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Section 3
Development Justification and Alternatives

3 Development Justification and Alternatives

3.1 Project Justification

The proposed Outer Harbour Development in Port Hedland is necessary to ease growing capacity constraints in the inner harbour of Port Hedland and ensure BHP Billiton Iron Ore's export capacity is sufficient to meet growing global iron ore markets.

The global market for iron ore is projected to increase over the next 10 years, fuelled in particular by demand from China. In 2008-09, more than 326 million tonnes of bulk commodities (comprised mainly of iron ore) were exported from Western Australia's Pilbara region. More than 530 million tonnes per annum (Mtpa) are forecast to be exported from the Pilbara by 2015, and as much as 750 Mtpa by 2020 (Government of Western Australia 2010).

The increased market demand for iron ore has resulted in a number of proposed expansions within the inner harbour of Port Hedland, such as the South West Creek Development. The inner harbour and associated departure channel is rapidly approaching capacity, limiting further growth within the harbour. The proposed Outer Harbour Development will enable BHP Billiton Iron Ore's export capacity to meet projected increases in production from the region, and remain competitive as market demand increases.

A number of other (non BHP Billiton Iron Ore) projects are planned to increase the capacity of Port Hedland. These include:

- proposed Utah Point operations;
- proposed Fortescue Metals Group (FMG) expansion operations at Anderson Point;
- proposed Roy Hill operations at South West Creek; and
- proposed North West Iron Ore Alliance (NWIOA) operations at South West Creek.

3.2 Project Benefits

BHP Billiton Iron Ore's growth brings with it considerable economic benefits for the region and the State, including Government taxes and royalties currently in the order of A$2.2 billion, new business opportunities for suppliers of goods and services, and employment and contracting opportunities.

At the national, regional and local levels, BHP Billiton Iron Ore shares responsibility with governments, local suppliers, contractors and employees for ensuring that the wealth generated from natural resources drives community development that leaves a positive legacy for future generations. BHP Billiton Iron Ore's investment in Pilbara communities for the 2009/2010 financial year was in excess of A$36 million.

It is estimated that the proposed Outer Harbour Development will create approximately 2000 jobs during construction, and 200 to 300 jobs during operations. In addition there will be local content benefits of locally purchased goods and services.

3.3 Evaluation of Alternatives

BHP Billiton Iron Ore has incorporated principles of sustainability and risk management (refer **Section 1.2.4**) into the Outer Harbour Development through the integration of the engineering design and impact assessment processes. An iterative process has been followed, where evaluations were made on several occasions, with design modifications or management measures applied each time, to establish cost-effective and environmentally, socially and culturally acceptable outcomes.

During the Concept Phase (identification), BHP Billiton Iron Ore evaluated a number of alternative sites for achieving increased export capacity in the Pilbara region of Western Australia. Each option was evaluated against technical, economic and social impact criteria. The site options were also evaluated using 'cleaner production' assessments to determine the potential to reduce resource use (i.e. minimise water use) and emissions (i.e. dust emissions) associated with the transfer of iron ore from car dumpers, through to shiploaders.

During the Selection Phase particular attention was directed towards evaluating preliminary design options for materials handling, location of the stockpiles and the rail spur.

Summaries of the key alternatives evaluated during the concept and selection phases of the engineering studies are discussed in **Sections 3.3.1** and **3.3.2**.

3.3.1 No Action Alternative

This section addresses the consequences of not proceeding with the Outer Harbour Development. Although the No Action Alternative would eliminate any environmental impacts associated with the project, the need for additional port capacity and increasing demand for iron ore would remain.

The consequences to BHP Billiton Iron Ore of not proceeding with the Outer Harbour Development would be failure realise the objectives detailed in **Section 1.1.3**.

Impacts would include loss of:

- employment opportunities – the Outer Harbour Development is expected to create 2,000 jobs during construction, and 200 to 300 jobs during operations; and
- local content benefits of locally purchased goods and services.

If the need for additional port capacity is not addressed, it has the potential to result in:

- limitations to port export capacity;
- increased waiting time for vessels to access port facilities;
- higher risk of vessel collisions or interactions; and
- increased pressure on the inner harbour environment.

3.3.2 Concept Phase – Port Site Selection

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 (**Figure 3.1**). 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.

Criteria for Assessing Options

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, identified based on a desktop review of previous studies, navigation charts and topography were (**Figure 3.1**):

- Port Hedland;
- Cape Keraudren;
- Depuch Island;
- Ronsard Island; and
- Cape Thouin.

