific	Where marine monitoring indicates unacceptable impacts are occurring.	Reduces plume concentration but benefit needs to be balanced against increased time scale for dredging

areas or at certain times when sensitive resources may be affected.		
Minimal overflow to be used when dredging very low density sediments.	When dredging low density sediments with TSHDs.	Reduction in the spatial and temporal extent of the sediment plume.
Minimise the use of the lean mixture overboard system by planning dredging operations to minimise turning.	Where practicable through project.	Reduction in the spatial and temporal extent of the sediment plume.
Minimise losses of sediment from TSHD during sediment transport by: - Using lower hopper fill levels in the TSHD during poor sea-state conditions. - Raising hopper overflow levels to the highest point during transport.	Throughout project.	Reduction in the spatial and temporal extent of the sediment plume.
Within operational constraints, sailing routes will be planned to minimise the generation of propeller wash from TSHD (for example the dredged channel will be used were practicable).	Throughout project.	Reduction in the spatial and temporal extent of the sediment plume.
Limiting TSHD hopper dewatering activities to within the spoil ground or dredge areas.	Throughout project.	Reduction in the spatial and temporal extent of the sediment plume.
Place material directly behind CSD ladder to minimise the abrasive path while dredging rock. Where this is not possible, use as short a pipeline as possible.	Throughout project.	Will reduce the amount of fine material created leading to a reduction in the spatial and temporal extent of the sediment plume.
Apply restrictions (to where dredging occurs) during certain periods to avoid specific areas. Could include seasonal, tidal or weather restriction.	Where marine monitoring indicates unacceptable impacts are occurring.	Avoidance of specific receptors at certain times throughout the project.
Zonal restrictions to certain areas to reduce concentration or location of plume at certain times.	Where marine monitoring indicates unacceptable impacts are occurring.	Can reduce impact of plume but maintain dredging activity within an area.
Use of crew trained as Marine Fauna Observers and marine fauna exclusion zones to minimise the risk of vessel strike or	Throughout project.	Reduces the risk of marine fauna injury or mortality.

entrainment of fauna in the dredging equipment (refer to Marine Fauna Management Plan).		
Within operational constraints, only turn on dredge pumps while the draghead or cutter head is close to the seabed.	Throughout project.	Reduces the risk of marine fauna injury or mortality.
Undertake vessel risk assessment and if necessary vessel inspections with respect to invasive marine species.	Prior to mobilisation of all vessels and immersible equipment.	Reduces the risk of the introduction of invasive marine species.
Monitoring of water quality (turbidity) and benthic health will be undertaken. As appropriate, the results of this monitoring will be used to apply further management measures to minimise impacts. Potential management measures that may be applied include: - reduction or temporary cessation of overflow during times when the dredge plume is likely to further impact the affected area. - optimisation of disposal location based on met-ocean conditions (i.e. use of alternate spoil grounds). - A reduction in the amount of dredging to be undertaken on a daily basis. - re-location of dredging operation within dredging area. - temporary cessation of dredging activities.	Where marine monitoring indicates unacceptable impacts are occurring.	Will mitigate any observed environmental impact.