A conceptual study of these alternative port locations was conducted. The Cape Karaudren, Depuch Island and Cape Thouin sites were discounted early in the process due to physical, operational and environmental constraints (**Table 3.1**). The study then focussed on further investigations for Ronsard Island and Port Hedland, and in particular Finucane Island. The study focussed on the socio-economic and engineering aspects of each site, as limited environmental information was known for many of the locations. At each site conceptual engineering indicated that most of the sites considered would require dredging to enable vessels (departure channel depths of approximately 15 m) to access berths closer to the shore, limiting factors for berth location include conveyor lengths, especially over water, causeway lengths (and material required to construct these) and potential for inundation. From a socio-economic perspective the Port Hedland development option offered benefit to the Town of Port Hedland, and continued to build on BHP Billiton Iron Ore's community and partnerships programmes already implemented.

Table 3.1 – Alternative 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).	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. To achieve depths of – 14m LAT (vessel access), requires 16 km dredged channel.
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 (Worley Parsons, 2007).
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 (Biota, 2010). 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 (Worley Parsons, 2007). Likely to have various archaeological and anthropological / ethnographic survey sites of importance (Worley Parsons, 2007)
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.

Based on the Pilbara Port Study (Worley Parsons 2007), Ronsard offered the preferred location for a new port facility (greenfield development) in the Pilbara. The study does not take into consideration the leverage BHP Billiton Iron Ore would have by locating adjacent to its existing operations at Port Hedland and leveraging off the existing supporting infrastructure already developed there.

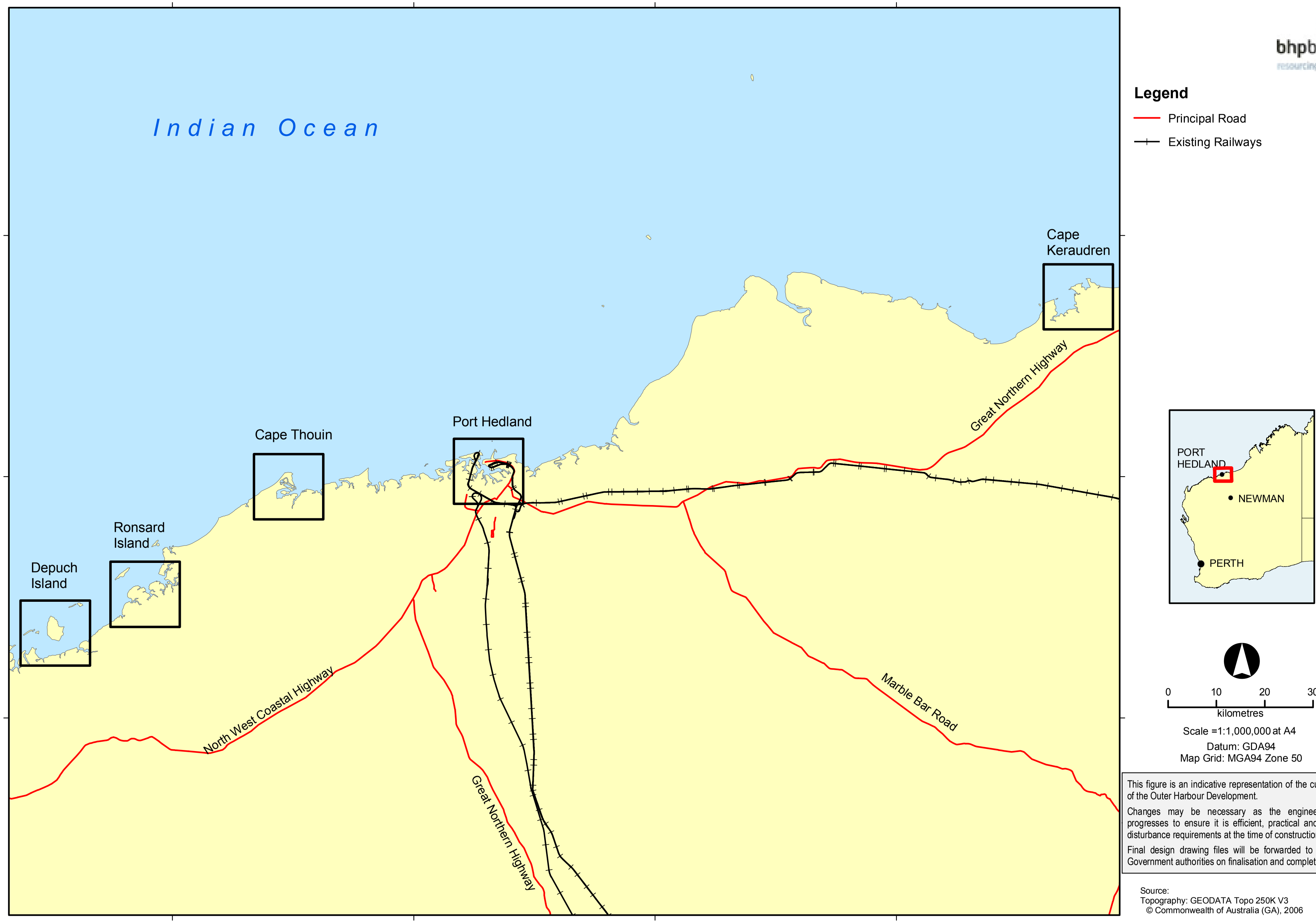
BHP Billiton Iron Ore then focussed studies on further investigations for locating the proposed Development at Port Hedland (brownfield development), in particular Finucane Island.

Selected Option

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 four spoil grounds offshore) as compared to the relatively un disturbed 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 and are discussed in Section 2;
- 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 optimises the current operations. 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.



This figure is an indicative representation of the current design of the Outer Harbour Development.

Changes may be necessary as the engineering design progresses to ensure it is efficient, practical and within land disturbance requirements at the time of construction.

Final design drawing files will be forwarded to the relevant Government authorities on finalisation and completion.

Source:
Topography: GEODATA Topo 250K V3

Figure 3.1 Alternative Port Locations

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3.3.3 Selection Phase

Subsequent to the selection of Finucane Island as the port location, several design alternatives were evaluated. A summary of these design alternatives is provided in **Table 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 (channel alignment Options 2 and 3 (**Figure 3.2**) share a single wharf location). 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 (refer to **Figure 3.2**).

Table 3.2 – 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
Shipping 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

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.

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 (refer **Figure 3.2)**:

- 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 areas of coral and avoids the most sensitive marine areas.

Dredge Spoil Disposal

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 (**Figure 3.3**) were not considered as options due to future usage requirements by PHPA and a lack of capacity for the total volume of proposed Outer Harbour Development dredge material.

Nine preliminary offshore spoil ground locations were identified using available bathymetric data (**Figure 3.3**). 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 four preferred locations to support this project, designated as Spoil Grounds 2, 3, 7 and 9 (**Figure 3.3**). All of these offshore spoil grounds are located in Commonwealth water at depths greater than 10 m Chart Datum (CD) and are clear of existing and proposed channels and anchorages. Spoil Ground 7 is the preferred location, whilst the smaller spoil grounds 2, 3 and 9 have been identified as potential contingency spoil grounds to be utilised to reduce potential environmental impacts associated with the dredging programme. BHP Billiton Iron Ore also proposes to use remaining capacity in Spoil Ground One.

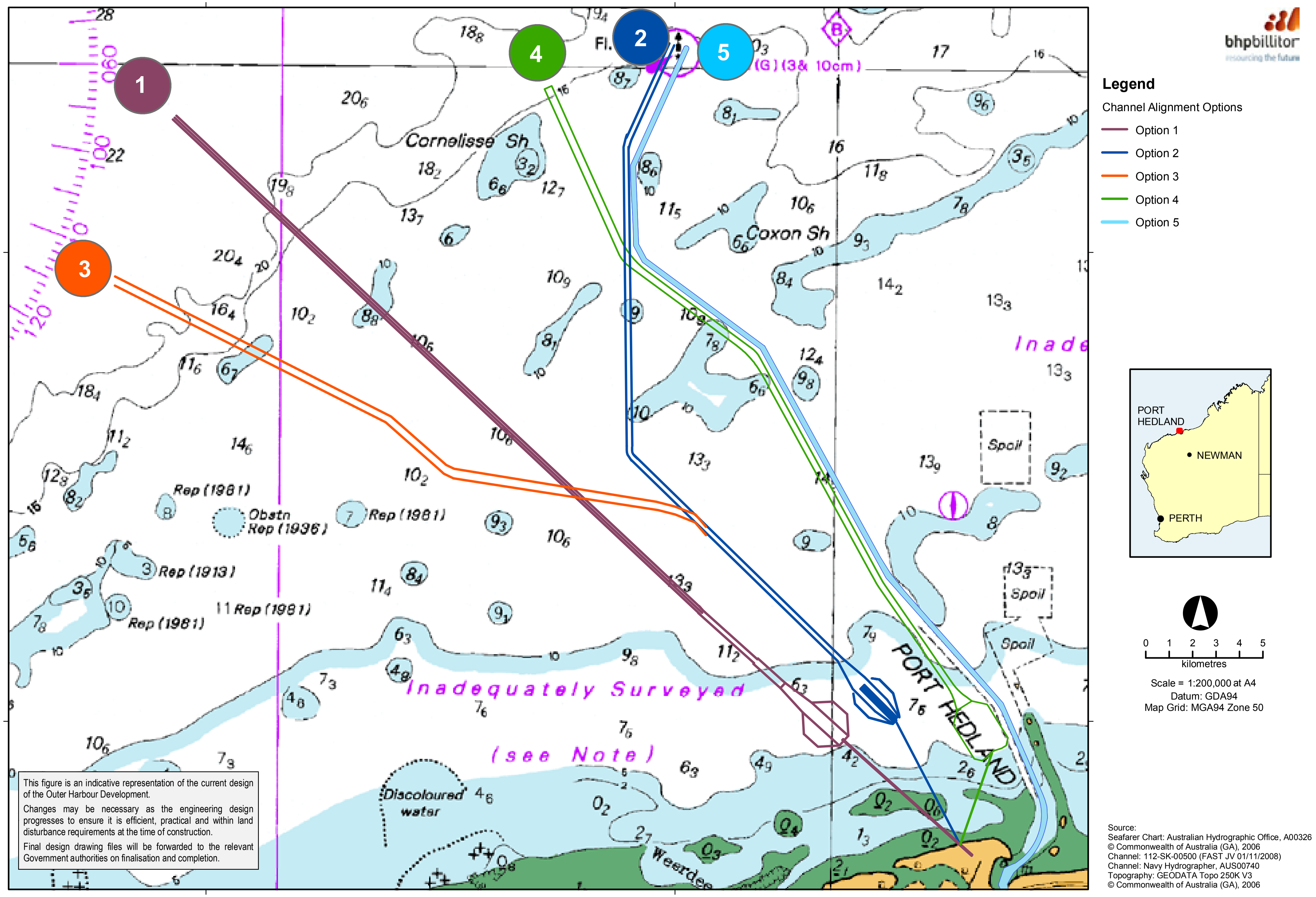

Figure 3.2 Shipping Channel Alignment Options

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The final spoil grounds to be used will be determined by the outcomes of the recent geotechnical drilling programme, subsequent review of the dredging programme, refined engineering design and dredging programme optimisation, ongoing consultation with the PHPA and plume modelling validation trials.

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 (approximately 7 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 proposal will bring material onshore and dispose 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.

Rail Location

Additional rail capacity will be required for the proposed Outer Harbour Development to transport the increased incoming ore from the existing BHP Billiton Iron Ore Port Hedland-Newman rail line to the new rail loops at the proposed Boodarie stockyards. During the Selection Phase Study, three new conceptual rail spur alignments were evaluated including a North-Western (Option 1), Eastern (Option 2) and Central (Option 4) route. The North-Western alignment (Option 1) also incorporated two additional options (i.e. South-Western (Option 3) and Central-Western (Option 5)). These two options linked to the existing Port Hedland-Newman Railway at chainage marks further south of the 26 km Chainage Mark (**Figure 3.4**).

All five options assume a new rail alignment and diverge to the west from the Newman-Port Hedland rail line, and then north to the Boodarie Stockyards. The Eastern Route (Option 2) travels east of the proposed Boodarie Industrial Estate, and then alongside the FMG rail line, before linking up with the existing company's Goldsworthy Railway. The Central Route (Option 4) bisects the proposed Boodarie Industrial Estate and therefore was deemed to limit optimal development of the estate. The Western Route options (1, 3 and 5), whilst longer and with a larger development footprint, were determined to have the least negative impact when technical, environmental, and social factors were considered together.

Options 1, 3, 4 and 5 (**Figure 3.4**) were sufficiently distant from communities at South Hedland and Wedgefield and the housing development at White Hills, such that adverse impacts on social sustainability due to the proposed rail spur were not envisaged. Preliminary desktop heritage surveys identified several indigenous heritage sites; however, none of the proposed rail spur alignment options directly impacted any of these known sites.

From a hydrological perspective, the North-Western alignment (Option 1) represented the best option for mitigating potential flooding impacts because it has a minimal footprint in the floodplain. This rail route is located west of the South West Creek flood extent and east of a ridge separating it from flooding of the Turner River. The North-Western alignment option also avoids the proposed Boodarie Industrial Estate and does not restrict site access. Furthermore, the crossing of this alignment at the Great Northern Highway satisfies the Main Roads Western Australia (MRWA) requirement for a minimum separation from the FMG Railway crossing.

Criteria for Assessing Options

The options were evaluated based on:

- social sustainability (of which noise was a key driver);
- Indigenous heritage sites;
- hydrological impact;
- land tenements;
- interaction with FMG Railway;
- interaction with existing road and utilities infrastructure;
- preservation of access for planned or proposed future infrastructure; and
- relative cost.

Selected Option

The North-Western alignment (Option 1), herein after referred to as the Western Spur railway, was selected as the preferred option for the development of a new railway due to the following factors:

- it provides the best option for flooding impacts with a minimal footprint in the flood plain;
- it does not restrict the development potential of the proposed Boodarie Industrial Estate;
- it aligns with the Town of Port Hedland Master Plan;
- it satisfies MRWA requirement for a minimum separation between FMG and proposed rail spur crossings of the Great Northern Highway;
- it includes capacity for future rail expansion by BHP Billiton Iron Ore or other parties; and
- it is a sufficient distance from the communities at South Hedland and Wedgefield and the housing development at White Hills to have minimal impact.

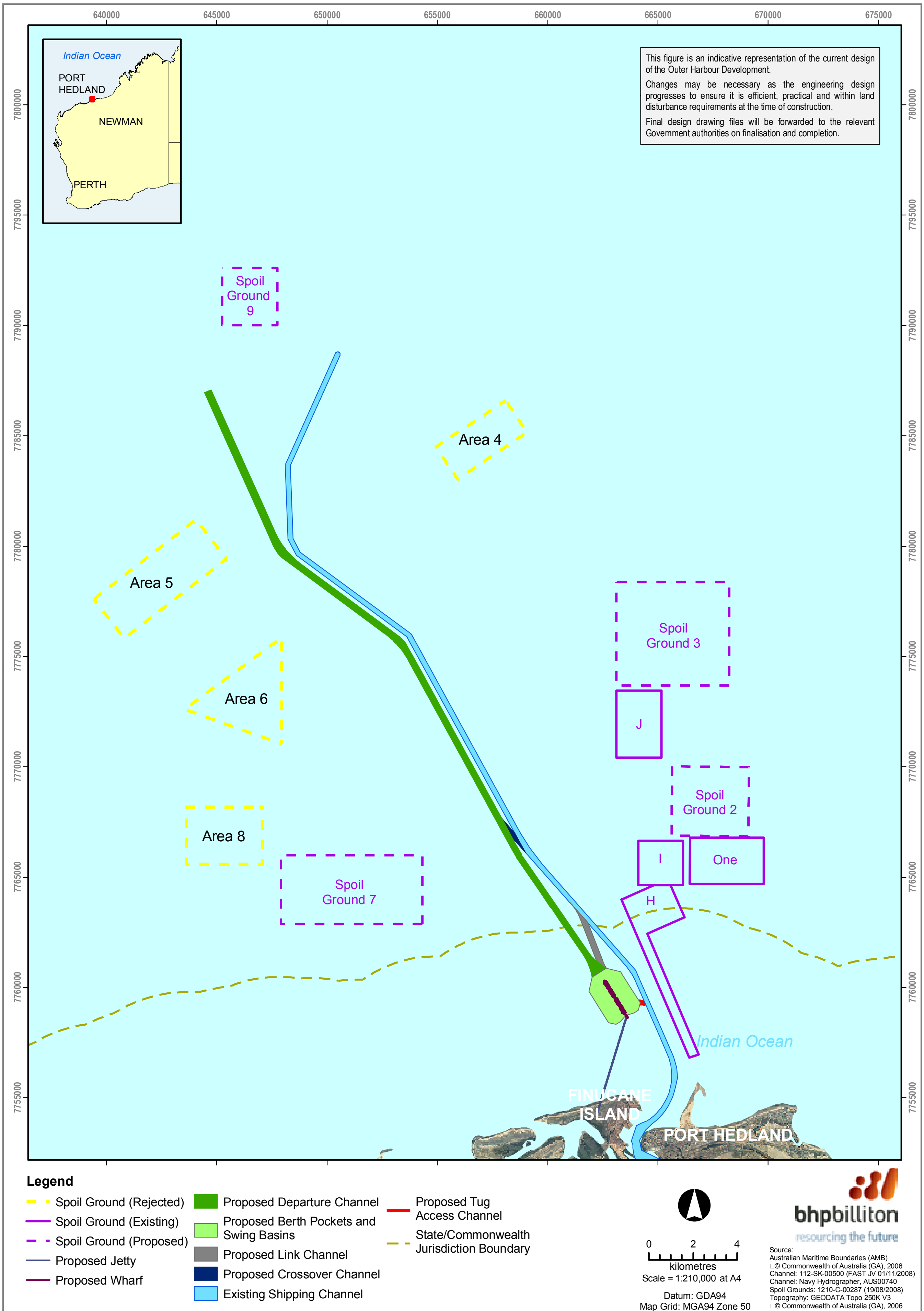

Figure 3.3 Preliminary and Proposed Spoil Ground Locations

The proposed staging of the Western Spur railway and the inclusion of loops joining it to the existing Goldsworthy rail line will be further refined during detailed engineering. This will be undertaken along with the refinement of the location of the proposed Western Spur railway line within the proposed disturbance envelope footprint, following site geotechnical investigations.

Infrastructure Corridor

The infrastructure corridor alignment was chosen due to limitations on the capacity of large conveyors for vertical and horizontal bends or curves. Bends and curves in the conveyor system each require a transfer station. To minimise the number of transfer stations in the corridor the alignment therefore needs to be straight. In addition, the topography of the coastal area of Port Hedland harbour and Finucane Island offer limited alignment choices from Boodarie stockyards that also minimise the potential to be impacted by storm surges, or the large tidal ranges experienced. Placement of the corridor further to the west of Finucane Island was constrained by heritage issues.

During the Selection Phase, environmental and sustainability outcomes were maximised by expanding the existing, decommissioned Hot Briquetted Iron (HBI) Plant conveyor corridor to accommodate the project infrastructure corridor (from Boodarie to Finucane Island). The alignment and construction methodology for the conveyor corridor crossing have been chosen to minimise the potential for impacts on mangroves. In addition, a tidal flushing study undertaken by APASA (2009b) demonstrated that the tidal flows between the proposed causeway and existing causeway can be maintained through the inclusion of culverts. The proposed causeway structure (adopting the 15 culvert design option) with the end-over-end construction methodology is the preferred option.

Subsequent to these considerations and the initial phase of the engineering option selection process, the preferred construction methodology for the conveyor corridor crossing of West Creek was selected. Two methodologies were considered suitable to support the conveyor corridor:

- Option 1 – construction of a full length solid causeway; and
- Option 2 – construction of a solid causeway with culverts.

Criteria for Assessing Options

Each option was assessed against three key criteria, namely:

- impacts to mangrove habitats;
- constructability and engineering constraints for construction in the area; and
- capital expenditure.

Selected Option

Option 2 was the preferred option, with the corridor to be located adjacent to the existing corridor due to the close proximity of the west of Salmon Creek and adjacent mangroves. The conveyor transfer station on Finucane Island is located to the west and adjacent to BHP Billiton Iron Iron Ore's existing operations as geometrically the conveyors cannot pass over the existing operations at Finucane Island. A reduction in the corridor width to the minimum required to fit the overland conveyors, access road and abutments, and use of end-to-end construction methodology will minimise the construction footprint (the construction corridor will therefore be the width of the causeway). The addition of culverts into the solid causeway will maintain hydrological flows and associated mangrove productivity.

Option 1 was not preferred in the selection process due to the potential for significant impacts to sensitive mangrove habitats associated with changes in hydrological flows caused by blocking tidal flows in West Creek.

Location of Stockyards

New stockyards will be constructed to deliver ore for shipment. Several options were considered for the location of the new stockyards, including Finucane Island and the now decommissioned HBI Plant at Boodarie.
A greenfield site and a brownfield site on Finucane Island were considered as potential stockpile areas. The brownfield site was discounted due to the unsuitability of site geometry (land area) and the ground conditions. The greenfield site on Finucane Island was discounted due to land availability, unacceptable Indigenous heritage impacts and increased noise and dust impacts.

Criteria for Assessing the Options

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

- potential terrestrial environment impact;
- Indigenous heritage sites;
- hydrological impact;
- land tenements;
- social sustainability (of which dust was a key driver) as well as recreational use of Finucane Island;
- potential to build the most efficient layout due to larger available area;
- potential for future expansion; and
- proximity to, and opportunity for synergy with existing infrastructure.

Selected Option

New stockyards and associated infrastructure will be constructed at Boodarie. Although Finucane Island represents a smaller clearing footprint, new stockyards at Boodarie provide the opportunity to utilise existing infrastructure (associated with the decommissioned HBI Plant), previously disturbed land and optimise the layout. This optimisation will result in decreased water use and a reduction in dust emissions within the Town of Port Hedland.

3.4 Definition, Execution and Operational Modifications

Based on the conceptual design for a port located at Finucane Island, a preliminary environmental risk assessment was undertaken to identify relevant environmental factors, additional information required, and the investigations to be undertaken, as described in the *Port Hedland Outer Harbour Development Environmental Scoping Document* (BHP Billiton Iron Ore 2008a).

As additional information on the existing environment became available, the preliminary environmental risk assessment was reviewed giving consideration to the implementation of mitigation and management measures which are standard industry practice. Resultant impacts representing a medium or high level of significance were reviewed to explore opportunities to modify design parameters, and identify management practices and controls to mitigate potential impacts. The Hierarchy of Controls was applied in accordance with the 'As Low as Reasonably Practicable' (ALARP) principle. This was an iterative process and included:

- modifying design (if practicable) to avoid the impact altogether or to limit the severity of the impact;
- developing construction and operational practices to minimise impacts;
- where impact could not be avoided, identify remediation actions;
- designing monitoring programs to detect impacts; and
- developing contingency measures if outcomes are greater than predicted.

As specific management measures were developed, the significance of the residual impact was re-assessed to determine whether standards of acceptability were met.

Design, construction and operational practices modified to prevent or limit adverse impacts resulting from the proposed Outer Harbour Development are provided in **Table 3.3**. Key examples of management and mitigation initiatives include:

- preliminary design of jetty modified to accommodate access for recreational boaters to pass under the elevated jetty at controlled locations, subject to relevant goverment approvals;
- preliminary design of jetty abutment modified such that abutment is located atop limestone cliff, minimising impacts on BPPH and coastal processes;
- the development and implementation of construction procedures to minimise disturbance during construction and optimise the opportunities for the recovery of vegetation. For example the preliminary design of the causeway modified to minimise potential impacts to the mangroves (width of the causeway reduced by 70 m) by using a different construction methodology, and incorporating culverts; and
- implementation of proactive dust management system to predict adverse meteorological conditions. Ensures appropriate dust suppression processes are implemented.

BHP Billiton Iron Ore has recently undertaken a series of Rapid Growth Projects (RGP) within the inner harbour at Port Hedland, which have included dredging, spoil disposal, removal of mangroves and construction of new berths. During construction of these projects, BHP Billiton Iron Ore along with the construction and dredging contractors has developed environmental management procedures to manage the potential impacts. The dredging and construction programmes have been successfully implemented and have met the conditions outlined in the relevant Ministerial Statements for these projects.

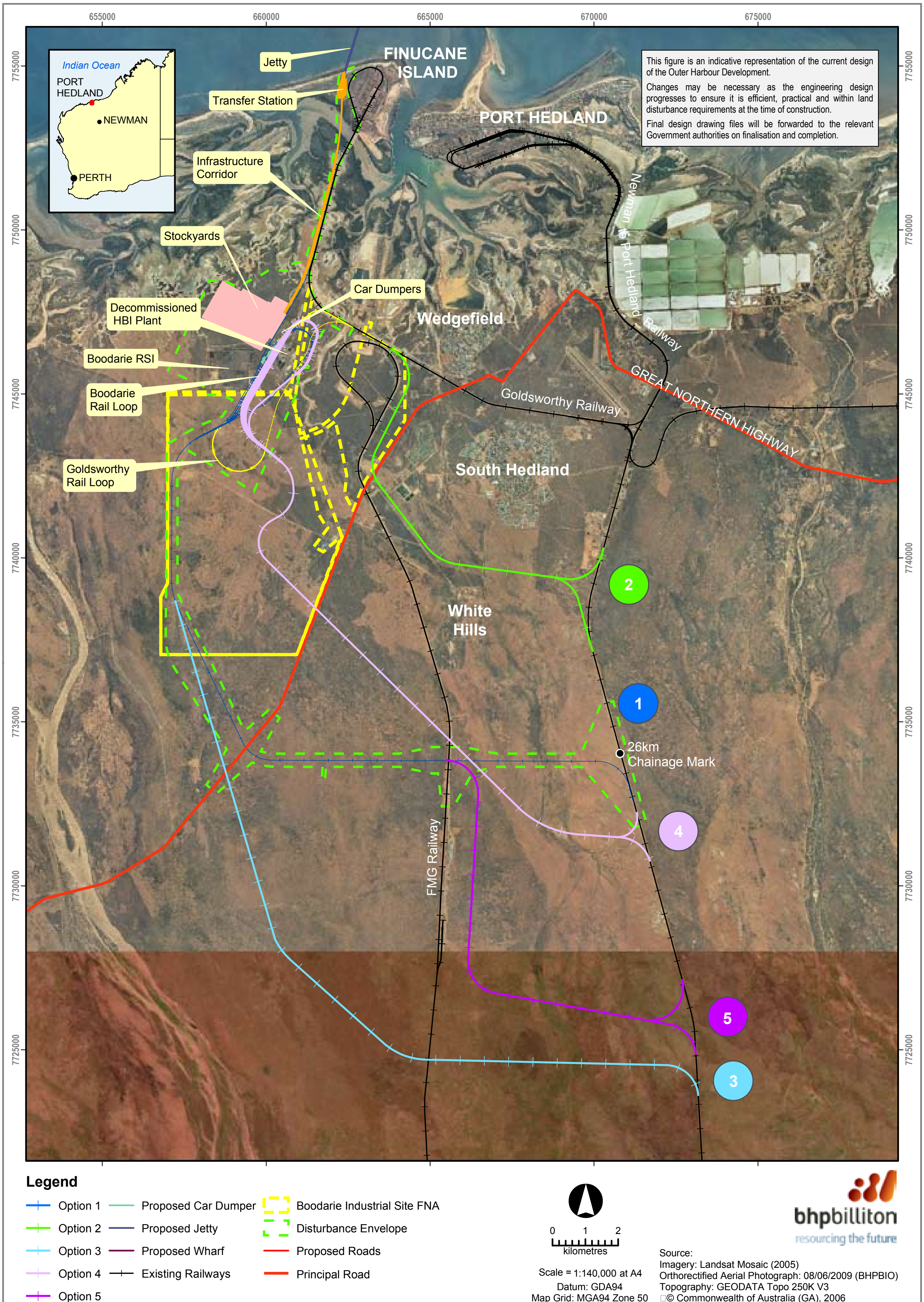

Figure 3.4 Rail Options

Table 3.3 – Summary of Definition Design, Construction and Operational Modifications and Resultant Benefits

Project Phase	Project Component	Modifications	Resultant Benefits
Definition	Jetty and Wharf	Preliminary design modified to accommodate access for recreational boaters to pass under the elevated jetty at controlled locations. BHP Billiton Iron Ore seeking required approvals.	Reduced light spill and sky glow resulting in minimised impacts to turtles. Reduced disruption to recreational boating community through opportunity to allow access under the jetty.
		Preliminary design modified to include high pressure sodium or other appropriate technology and asymmetric distribution floodlight luminaires along jetty and wharf structure.	
	Jetty Abutment	Preliminary design modified such that abutment is located atop a limestone platform and therefore minimised in area.	• Elimination of direct removal of BPPH, as limestone platform supports ephemeral BPP communities. • Mitigates impacts to seasonal longshore sediment transport though minimising footprint.
	Infrastructure corridor across West Creek	Preliminary design modified such that current tidal exchange can be maintained.	Minimise long-term impacts on mangroves due to changes in tidal flow regimes.
	Stockyards located at Boodarie	Optimisation of proposed stockyard layout, resulting in a reduced number of conveyors, overall conveyor length and transfer stations.	• Further reduced project footprint. • Decreased energy usage. • Reduced noise and dust emissions.
	Railway	Preliminary design modified to include culverts/ diversion channels to maintain water flows across the landscape.	Minimise degradation of vegetation due to drainage shadow effects or localised flooding.
		Project design modified to incorporate additional erosion and sediment controls.	Minimise erosion and the potential for changes in natural drainage patterns.
	Roads	Incorporation of the existing road network associated with the former HBI plant as an integral part of the Outer Harbour Development, wherever practicable.	• Reduced project footprint. • Reduced requirement to import and/or source road base fill material. • Reduced vegetation clearing requirements.
		Preliminary design modified to include a grade separation at the intersection of Great Northern Highway and the Western Spur.	Avoid congestion and road safety issues.
Construction/ Execution	Dredge Spoil Disposal	Refinement of proposed offshore spoil disposal grounds in response to marine environmental baseline studies and impact assessment.	• Avoidance of sensitive marine habitats (such as corals). • Identification of appropriate ecological threshold trigger levels to protect coral health during the dredging program.
	Dredging and Marine Construction Activities	Implementation of slower vessel speeds and observer programs.	Minimise the impacts to marine fauna due to vessel collisions and entrainment.
		Minimisation of lighting on construction and dredging vessels to the lowest minimum levels required for safe working conditions.	Minimise behavioural impact on turtles.
		Implementation of soft-start piling.	Minimise underwater impacts on marine fauna by diverting fauna away from construction activities.
	Infrastructure corridor across West Creek	Removal of mangroves and other vegetation using both land based and floating equipment where appropriate, access paths will be minimised through the mangroves and will not disturb outside the approved project footprint.	Minimise disturbance and removal of mangroves.
	Terrestrial Construction Activities	Progressive rehabilitation of disturbed areas, which are no longer required.	Minimise dust generation.

Table 3.3 – Summary of Definition Design, Construction and Operational Modifications and Resultant Benefits (continued)

Project Phase	Project Component	Modifications	Resultant Benefits
Operation	Lighting	Minimisation, where possible, of lighting required during construction and for security purposes whilst maintaining compliance with levels required for safe working conditions.	Reduced light spill and sky glow resulting in minimised impacts to turtles.
	Energy Efficiency	Implementation of runtime efficiency (conveyors will be shutdown during no-load periods), energy efficiency (lighting), alternative energy, and during maintenance.	Reduced greenhouse gas emissions.
	Water Conservation	Revision of preliminary design to maximise the use of re-cycled water.	Minimise use of potable water.
	Dust Management	Implementation of proactive dust management system to predict adverse meteorological conditions.	Ensures appropriate dust suppression processes are implemented.
		Application of chemical surfactants on stockpiles and open areas.	Reduced dust emissions due to wind erosion.